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CODE RED FOR EARTH

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BOOK OF FULL TEXT PROCEEDINGS VOLUME 2

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VOLUME 2

CODE RED FOR EARTH

UNION OF TURKISH ARCHITECT AND ENGINEERS (UCTEA)
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Preface

The IFLA World Congress holds a special historical significance for Istanbul and Turkish landscape architecture. The 15th IFLA World Congress was held in Istanbul on 6-9 September 1976, at a time when IFLA Regions had not yet been formed. The Congress was inaugurated by IFLA President Prof. Hubert B. Owens, Turkish Landscape Architecture Association President Prof. Dr. Yüksel Öztan, and representatives from the Council of Europe and UNESCO, both of which supported IFLA at that time. **Forty-eight years later, the IFLA World Congress returns to Istanbul for its 60th edition**, symbolizing not only a profound continuity in the global landscape architecture community but also Istanbul's enduring role as a crossroads for innovation, collaboration, and dialogue in this field.

The **60th World Congress of the International Federation of Landscape Architects (IFLA)**, hosted by the **Union of Chambers of Turkish Engineers and Architects (UCTEA) Chamber of Turkish Landscape Architects (CTLA)**, took in Istanbul between 4-6 September 2024 under the theme **"Code Red for Earth"**, emphasizing the urgent need for humanity to take action against the escalating environmental crises threatening our planet. The opening ceremony of the Congress was delivered by IFLA World President **Bruno Marques**, CTLA President **Barış Işık**, and Organizing Committee Chair **Yasin Otuzoğlu**, along with distinguished domestic and international keynote speakers.

As the most significant annual event for the landscape architecture profession, the IFLA World Congress serves as a vital platform for dialogue among professionals, researchers, educators, students, and stakeholders. It offers a unique opportunity for professional development, intercultural exchange, and discussions on innovative approaches to address the profound challenges faced by our natural and built environments.

The Congress paper process was managed and finalized by the **Call for Abstracts and Reviews Committee**, while the Congress themes and sub-themes were identified by the **Theme Selection Committee** as outlined below:

Codifying Code Red (Eco-Emergencyi Global Solidarity)

- Natural Processes and Disasters
- Ecological or Environmental Degradation
- Climate Crises and Impacts
- Urbanization and Sprawl
- Human Factors and Impacts

Sustaining Life (Protection, Mitigation and management)

- Landscape Patterns and Processes
- Biodiversity
- Ecosystem Services
- Heritage Planning & Conservation
- Environmental and Coastal Mitigation
- Collective Memory

Cultivating resilience (Sustainable and Resilient Communities)

- Water and Food Security
- Energy Security & Clean Energy
- Disaster Resilience
- Climate Action
- Environmental Health & Well-being
- Traditional Knowledge & Indigenous Practices
- Sustainable Practices

Acting for All (Diversity, Equity and Inclusion)

- Inclusive Community
- Environmental Justice
- Action, Advocacy & Governance
- (Im)migration & Refugees
- Social (In)equality
- Behavior & Perception

Engaging with the Traditional (Innovation, Technology and Big Data)

- Digital Transformation
- Artificial Intelligence
- Augmented Reality
- Interaction Design (IxD)
- Big Data & Smart Cities
- Green Technology

Protecting The Process (Monitoring, Assessment and Application)

- Procedures & Methods
- Change Detection
- Landscape Performance
- Participatory Research
- Temporality & Interim Use
- Application & Maintenance

Building Bridges, Breaking Barriers (Education and Practice)

- Design Education & Pedagogy
- Pedagogical Challenges
- Multidisciplinarity & Transdisciplinarity
- Communication and Collaboration
- Codes and Ethics
- Continuing Education

"Code Red for Earth" calls for immediate and collective action to combat environmental degradation, climate crises, and their extensive impacts on ecosystems and human communities. The Congress invited policymakers, academics, professionals, and individuals to work together toward a sustainable and resilient future. It underscored the mediating and transformative role of landscape architecture in reconciling nature and built environments, reaffirming the profession's relevance in addressing today's pressing challenges.

This book constitutes **Volume 2 of the Full Text Proceedings** and includes the papers submitted for publication by authors whose works were presented as oral and poster contributions in Istanbul within the Congress's two tracks of **scientific or practice**. In other words, this book includes only the papers submitted for full-text publication and does not encompass all oral and poster presentations delivered during the Congress. Many impactful papers presented during the event illuminated the scientific, artistic, technological, and social future of landscape architecture. The content and information presented in the papers included in this book are the sole responsibility of their respective authors.

This publication reflects the spirit of the 2024 Congress, showcasing the collaborative efforts, pioneering research, and innovative solutions that emerged during the event. It is designed to contribute to the field and inspire further exploration of solutions to the environmental challenges defining our era.

We extend our heartfelt gratitude to all participants, organizers, and contributors who made this Congress and its proceedings possible. Through unity and innovation, we believe meaningful steps can be taken to address the pressing challenges of our time.

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Content

CODIFYING CODE RED

Impact on City Image of Bingöl's Native Oaks

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Abstract

Native plants in urban areas have important ecological functions. Also they can define and characterize the city, contribute to its identity, and strengthen the belonging sense of locals. In this research, oaks (Quercus spp.) growing naturally in Bingöl City were discussed. Human pressures have resulted in the disappearance of oaks in urban areas, leaving them only on the peripheries of the city. To better understand the local people's perspective on this change in Bingöl and the impact created, interviews were conducted with participants selected from the locals. A semi-structured interview paper was prepared and interviews were conducted with 10 participants from different age groups. As a result of the interviews, differences were observed in terms of perspectives and experiences on oak trees among participants representing different age groups. Since oak vegetation has declined from the city center towards its peripheries due to human pressures, the oaks have been declined to "greenery" in the mountains surrounding the city. Therefore, the correlation established with oaks in the past could not be transferred to the future. Including in urban landscape of naturally growing oak species will contribute to re-strengthening this correlation.

Keywords: Bingöl, native plants, oaks, city image, interview

1. Introduction

With its cultural, social and economic dimensions, urban landscape is a complex structure arising from the human-environment relationship. Shaped by social values, beliefs and symbols, this landscape is constantly transformed by changes in social structure, lifestyle and global economy, and physically reflects urban identity (Kaymaz, 2013). Urban identity has a strong connection with history and heritage as a reflection of shared memory and experiences (Zukin, 1995). In this context, physical space and human identity are interrelated and mutually interactive (Lalli, 1992).

The common characteristics of the urban environment, influenced by cultural, historical and socio-economic factors, define the urban identity of a place at a macro level. Urban identity, which deals with the shaping of individual identity, belonging and experiences by the urban environment, focuses on individual and group identities at the micro level (Figure 1) (Mansour et al., 2023).

According to environmental psychology, people naturally tend to develop a sense of belonging. A sense of belonging and attachment is important for community formation, a sense of security and emotional bonds. Place identity is strongly linked to a sense of place attachment and belonging, and carries "meaning" for the individual and society beyond physical appearance. (Kaymaz, 2013).

Figure 1. The intersection of urban identity of a place and people's urban identity (Mansour et al., 2023).

Identity, which is constructed by the social structure (Lalli, 1992), consists of 3 components of the image together with meaning and structure (Lynch, 2016). Therefore, urban identity has an impact on urban image (Demirseren Çöl, 1998), and each identity component in the urban area has an impact on the formation of the image with the meaning it carries.

Urban identity elements are represented by the city's natural environment, built environment and social environment. Natural environmental features are represented by elements such as topography, vegetation, climatic characteristics, soil structure, water element and geological structure (Ocakçı & Aydın Türk, 2012). In today's cities, although urban identity is generally perceptually represented by structural elements, plant material has symbolic potential (Karaşah & Sarı, 2018). In addition to spatial features such as architectural structure and street texture, the landscape presented by local plants has a complementary feature to the city image (Oktay, 2002). Plants can create images with their form, historical and cultural uses, ecological characteristics and environmental effects (Yurtcan & Akbana, 2023), and contribute to urban identity and aesthetics by being associated with the cities whose landscapes they affect (Göncü, 2007; Karaşah & Sarı, 2018).

Planting design in urban areas contributes to the formation of social memory. However, urban spaces that change frequently due to reasons such as the removal of green areas from urban areas or the spread of exotic species can weaken social memory. Therefore, it may cause difficulties in transferring social memory to future generations, erosion of the sense of attachment to place and loss of identity (Zeybek, 2020). The use of natural vegetation in urban areas contributes ecologically due to its more restrained characteristics compared to exotic plants. In addition, it allows the creation of a protection area for natural plants in the urban area and allows the public to recognize these plants (Tırnakçı & Aklıbaşında, 2023). Attitudes towards trees in urban areas affect people's interaction with the natural environment and their ability to incorporate trees into the landscape. Leaving tree cover to natural regeneration and encouraging afforestation areas can increase vegetation cover, while practices such as removal, felling, mowing and pesticide use can reduce vegetation cover (Nowak et al., 1996). Therefore, the attitudes and policies of public institutions to protect urban vegetation can influence the attitudes and sense of ownership of urban residents.

This research aims to examine the identity value that oak species growing naturally in Bingöl bring to the city and their impact on the city image.

2. Material and Method

Bingöl is located in the Eastern Anatolia Region of Turkey and is divided into two parts in the north-south direction by the Çapakçur Valley. In 1945, due to the risk of flooding, the old settlement of the city was moved from the valley to the flat area in the south, and (Kavut & Sümer Çakır, 2021). İnönü, Bahçelievler and Mirzan neighborhoods were established between 1945 and 1955. After 1955, the city expanded towards the south and southeast (Soylu, 2010). Bingöl experienced 8 major earthquakes between 1949 and 2005. The most severe earthquakes were 6.7 magnitude in 1949, 6.8 magnitude in 1971 and 6.4 magnitude in 2003 (BDTİM, 2017). After the 1971 earthquake, the Kültür Neighborhood was established in the southeast of the city (Soylu, 2010). After 1980, migration to the city increased and construction started in the forested area north of Çapakçur Valley. After the 2003 earthquake, TOKI residences were built in this area (Baş & Avcı, 2021). Following the process that started with the relocation of Bingöl city center, the forested area was gradually eroded with the effect of urbanization that accelerated with the increase in population after 1980 (Figure 2).

Figure 2. Changes in Bingöl's green areas due to urbanization (a) Dec. 1985, (b) Jul. 2008, (c) Jun. 2011, (d) Jun. 2008, (e) Apr. 2024

According to the data between 1961 and 2023, the average annual temperature of Bingöl is 12.2 C˚. The lowest annual average temperature is -2.2 C˚ in January, while the highest annual average temperature is 26.7 C˚ in July. The average annual total precipitation of Bingöl is 947.6 mm. The highest average monthly total precipitation is 138.6 mm in January, while the lowest average monthly total precipitation is 4.3 mm in August (MGM, 2024).

Bingöl city has 264,926.00 ha of forested area. This amount corresponds to 33% of its total area. Approximately 8% of the total forest area is forested and the remaining 92% is coppice forest. Approximately only 17.6% of the total forest area is in normal structure and 82.4% is in degraded structure. Bingöl, which is located within the Elâzığ Forest Management Zone, is one of the cities with the richest oak distribution in the region (Figure 3) (OGM, 2013).

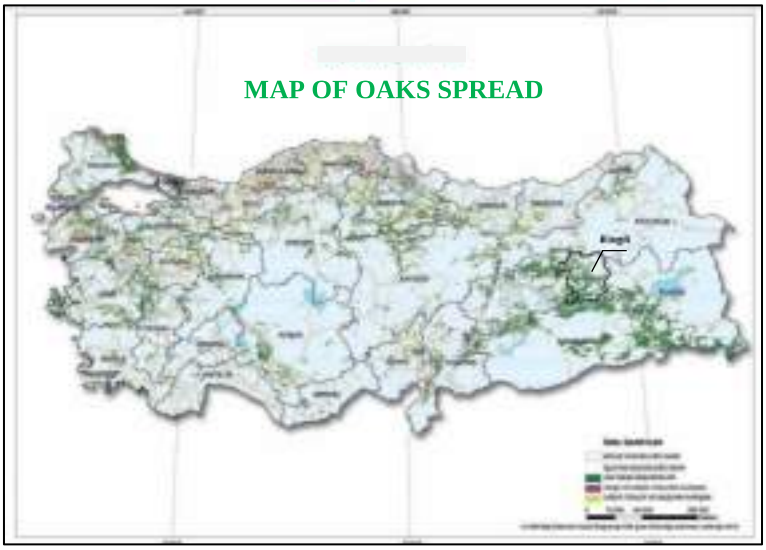

Figure 3. View of Bingöl on the oak distribution map of Türkiye (OGM, 2013).

Meral, (2021) identified 14 different oak species growing in Bingöl and stated that 2 of them, *Quercus petraea subsp. pinnatioloba* and *Quercus macranthera subsp. syspirensis*, are endemic (Table 1).

Table 1. Oak species naturally growing in Bingöl (Meral, 2021).

Genus	Species	Subspecies
Quercus	*brantii*	
	infectoria	*boissieri*
		infectoria
	libani	
	petraea	*petraea*
		iberica
		pinnatioloba
	pontica	
	robur	*robur*
		glabrescens
		pedunculiflora
	coccifera	
	macranthera	*syspirensis*

In this study, it is aimed to understand the identity value that the oak species that grow naturally in Bingöl city give to it and the effect of this identity on the city image. For this purpose, qualitative research techniques using interview technique were utilized. Ten locals of Bingöl from different age groups participated in the research. Before conducting the interview technique, a semi-structured questionnaire consisting of open-ended questions including demographic questions was prepared (Yıldırım & Şimsek, 2016). The interviews were initiated after the approval of the ethics committee of Bingöl University dated 17/01/2024 and numbered E.140616. Interviews were conducted separately with each participant. Audio recordings were taken during the interviews, and the participants were informed beforehand and their consent was obtained.

Content analysis was used to analyze the interview findings. During content analysis, categories were created according to the answers given by the participants (Yıldırım & Şimsek, 2016). In line with the purpose of the research, the framework was drawn in 6 categories. The interview questions prepared for the research were prepared according to the concepts included in the framework, making it easier to organize the data according to the concepts.

3. Findings

3.1 Demographic Characteristics of Participants

The participants in the study were selected from different age groups, different genders, local people of Bingöl, people who have spent all or most of their lives in Bingöl, and people who have not severed their ties with the city (returning to live in the city even if they are outside the province for reasons such as work and/or education). 4 of the participants were women and 6 were men. The study included 5 high school and 5 higher education graduates. The age range of the participants was 25-77. The demographic characteristics of the participants are shown in Table 2.

Table 2. Demographic characteristics of the participants

	Gender	Birth Date	Education
P1	Male	1981	Bachelor's
P2	Male	1981	Bachelor's
P3	Female	1970	High school graduate
P4	Male	1950	Bachelor's
P5	Female	1999	High school graduate
P6	Female	1998	High school graduate
P7	Male	1980	Bachelor's
P8	Male	1993	High school graduate
P9	Female	1947	Bachelor's
P10	Male	1987	High school graduate

3.2 Landscape Value Added by Bingol Oaks to The City

The contribution of oak to the green appearance surrounding Bingöl city center was not denied by all participants. While most of the participants considered this view as an element of natural beauty, some participants emphasized it as a feature that distinguishes the city from neighboring cities (Figure 4). When Bingöl and its neighboring cities are compared, it is seen that oak groves add a green character and originality to Bingöl. It can be said that this green character adds aesthetics to the urban landscape and strengthens the perception of natural beauty. The answers of all participants regarding this part of the research are grouped as in Table 3.

Table 3. Categories of landscape value to the city

Category	Subcategories	Frq.	Participants
Bingöl's oaks effect on Landscape Value	A unique value that discriminates Bingöl from the surrounding cities,	6	P1, P2, P6, P8, P9, P10
	Green appearance around the Bingöl	9	P1, P2, P4, P5, P6, P7, P8, P9, P10
	Strengthen the perception of natural beauty by providing an aesthetic image around the city.	7	P3, P4, P5, P6, P8, P9, P10

Figure 4. Landscape change at the same points; (a) Bingöl to Elazığ, (b) Elazığ to Bingöl, (c) Bingöl to Muş, (d) Muş to Bingöl

3.3 Bingöl's Oaks Impact on City Culture

In the past, the people of Bingöl utilized oaks extensively in daily life, including goat breeding, cooking, construction, beekeeping, and medicinal uses. Oaks also played a role in social activities like picnics, honey collection, and games, fostering community bonds. However, these oak-based practices have largely disappeared in the city center, persisting only partially in rural areas. While oaks were once a significant economic and social resource, their role in urban social life has nearly vanished. Participant responses related to this topic are summarized in Table 4.

Table 4. Categories of impact on city culture

Category	Subcategories	Frq.	Participants
Bingöl's Oaks Effect on City Culture	Impact on gastronomic culture (baking, cooking, dishes etc..)	6	P1, P2, P3, P5, P6, P9
	Outdoor culture shaped by oak trees (picnic, going together to collect firewood or honey etc…)	7	P2, P5, P6, P7, P8, P9, P10
	Impact on agricultural production culture (beekeeping, goat and goose growing etc…)	8	P2, P3, P4, P6, P7, P8, P9, P10
	Impact on daily and traditional practices (firewood, shelter, wooden production, farmatology, cleaning with ash etc…)	8	P1, P2, P3, P4, P7, P8, P9, P10
	Similarities among oaks and locals; stubbornness (even if you prun of the bottom, oaks renew itself.)	2	P1, P2

3.4 Bingöl's Oaks Impact on Ecosystem Services

Participants interpreted oak groves as a source of fresh air, clean and abundant water, food and shelter for animals. They also mentioned landslide prevention and cooling effects. It was stated that the change of oaks in the city center caused the ecological benefits provided by oaks to decrease in urbanized areas. Therefore, it is seen that the air, water and soil quality of Bingöl city and the presence of wildlife are associated with Bingöl's oaks. Although there are positive images of ecosystems, there are also negative statements about wildlife. This may be due to the fact that the new generation's interaction with wildlife is interrupted due to their life in the city.The answers of all participants regarding this part of the research are grouped as in Table 5.

Tablo 5. Categories of impact on ecosystem services

Category	Subcategories	Frq.	Participants
Bingöl's Oaks Effect on Ecosystem Services	Impact on air quality (cleaning air and cooling)	7	P1, P2, P3, P5, P8, P9, P10
	Impact on wild life (animals that use oaks as shalter or food source)	4	P1, P2, P5, P6
	Soil retention and enrichment effect (protect to landslide, fallen leaves become fertilizer)	6	P4, P5, P6, P7, P8, P9
	Impact on water quality; (cleaning water and water resources enrichment)	6	P1, P3, P4, P6, P8, P9

3.5 Bingol's oaks: Urban Area Transformation and Its Effects

This section explores the cause-and-effect dynamics of Bingöl's transformation, highlighting generational differences in perception. Participants over 70, who witnessed the relocation of the city center from Çapakçur Valley, shared insights from the early stages of this shift. Those aged 35–70 observed ongoing changes and shared intergenerational experiences, while participants under 35 focused on post-2003 transformations. Key changes include urbanization, reduced water resources, declining air quality, shifts in outdoor activities, and a loss of traditional products. The rural landscape has largely been replaced by an urban one. Participant responses are summarized in Table 6.

Tablo 6. Categories of change and effects of change in urban areas

Category	Subcategories	Frq.	Participants
Bingol's oaks: Urban area transformation and its effects	Urban development between 1945 and 2003 (Moving the settlement out of the valley and urbanization of the forested areas on the southern slope)	4	P1, P2, P4, P7
	Urban development after 2003 (Post-earthquake migration and urbanization of the forested areas in the northern slope)	6	P1, P2, P3, P5, P6, P8
	Impact on traditional production practices (Decline in animal husbundry and beekeeping in the city center)	7	P1, P2, P4, P5, P7, P8, P10
	Outdoor activities and social relationships (Decrease in activities such as collecting firewood and honey, and picnicking in areas with oaks)	3	P1, P2, P9
	Effects on air and water quality in the city center (Decrease in water sources and water quantity, as well as a reduction in clean air in the center)	4	P1, P3, P6, P9
	Impact on landscape change in Bingöl city center (Oak trees remaining in limited areas, such as cemeteries and campus, and on the periphery)	7	P1, P2, P3, P5, P7, P8, P9

3.6 Bingöl's Oaks Effect on Memories of Participants

This category constitutes the second part that is important for understanding the cause and effect relationship in the research. In this category, the "meaning" component of Bingöl's oaks in the urban image was evaluated through the memories of the participants. When their memories are evaluated, it can be seen that Bingöl's oaks play an important role in strengthening the participants' sense of belonging. In addition, it was determined that the memories they accumulated in oak areas have a socially unifying effect. It can be said that especially in participants over the age of 35, a sense of ownership of oak trees and urban culture through oaks and a way of living in harmony with wildlife has developed. The answers of all participants regarding this part of the research are grouped as in Table 7.

Table 7. Categories of impact on memories of participants

Category	Subcategories	Frq.	Participants
Bingöl's oaks effect on memories of participants	Source of income (collecting wood for heating, cooking and selling, collecting honey for eating and selling.)	6	P3, P4, P6, P7, P8, P10
	Interaction among wildlife and locals (encountering and interacting with animals such as partridges, squirrels, wolves, pigs, or insects in recreational and non-recreational activities)	6	P1, P3, P7, P8, P9, P10
	Social sharing (picnicing together, acting together to provide daily needs, mutual trust and protection)	8	P1, P2, P3, P4, P7, P8, P9, P10
	Playing games and socializing during childhood (connecting with the past, playing games and creating games together)	4	P1, P3, P5, P7

3.7 Evaluation of The Lack of Oaks in The Urban Area of Bingöl

Participants over 35 years of age generally stated that the new generation does not know this plant and are deprived of their experiences. In addition, the participants mentioned that with the understanding of the importance of water today, they could not utilize the benefits of oak in this context. Participants under the age of 35 stated that oak is not preferred because it grows slowly and its use as a solitary plant does not look good. The lack of oak in urban areas can lead to the loss of cultural urban memory over time and reduce the ecological awareness of the new generation. In addition, the aesthetic views of the new generation may negatively affect conservation awareness. The answers of all participants regarding this part of the research are grouped as in Table 8.

Table 8. Categories of evaluation of the lack of oaks in the urban area of Bingöl

Category	Subcategories	Frq.	Participants
Evaluation of the lack of oaks in the urban area of Bingöl	Its place in the public memory has been erased over time and the new generation has not recognized it (children and young people have not recognized the oaks, and it has been erased from the social memory because it is not in sight)	5	P1, P2, P3, P6, P9
	The value of as an ornamental plant (the desire of the older generation to increase its use, the change in the aesthetic perception of the younger generation, its slow growth)	7	P2, P4, P5, P6, P8, P9, P10
	Environmental impact (eduction of green areas in urban areas, decrease in air, water and soil quality, use of plants that require irrigation and risk of drought)	7	P1, P2, P3, P5, P6, P7, P8,
	Impact on cultural practices in the city center (due to the reduction of the oak tree's presence because of urbanization, cultural practices cannot be conducted in the center and are not transmitted to the younger generation)	4	P3, P5, P7, P8

4 Discussion and Conclusion

One's relationship with one's physical environment is often assessed on the basis of concrete experiences. Therefore, the individual's focus is on places that he or she can directly experience and that are subjectively meaningful to him or her. As a substratum of social, emotional and action-based contents, the environment gains its symbolic significance primarily through this concrete relationship (Lalli, 1992). When the past and present experiences of the people in oak forests are evaluated, it is clear that oak trees give meaning to Bingöl. However, technological change in urban construction as well as urbanization has affected its presence in the urban area in parallel with the need for oak in the city center. The attitudes of professionals working in the city, which are not oriented towards protecting the oak, have negatively affected the attitude of the public towards the oak and the motivation to protect it. This situation has caused the city center's former densely forested, green and rural landscape structure to be pushed to the periphery. The economic, ecological and cultural benefits of oak in the city center have also diminished. According to Chen et al. (2020), protecting forests means protecting the ecosystem services as well as the cultural value these forests provide. According to Alp and Botan (2019), while carrying out landscape design and planning studies, it is necessary to identify the natural assets valued by the people of the region and to understand the cultural knowledge and experience. The protection of local plant species will contribute to the transfer and preservation of cultural memory from the past to the present.

The oak forests in Bingöl clearly add an identity to the city. The cultural effects created by the oaks are meaningful factors for the locals. The evaluations made within the scope of the study are given below;

❖ Especially when the city is reached from the east and west, the change in the presence of oaks begins in a remarkable way. This situation brings with it the feeling of “I have arrived in Bingöl” or “I am in Bingöl”. However, when one enters the city, one encounters an oakless center at the same speed. Despite this, oaks can be seen from almost every point of the city center on all the hills surrounding the city of Bingöl. However, they are not perceived as oaks but only as “greenery”.

❖ Oaks have been used as a source for many traditional products and activities. Therefore, it causes the image of the source of income through cultural practices. However, due to technology and urbanization, these practices have almost disappeared in the center.

- Oaks have created images that highlight biodiversity and ecosystem services in the city.
- The change in the center due to urbanization and migration has created images of natural and cultural changes. The rural landscape view has been replaced by the urban landscape view.
- The participants of the study think that oak is a strong tree. Oaks strengthen participants' sense of belonging. Memories associated with the oaks have a socially unifying effect. As interaction with the oaks has decreased, the sense of belonging to the city and its culture has decreased.
- The absence of oak in the city center has weakened social and collective memory over time. It has caused a lack of cultural transmission and direct experience. It has raised concerns that the new generation's recognition and protection of oaks.
- Native plants serve not only the natural environment but also the cultural ecosystem. Hence, the preservation of native plants in their natural environment and their retention in collective memory are interrelated processes that reinforce each other.

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Park City Theory: Urban Park System under High-density Urbanization

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Abstract

The rapid development of high-density urbanization poses challenges to ecology and human health. Parks and park systems are important infrastructure and quality ecological products for achieving people's growing desire for a better life. In combination with existing policies, we expanded and refined the park city proposal into the Park city theory, including an emphasis on ecosystem protection, fairness, livability, ecological value, economic vitality, urban environmental resilience, and governance level. Based on the theory of Park city, we sort out the existing standards and norms, and put forward the idea of Park system construction, including urban development mode based on "Scenario concept" and park system construction based on the "Five-state synergy theory". The team not only explored the theoretical system of Park city and Park system construction, but also carried out practice based on local characteristics in Chengdu, a big city in southwest China, and achieved good results. Currently, many cities in China are exploring innovative practices in the Park city and exploring the plan to promote green and high-quality urban development by building high-quality park systems.

Keywords: Park city, high-density urbanization, park system, five-state synergy, well-being

1. Introduction

With the development of urbanization and industrialization, climate crisis and environmental issues have become common themes facing the world. Green, resilient, and sustainable development have become the main targets of urban development.

For high-density urbanized areas, fragmentation of ecosystems and habitability of urban ecosystems are affected by rapid urban expansion, posing challenges to the health of urban residents in the post-industrial development stage, especially during epidemics. Park and park systems, as the space for recreational activities and supporting facilities for residential areas, are important infrastructure and high-quality ecological products to realize people's increasing desire for a better life.

2. Material and Method

2.1 The proposal of park city

In 2018, the idea of Park city was first put forward, advocating that urban development should pay attention to ecological values. The national proposal indicates that Tianfu New District in Chengdu (a big city in southwest China), is an important node for the construction of "the Belt and Road Initiatives" and the development of "the Yangtze River Economic Belt". It must be planned and constructed well, especially to highlight the characteristics of the Park city, take ecological values into account, strive to create new growth poles, and build inland open economic highlands" (The four chapters of Outlook News Weekly, 2023).

In January 2022, China state council approved Chengdu's construction of a Park city demonstration area to practice the new development concept (Chengdu Daily, 2024). In February 2022, the National Development and Reform Commission, the Ministry of Natural Resources, and the Ministry of Housing and Urban-Rural Development issued the "Overall Plan for Chengdu to Build a Park City Demonstration Area Practicing New Development Concept", which proposed to explore new practices of harmonious integration of mountains, rivers, cities and new paths for the transformation and development of super-large cities, building a demonstration area for the urban practice of green water and green mountains, for urban people to live and work, for urban governance modernization (Chen, 2023), putting emphasis on new development and people-oriented concepts. The circular required advancing both constructions of ecological civilization and economic and social development while promoting a city landscape interwoven with park scenery.

The proposal of Park City clarified four key points for the demonstration area construction in Chengdu, including the green ecological background, livable and beautiful life, suitable for the excellent environment, and modern governance system (Shi et al., 2022).

2.2 The connotation of park city

Park City is a new urban development concept in the post-industrial development stage, emphasizing the integration of mountains, rivers, people, and cities. Its core value is to promote the harmonious coexistence of city and nature.

The concept of the Park City is mainly embodied in the following aspects: firstly, pay attention to the protection of the urban ecosystem and shape the urban form integrated with nature; secondly, pay attention to a fairer park system to serve a livable environment and beautiful green life; thirdly, pay attention to the ecological value of green space and activate urban economic vitality; fourth, pay attention to urban ecological resilience and improve urban governance level.

2.3 The construction of park system

As a kind of modern urban infrastructure, parks are regarded as a good way to solve the "urban disease" in different stages of urban development. With the development of modern cities, the systematic construction of parks has effectively improved the quality of the urban environment and played a positive role in the restoration of the ecological environment. The Park system is a recreation service system composed of reasonable allocation of various types of parks at all levels of the city to meet the diversified leisure and recreation needs of the public (Cai et al., 2020).

In China, according to the classification of urban construction land and the characteristics of park resources and environment, according to the scale, service function, and construction characteristics of parks, the types of parks include National parks, Natural landscape parks, Country parks, Urban parks, and Greenway park. As park green space in urban construction land, urban parks are divided into Comprehensive parks, Specialized park, Neighborhood park, Amenity park, and Pocket parks (Practice revision of urban green space classification standard, 2017) (Figure 1).

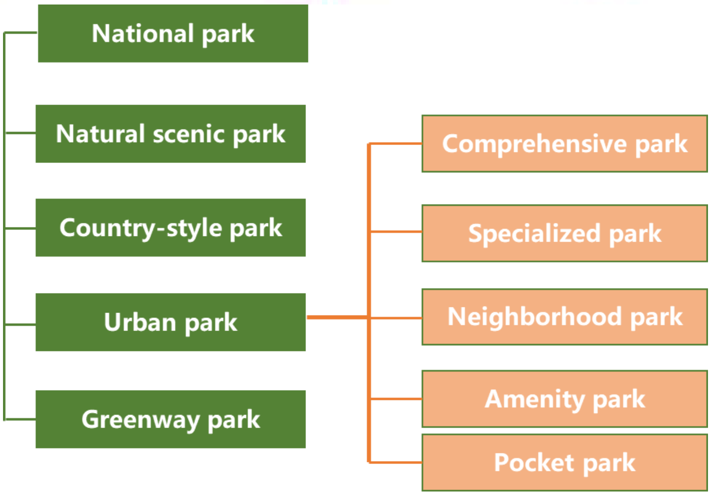

Figure 1. Park classification diagram

According to the concept of Park city, the layout of the Park system should follow the regional natural law and the characteristics of the urban ecosystem, and actively play the ecological functions of the Park system in biodiversity protection, rain and flood natural storage, urban microclimate regulation, carbon fixation and oxygen enrichment, etc.

The Park city theory emphasizes the organic integration of park system layout and urban development pattern, and advocates the coordinated layout of urban public service facilities and park system, so as to enhance the accessibility and fair use of parks (Figure 2).

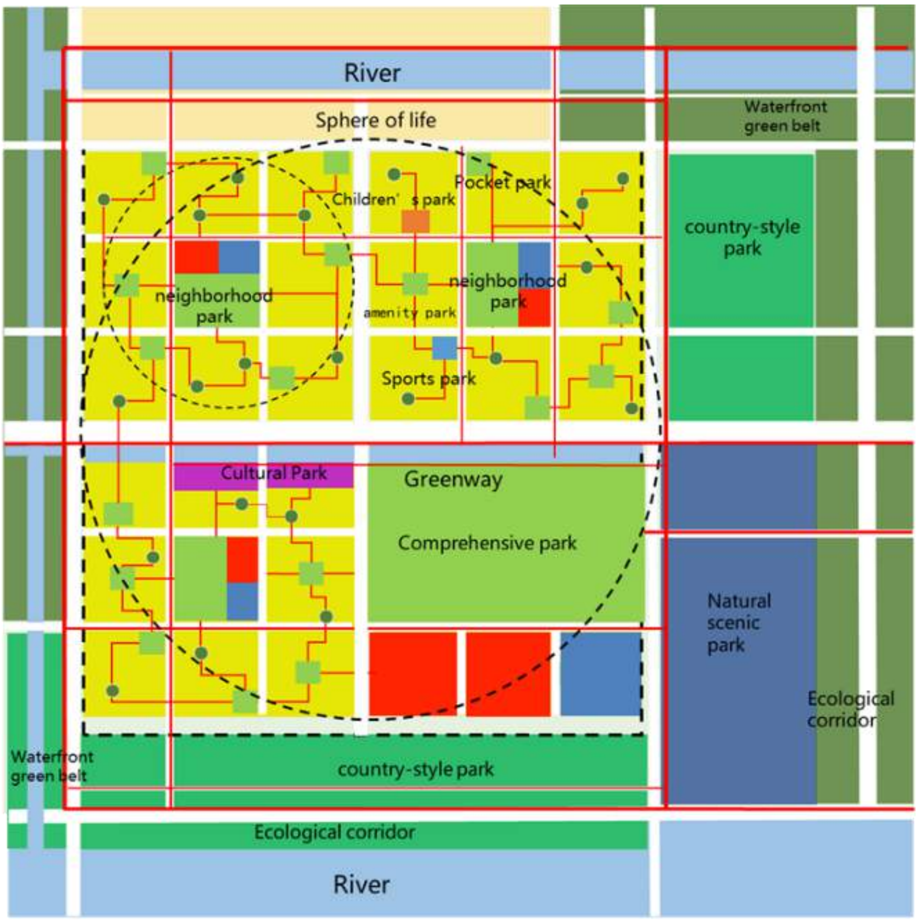

Figure 2. Schematic diagram of multi-type park layout

3. Findings and Discussion

3.1 Urban development model based on the "Scenario concept"

With the development of post-industrial society, more attention is paid to the shaping of the urban environment, the protection and utilization of urban context, and the display of urban regional characteristics. Shaping diversified urban scenes and providing suitable urban space for new economies, new business forms, and new consumption are the focus of urban practice in current scenes. The scene pays more attention to the emotional value of citizens 'use of urban space and the allocation of comfort objects, reflecting the idea of "people-centered", which plays an important role in enhancing the vitality of urban public space and shaping an excellent living environment.

3.2 The key point of park system construction based on "Five-state synergy theory"

Since 2018, our team has emphasized the importance of urban park systems, exploring and implementing Park city theory in Chengdu, a large southwestern city with a population of about 17 million, exploring the multi-dimensional and multi-modal integration layout of cities and parks. According to the characteristics of Chengdu's resources and environment, in the innovation practice of Park city, we put forward new urban construction modes such as the industrial park scene, rural park scene, landscape ecological scene, cultural Chengdu scene, greenway park scene, urban gateway park scene, urban park block scene, and urban park community scene. (Wang et al., 2021).

Based on the Urban development model of "scenario city" and the practice of Park city in Chengdu, we innovatively put forward a "Five-state synergy theory"(Wu et al., 2018). For the integration of park system and urban construction, we believe that the ecological benefits and efficacy of park system should be considered as a whole, the integrated layout of park system and city should be promoted, the cultural charm of the city should be displayed through park system, the vitality of places should be stimulated, and a diversified and inclusive urban spatial environment should be created (Wu et al., 2018).

The first state is paying attention to ecology, promoting the coupling of ecosystem and urban complex system, improving urban ecological benefits, enhancing urban resilience, increasing biodiversity, and improving air and water quality.

The second state is paying attention to the form, strengthening the park and the city in the spatial form mosaic, optimizing the spatial layout of the city and the park, and increasing the accessibility of the park.

The third state is paying attention to context, especially the park's integration, displaying regional culture and site context, strengthening the natural cultural characteristics and distinct landscape characteristics of the city.

The fourth state is paying attention to functional formats, including the mixing of parks and surrounding urban industries, creating a suitable environment to activate science and technology industries, creative industries, etc., and promoting the upgrading of commerce and service industries.

The fifth state is paying attention to vitality and diversity, providing comfortable environment scenes through park system construction, stimulating new consumption and leisure vitality of the city, and providing places for sports activities, leisure tourism, and brand communication in high-quality urban green space (Wang et al., 2021).

4. Conclusion

Through the Park city exploration and the Park system practice, the sustainable development level of Chengdu City, primarily the high-density areas in Chengdu, has been promoted, creating a green, livable, and internationally recognized destination.

At present, nearly 100 cities in China are exploring the innovative practice of Park city, aiming at exploring the construction of high-quality park systems to promote the green and high-quality development of high-density urbanization areas in cities, during current high-quality development stage of urbanization.

The Park city theory of "five-state synergy" and "scenario concept " proposed by the China Academy of Urban Planning & Design won the first prize in the CHSLA Science and Technology Progress Award in 2021.

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After the Flooding: Living within a Mediterranean Torrentscape

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Abstract

*The double cataclysmic flood events that struck the city of Volos, on September 5th-6th and 25th-27th 2023, undeniably served as a dramatic awakening to the reality of climate collapse in the region of Thessaly. This publication heralds a 'Code Red' alert, highlighting the perilous state of the symbiotic relationships within the diachronic torrentscapes of Volos, a city built and expanding between the catchments of three torrents, namely: Krafsidonas, Anavros and Xerias. Utilizing an interdisciplinary approach, the research endeavors to investigate the dynamic relationships along the riparian area of the Krafsidonas torrent within Volos' urban fabric, the torrent-bank communities and urban ecosystems. A diachronic diagrammatic mapping, tracing the history of human interactions with, and interventions to, the Krafsidonas, within its catchment is deployed; additionally, the research explores the fragility of vulnerable areas prone to flooding through the analysis of forecasted flood maps. Furthermore, the way the floods affected the signifier 'Krafsidonas' within the imaginary of inhabitants is questioned through an ethnographic fieldwork. Ultimately, the research addresses how expressions of a more 'symbiotic' co-evolution of urban, social, and natural agents, including the torrent system, could be fostered through strategic plann*ing and design interventions, investigated at the Department of Architecture of the University of Thessaly.

Keywords: Mediterranean torrentscapes, chrono-mapping, climate crisis remediation, symbiotic co-evolution, urban ecosystems, fieldwork.

1. Introduction

Floods are certainly not new to the Mediterranean region: whether 'flash-flooding from torrential winter rain' or 'large or small perennial rivers bursting their banks' (Horden & Purcell, 2013), their occurrences have left evident traces in the sedimentology record. Indeed, "…floods large enough to have left conspicuous evidence in the records of the sediments have (…) always been characteristic of the Mediterranean life" (Horden & Purcell, 2013). However, extreme flood events[1], such as those in September 2023 in the region of Thessaly, Greece, revealed the vulnerability of Mediterranean Torrentscapes and the communities around them, exposing the challenges within the current *climatic regime***.** The *new climatic regime* (Latour, 2018) is manifested by the succession of climate collapse events all over the globe, raising the necessity to respond to a series of emergencies such as: ecosystem and biotope disasters, large-scale destruction of human-made material environments -including housing, public spaces, educational and cultural facilities, governemental and commercial structures-, but also areas of urban ecosystems, where ecotopes and urban complexity entangle. An important facet of the new climatic regime is the global suffering of 'climate refugees': humans or more-than-human lifeforms such as flora, fauna, and fungi. *"Now if there is no planet, no earth, no soil, no territory to house the Globe of globalization toward which all these countries claim to be headed, then there is no longer an assured "homeland," as it were, for anyone"* Latour, 2018). As a direction to solve these very intense, almost desperate situations, Latour expresses the following necessity: *"...we would have to be able to succeed in carrying out two complementary movements that the ordeal of modernization has made contradic tory: attaching oneself to a particular patch of soil on the one hand, having access to the global world on the other" (*Latour, 2018).

The "attachment to the soil" is a parameter which simultaneously has material and immaterial properties: assuming, on one hand, architectural and urban design forms, and, on the other, entailing psychological, sociological, and anthropological aspects. We have been aware that *repair* is as much a social process as a technical one: *"Repairing a road for instance is not just a job for engineers. Because a road represents a social relationship. Rebuilding it is not enough if we don't know what kind of relationships we had, we have, and we would wish to have"*[2] with the landscape entities we deal with (Papailias, 2024). This question captures in a concise way the necessity for an interdisciplinary approach, which combines humanities, social sciences and engineering fields.

This research, attempted by the ‘Torrentscapes’ research team, is an ongoing project (Dimitrakopoulou et al., 2025). It started when we decided to create an interdisciplinary-transdisciplinary team to answer two further questions: How do we respond to the extreme need to develop a new landscape design methodology for the Mediterranean torrentscapes? Is design enough, or should we find ways to engage local society in this paradigm change? The research team members are architects, social anthropologists, urban planners, forest engineers, and hydraulic engineers. The focus of this interdisciplinary research is to investigate the dynamic relationships mainly along the riparian area of the torrents within Volos' urban fabric, emphasizing the interconnectedness of torrent-bank communities and ecosystems with water flux, landscape design, and urban public space.

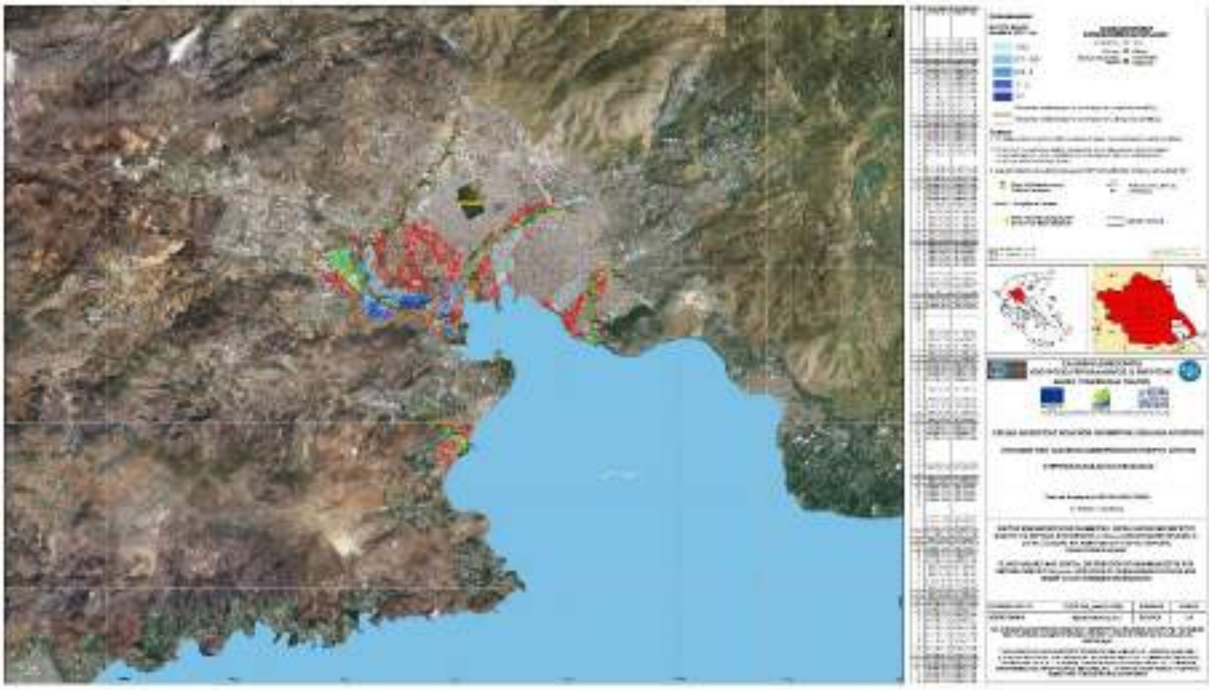

Figure 1. Vulnerability map of the city of Volos to flood events (Source: Ministry of Environment and Energy)

2. Materials and Methods

Regarding the city of Volos, the prevalent media narrative attributed the disasters to the torrents themselves, unfairly vilifying the flow of these waters. Understanding the torrents and rivers as subjects could of course be, in another context, a way to address them from a -more-than-human eco-ontological standpoint; however, with the passage of time, it becomes clear that most top-down initiatives concerning the torrents of Volos did not include an understanding of torrents as agents that constantly transform the landscape. If that was the case, their riverbeds and bridgings would have been designed to include their dynamic transformations.

Instead, the dominant narrative currently circulating features various scenarios aimed at ‘fortifying’ the city against future flood events and includes discussions of 'climate crisis refugees'. Another central element in discourse is that the development of a more ‘resilient’ -literally more robust- anti-flood infrastructure. Could these scenarios be categorized as expressions of either torrent avoidance or tendencies to exclude torrents from everyday life? Do further irreversible changes loom over Volos' torrent landscapes? The prevailing sinister point of view dominated the conference that was held on 31/1/2024 at the Technical Chamber of the Magnesia Prefecture, even though discourses more inclusive towards Green and Blue

Infrastructures [BG-I] were expressed by a minority among the invited speeches, given by Professors of the Unviversity of Thessaly.

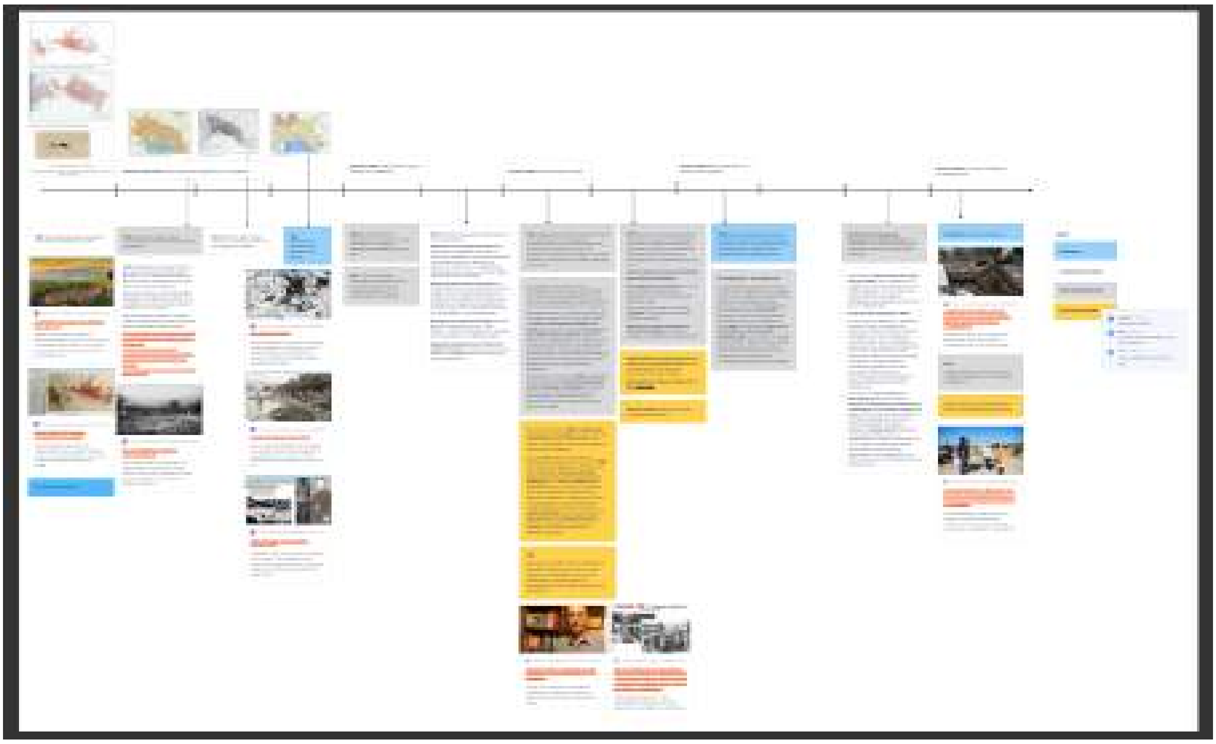

Figure 2. Chrono-mapping in progress of the relationship of Krafsidonas torrent with the city of Volos and the inhabitants of its riparian zone (Dimitrakopoulou & Diamantouli, 2024)

One of the key methodologies of the Torrentscape team entails a timeline comprising the relationships deployed between Krafsidonas torrent and the inhabitants of the riparian communities of its banks from the 19th century and during the 20th century up to today. This timeline could be referred to as chrono-mapping. Chrono-mapping makes visible the periods when the most critical top-down initiatives have transformed Krafsidonas' riverbed by imposing the logic of gray infrastructures, which often tended to transform the torrent bed into a regulated hydraulic infrastructure of the city (Figure 1, highlighted in blue). On the other hand, the bottom-up initiatives testify to the diachronically waved relationship between communities and the torrent.

Furthermore, as part of the methodology followed to investigate and express the unseen, latent, or potential future relationships between Krafsidonas torrent and the inhabitants of the riparian communities of its banks, research was held in the framework of graduate courses and integrated master courses two Departments of the University of Thessaly which are located in Volos, at the Department of History, Archaeology and Social Anthropology [School of Humanities and Social Sciences] as well as at the Department of Architecture [School of Engineering]. Thus, an interdisciplinary approach has been weaved to approach together the social characteristics and urban-landscape dimensions of extreme flooding events.

Methodological tools: A transdisciplinary approach combining Experiential Mapping, Interviews, and Interaction with social anthropological and architectural-anthropological approaches.

- Interviews with residents explore the impact of flooding on their perception of torrents, the city, and the Pagasitikos Gulf, focusing on socio-environmental relationships and social justice.

- Mapping in situ through the Four Trace Concepts' (Girot, 2009) methodology for intuitive landscape mapping and design. Participatory in situ mapping with inhabitants and discussions with them to assess flood impacts on households and public spaces, contextualizing the long-term effects of floods on the landscape and social practices.
- Design studios at the Department of Architecture, connected to water use for managing water as a shared common, focusing on urban landscape infrastructure solutions by designing for flood and drought extreme scenarios in the context of climate change.
- Historical chrono-mapping with delineation of the key milestones show the relationship between the city and its three torrentscapes, using archival research to trace infrastructural developments, flood events, and urban planning decisions shaping the torrentscapes and their relations to the city's inhabitants.

3. Findings and Discussion

3.1. Anthropological fieldwork

As a response to the floods of September 2023, Penelope Papailias, Associate Professor at the Department of History, Archaeology, and Social Anthropology, and member of the Torrentscapes team, launched an investigation into the floodings' aftermath and afterlives, from an anthropological perspective, drawing on the experience and knowledge base of social movements and theoretical writings in the Black radical tradition, decolonial ecology and environmental humanities.

Specifically, in the context of her graduate course, "Black Geographies: From the Middle Passage to the Black Mediterranean and Afrofuturism" in the masters' program on "Studies in Mobility", her students were prompted to use tools from the theoretical tradition of Black Geographies to address the double flood event that delayed the semester and flooded the building in which the class was held[3]. Given that the theoretical discussion on *"black geographies"* emerged out of the devastating dispossession of the black population of New Orleans after Hurricane Katrina in 2005, they were asked to think about their recent and 'intimate' flood experience through the prism of black geographies. Without conflating these different historical and cultural contexts, the perspective of Black Geographies -namely, subaltern or alternative geographic formations that work alongside or beyond traditional geographies as sites of struggle, helped to expose erasures and absences in discussions and approaches of 'our local' flood event, produced by dominant conceptions of mobility, place, space, nature, property and embodiment inscribed in western epistemologies and white environmentalism.

The students conducted interviews and engaged in ethnographic observation that led to the production of a podcast series, entitled "Debris." In his episode, "Nothing is going to save us. If we don't save ourselves we're dead", Conor Smith interviewed poultry farmers in a village of the Thessalian plain whose chickens all perished in the floods and conducted historical research, proposing to consider the climate collapse event, state abandonment of humans and other animals, but also responses to it based on solidarity, resistance and reciprocity, from the perspective of the history of plantations and decolonial ecology. Antonios Petras in his contribution, entitled "Mud, collective trauma and personal responsibility" drew on ethnographic research and his experience in aiding flood victims in Volos dig their houses out of the mud considered how the walls built by official organizations, but also by people themselves, failed to "protect" local people, but instead enclosed them and made them subject to more intense water and mud flows. Centering on the aesthetics of the flood's aftermath, including personal photographic archives and images of destruction, Konstantina Efaplomata contrasts the ideals of white environmentalism with the black radical tradition's understanding of nature and its alternative aesthetics.

A second related action was the development of a geolocated sound walk along the banks of the Krafsidonas torrent, entitled *The Water Remembers* (To Nero Thimatai), concerning the relationship of the Krafsidonas torrent with the riparian communities and the city of Volos. Based on historical and ethnographic research, including eleven interviews with residents, activists, teachers and archaeologists, foregrounding genealogies of capitalist development that negatively impacted the torrent (the railroad, factories, the port) and the relocation of vulnerable populations, such as refugees from Asia Minor post-1922, to this liminal and vulnerable landscape[4]. While the testimonies and historical documents demonstrate how the torrentscape became inscribed with social and political hierarchies and divisions with the torrent as border, the walk also attempts to imagine more sustainable and inclusive futures for the post-diluvian era by tracing past ecosystems and signs of symbiosis of human - and non-human - beings, as well as the long history of local social resistance to the violent treatment of the environment.

On Sunday December 15, 2024, sixty people joined in a collective walking and listening of *The Water Remembers*, including members of the Friends of the Krafsidonas, informants, residents, members of the university community and passers-by. As a provocative occupation (sonic and bodily) of the banks of the torrent, the walk also included happenings, such as the hanging of historical banners from social movements contesting the transformation of the Krafsidonas into a roadway, and proved an occasion for (re)connecting various groups and individuals interested in a different - more inclusive and habitable - future for this more-than-human landscape.

Figure 3. The route and poster of "*The Water Remembers*", the public audio walk along the banks of the Krafsidonas torrent, which took place on 15//12/2024. Graphics: Chrysa Lioti.

In contrast to the demonization of the torrent at the time of the floods, "The Water Remembers" counterposes a biography of the river, displacing the human species as the default center of history. In highlighting the relationships between people, natural elements and socio-political structures, the walk can be categorized as a public intervention in the emergent interdisciplinary field of Environmental Humanities, which seeks to demonstrate how the humanities and social sciences might contribute to the development of collective responses to the urgent planetary needs of the evolving climate crisis. On a theoretical and methodological level, the audiowalk was a continuation of the 2022 anti-tour "Decolonize this City!", which was conducted in Volos and used geo-located narratives and the collective and embodied practice of the audiowalk to highlight marginalized experiences and voices that are often erased or overlooked in dominant stories about - and trajectories through - the city. The Water Remembers has been geolocated on the platform Echoes for future individual and collective navigation (https://explore.echoes.xyz/collections/z3OQ7zUhfXs9EQGs). The testimonies and texts related to each of the twelve nodes of the walk can be accessed online: https://www.pelionsummerlab.net/tonerothimatai.html.

3.2. Design studios

At the Department of Architecture of the University of Thessaly, several Design Studios addressed the relationship between Krafsidonas torrent, the riparian communities, and the torrent-bank cityscape, designing public space proposals at various scales.

3.2.1. Architectural and urban design

The research hypothesis in Architectural Design Studio "What if?"[5] (Teaching Team: Kotionis Z., Vyzoviti S., Mitroulias G., Dimitrakopoulou, E.) was formulated as a critical response to the environmental effects and the social impact of Daniel and Elias Storms that flooded entire regions of Thessaly in September 2023, re-arranging the territory in mainland and coastline. Based on empirical evidence of the flood predicament, the studio investigated a new signification of water both as a destructive force of nature and as an agent of citizenship producing urban habitats. Water was conceptualized as a Latourean nature-culture hybrid[6], that is both a physical environmental resource and a contested fundamental human right.

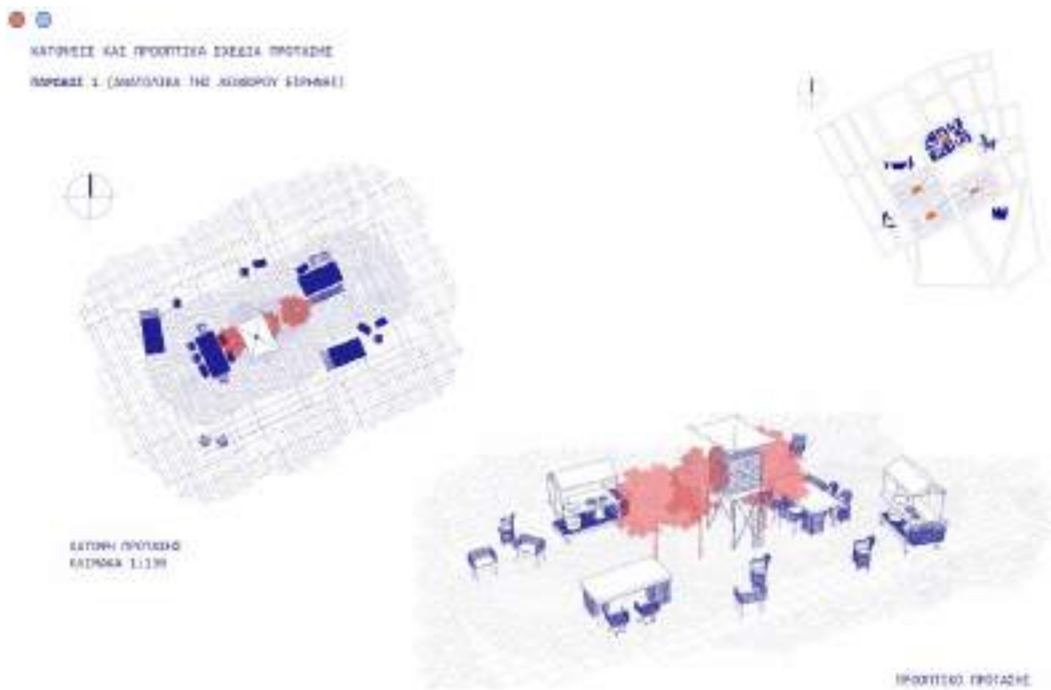

Figure 4. Proposal students' project "Tu Mahala" by students Papatheodorou Grigoria and Karkaletsi Stavroula , Integrated Master Level Architecture Design Studio "*What If*".

In the studio, the problematic of water was placed at the center of social and economic life and represented in speculative scenarios that explored autonomous sustainable systems of fair water harvesting and management through a series of projects. The notion of a sponge city generated a variety of design prerogatives for the physical and organizational interweaving of water ecosystems, urban culture, politics, and infrastructures, at various scales. Departing from the experience of water scarcity during the post- flood recuperation period of the city of Volos, the "Tu Mahala" project explored water harvesting and recycling at the scale of several building blocks in the urban fabric of Nea Ionia District (Figure 5). Investigating the water's processing exchange economy, the project revived the "Latres'" heritage: the collective laundries once serving the 1922 Refugee Settlement now turned into green patches. The students developed a new architectural language of easy-to-assemble structures and a DIY bricolage of standard household materials. Situated at the exterior of the dwellings, these assemblages of domestic furniture and equipment can support water management at the scale of the urban neighborhood scale. Water harvesting interlinks the cultivation of edible materials with the preparation of food. The project challenged the given social, economic, and productive hierarchy, providing alternative standards for the green transition with water at the core of city commons.

3.2.2. Post-Industrial design

The elective Design Studio *"EVERY(DAY) THING: A Workshop for Building Everyday Living Objects*", an undergraduate course (Teaching Team: Kotionis, Z., Dimitrakopoulou E.) which investigates how the use of utilitarian objects is forming everyday living, responded to the flooding of 9/2023 at the Magnesia prefecture where Volos city is situated. Since objects influence the everyday's life ritual (performativity), the student projects should analyze, conceive, and introduce both objects and performative modes of everyday living. The workshop is separated into two parts. The first part consists of interviews with the locals. For this year's workshop, due to the floods that happened, the students were tasked to be involved with people affected by the floods in their daily routines. They describe what happened during the storms and how they faced the consequences since they lacked infrastructure such as electricity or clean water.

The research examines the socio-environmental and gendered dimensions of households affected by crises, focusing on resilience, adaptation, and lived experiences. It involves mapping impacted households and documenting interior and courtyard conditions, material losses, and psychological impacts. First-hand narratives, particularly from women and caregivers, are captured through video interviews to highlight gender roles, care practices, and innovative responses to adversity. Key areas include repair and replenishment practices, creative solutions for managing water, energy, and infrastructure, and maintaining connectivity through material and digital networks. The study emphasizes themes such as gendered labor, everyday innovations, and the environmental dimensions of household resilience, providing insights into how households adapt and sustain themselves during disruptions.

These video-documented interviews focus on people's experiences and lead to the second part. In the second phase of the workshop, students design and construct objects for everyday living by activating and reusing a list of material objects of our common material culture. Certain design formulas and construction manuals are followed, using simple mechanical tools, handicrafts, and a low-technology process. Documentation of the condition in the interiors and courtyards of the houses, recording the losses, recording the grim experience and understanding/recording the repair processes, and remediation practices, recordings of water use patents and substitution of damaged domestic infrastructure (water, energy, connections to materials and digital networks) were part of the insitu findings and documentation.

3.2.3. Urban landscape design

The undergraduate design studio course "*Re-constructions of the Soil"* aims at the design of an inclusive landscape within a zone of extreme dynamic changes, such as that of the area along the Krafsidon torrent, in a way that could render it adaptable to extreme conditions of climate crisis. The experiential mapping approach to the area under study, recording the materials and beings that are part of the torrent-scape, is considered part of the design, in dialogue with the "*Four Trace Concepts*" (Girot, 1999) methodology. Through this process, the student groups produce their methodological tools. They compose their toolbox of conceptual tools, discovered textures and water-responsive materials, in situ architectural and other local structures, and envision types of interventions. Student team proposals are encouraged to include Blue Green Infrastructures (BG-I) and Nature-Based Solutions (N-BS) which are aimed to be designed as unified design gestures that host contiguous water-related processes an aesthetically unify with the proposal as an inseparable whole. At the level of strategic integration of the proposals into the urban design scale, as a general direction, the role of developing connectivity between the above-mentioned elements of the urban landscape, which intensifies their synergy, is highlighted (Georgi et al., 2021).

During the academic year 2023-24, the impact of the floods on the city of Volos acted as an incentive for the creation of additional methodological tools by the student groups to respond to the occurring extreme phenomena revealing the magnitude of climate crisis. Among them, student teams recorded the areas where rainwater was stagnant for weeks, as their ground lays about a meter beneath the city level (Figure 5).

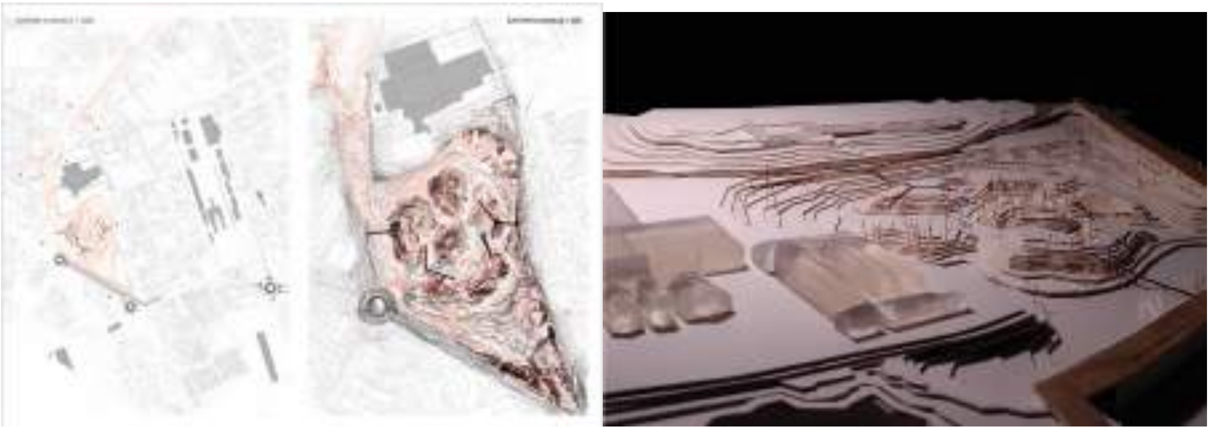

Figure 5. Proposal students' project '*Knittings'* by student team Glykeria Katopi, Eliza Thomaidou, Dimitra Zahou, Architecture Design Studio "*Re-constructions of the Soil*"

Through the architectural design of infrastructure related to the streambed, when a landscape logic is followed, the student groups realize that they could contribute to the design of a more sustainable city, comprising and reinforcing the relationship with its historic torrent, the Krafsidon, while designing landscapes that can receive part of the flood, like floor-rooms, or paths for the water to discharge from the areas where people live to rain-gardens, urban wetlands, and sponge-like parks, to protect the inhabited urban fabric from the following extreme outbreaks of the climate crisis.

4. Conclusion

Instead of a concrete conclusion, we refer to our analysis as an initiation of an effort to integrate a multifaceted approach to flood mitigation, that challenges the obsolete notion that less vulnerability is only linked with more massive and more robust grey infrastructure. Especially in the case of Mediterranean torrents, the need for a more holistic approach to mitigation of the impacts of flood events rises as a novel field for landscape-related research.

Mediterranean torrents can be "deceptive" in the sense that they primarily seem to form dry either dormant, slow-flowing riverbeds, whilst they can become dangerous during rare and rapid storms, which often trigger flood events. The objective to mitigate the effect of these flood events should not coincide with the exclusion of the Mediterranean torrents from our cityscapes.

In contrast, symbiotic modes of living along the torrents should be encouraged since torrent floods can be strategically mitigated through innovative urban public space design and peri-urban landscape infrastructure design. The interdisciplinary approach is indispensable, to help keep the practice of the symbiosis of Mediterranean cities with active water alive. Nevertheless, Mediterranean rivers and torrents have been thought of as multifaceted drivers of active landscape forces at least since the Homeric period: “The episode with Scamander (Iliad Book 21, 316-321) muddies clean breaks between human and non-human force, nature and culture, ethics and physics, people and things, superhuman and subhuman” (Holmes, 2015). Moreover, the presented investigation –via chrono-mapping– showcased ways by which the Mediterranean torrents of Volos have been integrated since historic times into the lives of local communities in multiple ways. Integrating torrents into the socio-ecological fabric requires recognizing their dual role as both hazards and resources. Adaptive practices, such as seasonal land-use planning, community-led monitoring systems, and the restoration of natural floodplains, can transform Mediterranean torrents into active components of sustainable urban landscape management. By aligning with the rhythms and dynamics of these waterways, mitigation strategies can foster resilience while maintaining the cultural and ecological integrity of Mediterranean regions.

Notes

1. Named after “Daniel and Elias”.
2. Podcast by Penelope Papailias, Associate Professor of Social Anthropology, University of Thessaly
3. Centering the Middle Passage of transatlantic chattel slavery and plantation history in global histories of modernity, capitalism and colonialism, the course “Black Geographies” brought into view diverse forms of (im)mobilities related to long genealogies of dislocation and disempowerment (surveillance,segregation, ghettoization, incarceration - but also trajectories of resistance (fugitivity, maroonage, black utopias).
4. *The Water Remembers* audio walk was developed in collaboration with the Pelion Summer Lab (PSL) for Cultural Theory and Experimental Humanities, which explored the theme of *Ec/o/ntologies* in 2023 (https://www.pelionsummerlab.net/ecoontologies-2023.html), and the initiative dĕcoloɴıze hellάş, with the financial support of the Experimental Humanities Collaborative Network (ECHN). Interviews were conducted by Penelope Papailias and Georgia Paveli; historical research by Georgia Paveli. The media production of the walk was coordinated by Constantinos Diamantis of the Fiji Office. The Krafsidonas Citizens’ Committee, The Friends of the Krafsidonas and the Iones-Cultural Center of People from Asia Minor, Nea Ionia, Magnesia also supported the creation of the audio walk.
5. Integrated Master Level Studio “ARCHITECTURAL DESIGN VII: What if?” was taught at the Department of Architecture, University of Thessaly during the winter semester of academic year 2023-24. It is noteworthy that at the beginning of this semester the building of the Dept. was flooded and out of order for 2 months.
6. According to the notion of the Parliament of things developed by Latour, B. (1993). We Have Never Been Modern. Harvard University Press.

Author Responsibility

Authors are responsible for the content of their papers.

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Agroecological Risk Assessment Based on Coupling of Water and Land Resources - A Case of Heihe River Basin

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Abstract

In the arid zone of northwest China, the Heihe River Basin (HRB) faces a fragile ecological environment, water degradation, and severe challenges in agricultural land use. Water shortages, declining land quality, and excessive agricultural activities exacerbate pressure on local resources. This study uses the Malmquist DEA and coupling coordination degree models to establish an agroecological risk assessment system focusing on water and land resource (WLR) coupling.

Using HRB data from 1995–2020, spatial autocorrelation analysis examines WLR matching, revealing trends in ecological risk evolution and spatial correlation at the county scale. Results show: 1) From 1995–2020, average ecological risks for water and land resources declined (0.933 and 0.938, respectively); 2) Coupling and coordination of ecological risks in upstream HRB increased, while the middle and lower reaches saw declines; 3) Panel model analysis identifies WLR matching as a key driver of ecological risk, with a positive correlation. This approach provides robust technical support for managing agroecological risks in arid regions.

Keywords: Agricultural WLR, ecological risk, data envelopment analysis, temporal and spatial variation, HRB

1. Introduction

Arid and semi-arid areas of China account for 52.5% of the whole territory. Affected by climate change and human activities, China is one of the most drought-prone countries globally. The arid area is about 2.8 million square kilometers, stretching from the northwest border to the west and reaching the west foot of the Great Khingan Mountains in the east. It includes about 965 counties in 16 provinces, cities, and autonomous regions; its total area accounts for more than half of the national area. However, Northwest China covers 83% of China's arid and semi-arid regions (Zhao et al., 2005). With the acceleration of the urbanization process, a series of activities such as over-cultivation and overgrazing by human beings have caused an increase in the pressure on agricultural WLR, further increasing the agroecological risks and thus adversely affecting the ecosystem and sustainable development of society.

Current studies on the ecological risk of soil and water resource utilization usually start from water or land resources alone, and we are short of the perspective of water and water resources coupling. For example, Jiang et al. (2017) used the average Dee's decomposition method to assess the risk of water scarcity in Heilongjiang province and its 13 prefecture-level cities based on the entropy-weighted physical element model. There is not much literature on ecological risk research using input-output methods. Yang (2016) constructed a coupled principal component analysis and data envelope model for land ecological risk assessment based on defining characteristics and connotations for studying ecological land use risks in the Changzhutan urban agglomeration. In addition, studies on agricultural WLR are mostly from the perspective of water and land matching. For example, Nan (2017) applied the WLR matching index to measure the matching status of agricultural WLR in the northwest dry zone and estimated the potential of agricultural WLR utilization under two scenarios. The lack of a coupled perspective to study water and land risks leads to the inability to synergistically optimize the sustainable use of land and water in arid areas.

Many measures of ecological risk are landscape-level, and few studies consider water and land use efficiency in a comprehensive way: most of the existing ecological risk studies have focused on metal pollution sources and landscapes (Liu et al., 2012), and ecological risk assessment specifically for agriculture is very rare (Li and Xing, 2012). The ecological risk research method system is mostly based on the perspective of landscape ecology. For example, Zhang et al. (2014) took the Shiyang River basin as the research object. They evaluated the spatial and temporal changes of ecological risk in the basin based on the landscape pattern. Studies on landscape patterns ignore the influence of socioeconomic factors, and their results make it difficult to guide urban planning. In addition, there are fewer studies on the ecological risk of coupled agricultural WLR and even fewer comprehensive studies involving their matching relationship with WLR. So, it is necessary to propose a measurement method for water and land ecological risk from the efficiency perspective.

Therefore, this study focuses on the spatial and temporal changes of ecological risk of agricultural WLR and uses the (1) Malmquist DEA model and the coupling index to construct a more complete agroecological risk assessment system for coupled WLR, assesses the ecological risk of agricultural WLR use in the HRB from 1995 to 2020. (2) The panel model explores the spatial driving effect of water and land ecological risks and proposes policy improvement recommendations. This study complements the research method of ecological risk and provides references for rational exploitation and management of agricultural WLR in arid areas.

Figure 1. Division of Districts and Counties in HRB

2. Material and Method

2.1 Study area

This study focuses on the agricultural water and land resources (WLR) risk in the Heihe River Basin (HRB), a typical inland river basin in China with a fragile ecosystem, significant water degradation, and severe agricultural land use challenges. Since the Western Region Development policy in 2000, comprehensive management has been strengthened, with key measures such as the 2001 water diversion policy and the "Water Allocation Plan for the Mainstream of the Black River" to enhance ecological restoration and rational water allocation (Zhao et al., 2005; Xiao et al., 2017). Further, the 2015 policy for sustainable agricultural and ecological protection and the 2018 unified water scheduling measures aimed to promote ecological and socio-economic improvements.

As China's second-largest inland river basin, the HRB spans 142,900 km², with over 30 tributaries and annual water resources of 4.173 billion m³ (Ning et al., 2008). Yingluo Gorge and Zhengyi Gorge divide the basin into upper, middle, and lower sections, each with distinct water resource conditions (Figure 1). Increased population and economic activities have intensified water scarcity and land desertification, highlighting the urgent need for ecological restoration as a basis for sustainable development (Qi et al., 2004).

2.2 Data sources

This study used data related to various types of land areas, agricultural water consumption, water pollution levels, and irrigated areas in the HRB. Data on various land areas were derived from the land use data of the HRB in 1995, 2000, 2005, 2010, 2015 and 2020, water resources data were obtained from the Water Resources Bulletin of Qinghai Province, the Water Resources Bulletin of Inner Mongolia Autonomous Region, the Water Resources Bulletin of Gansu Province, the Ecological and Environmental Status Bulletin, the China Water Resources Yearbook, the China Water Resources Bulletin, the China Water Resources Statistical Yearbook (1995-2020) and the National Tibetan Plateau Scientific Data Center (Deng, 2015; Wang, 2016a; Wang, 2016b), and socioeconomic data such as irrigated area were obtained from the Qinghai Statistical Yearbook, Qinghai Province Environmental Statistics Bulletin, Inner Mongolia Statistical Yearbook, Gansu Development Yearbook, Gansu Yearbook, Zhangye Statistical Yearbook, Jiayuguan Statistical Yearbook, Urban Statistical Yearbook (1995-2020) and ecological and environmental department websites were collected, and the method of searching for literature (Luo and Tao, 2018) was applied to obtain water consumption data for some missing years.

3. Findings and Discussion

3.1 Ecological risk assessment of land and water resources in the HRB

The DEAP 2.1 model measured the Malmquist index for 11 districts in the HRB from 1995–2020, yielding the time and regional WLR ecological risk values. The average ecological risk of agricultural water resources was 0.933, showing a decreasing trend (Table 1). Technological change (*Techch*) averaged 0.872, indicating progress in reducing water resource risks. Notably, ecological risk shifted from increasing (>1) to decreasing (<1) after 2005, reflecting the effectiveness of the 2000 water diversion policy (Ma and Tian, 2006). Efficiency change (*Effch*) was above 1 during 1995–2005 and 2010–2015, peaking at 1.329 (1995–2000), indicating limited technical efficiency improvements. Technological progress (*Techch*) exceeded 1 only during 2000–2005 (1.630), while scale efficiency (*Sech*) declined in 2010–2015, increasing ecological risks. Population growth and expanding arable land post-2000 drove higher agricultural water demand (Cheng et al., 2011), though technological advances post-2005 mitigated risks. Spatially, midstream regions exhibited the highest risk, followed by downstream and upstream areas. Among counties, Linze County had the highest risk (1.144), while Ejina Banner recorded the lowest (0.645), with significant variations across districts (Table 2).

Table 1 Agroecological risk index and decomposition of water in the HRB by time, 1995-2020

Time Period	Risk Index (*Tfpch*)				
	Technical Efficiency Index (*Effch*)			Technological Progress Index (*Techch*)	
	Pure Technology Efficiency Index (*Pech*)	Scale Efficiency Index (*Sech*)			
1995-2000	1.243	1.069	1.329	0.793	1.053
2000-2005	0.991	1.114	1.104	1.163	1.284
2005-2010	0.943	1.027	0.969	0.861	0.834
2010-2015	1.076	0.987	1.062	0.716	0.761
2015-2020	0.893	1.035	0.924	0.889	0.822
Mean Value	1.022	1.046	1.069	0.872	0.933

Table 4 Agroecological Risk of Water Index and Decomposition by Region in the HRB, 1995-2020

Region	Risk index (*Tfpch*)				
	Technical efficiency index (*Effch*)			Technological Progress Index (*Techch*)	
	Pure Technology Efficiency Index (*Pech*)	Scale Efficiency Index (*Sech*)			
Ejina Banner	0.844	0.945	0.798	0.809	0.645
Jinta County	0.963	0.991	0.954	0.879	0.839
Suzhou District	0.959	0.994	0.953	0.853	0.813
Jiayuguan City	1.000	1.000	1.000	0.874	0.874
Gaotai County	1.047	1.228	1.285	0.850	1.093
Sunan County	1.000	1.000	1.000	0.911	0.911
Linze County	1.051	1.239	1.302	0.878	1.144
Ganzhou District	1.310	0.892	1.169	0.862	1.007
Shandan County	1.072	1.214	1.302	0.853	1.110
Minle County	1.056	1.065	1.125	0.858	0.965
Qilian County	1.000	1.000	1.000	0.980	0.980
Mean Value	1.022	1.046	1.069	0.872	0.933

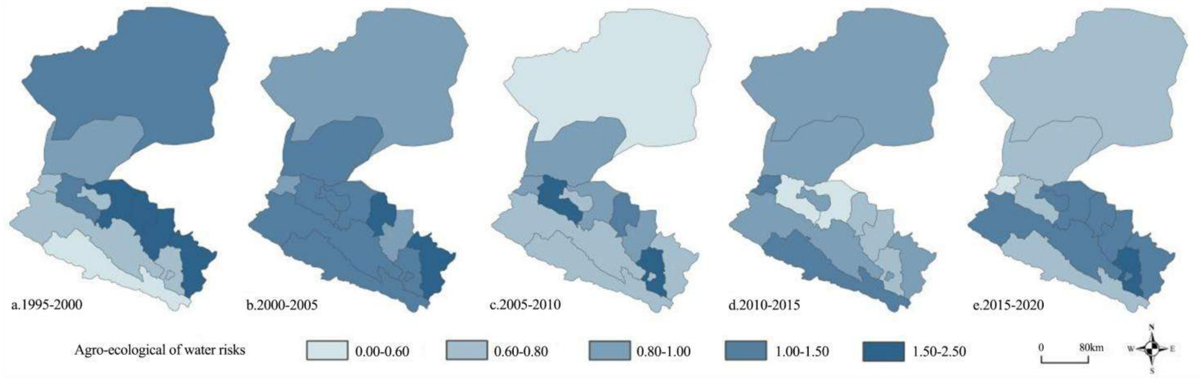

Figure 2. Agroecological of water risks by district and county in the HRB over time

3.2 Ecological risk assessment of land and water resources in the HRB

The greater the coupling index, the better the coordination of the two attributes, indicating a simultaneous increase in both attributes, which in this case represents a higher combined ecological risk unfavorable to agroecological security (Beekun and Glick, 2001; Huang et al., 2016). The coordination types of WLR in this study are classified as low, lower, medium, higher, and high risk based on their degree of coordination. From 1995 to 2020, the coupling coordination degree of ecological risk in the upstream HRB increased by 42.0%, decreased by 22.8% in the midstream and 12.0% in the downstream (Figure 3). The upstream shifted from low to high risk in 2000 and decreased to medium by 2005. In the midstream, areas like Gaotai County and Linze County were at high risk before 2000, but most districts saw a decrease in risk after 2005. By 2015, Jiayuguan City and Minle County experienced an increase in risk. The downstream shifted from medium to higher risk in 2005 to low risk after 2010, except for Jinta County, which remained at medium risk.

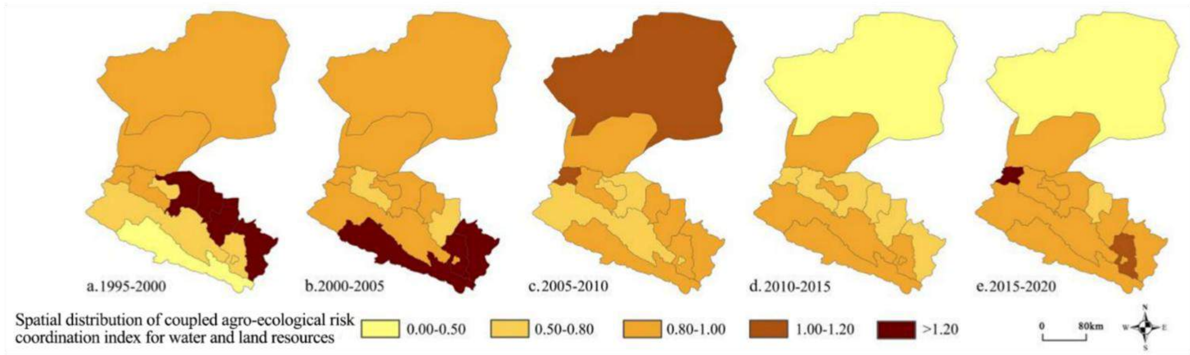

Figure 3. Spatial distribution of coupled agroecological risk coordination index for WLR in the HRB

3.3 Characteristics of Interannual Variation in Matching WLR in the HRB

Spatially, the WLR matching level in the HRB follows the order: upstream > midstream > downstream. District-wise, the order is Jiayuguan City > Ganzhou District > Suzhou District > Linze County > Shandan County > Minle County > Qilian County > Jinta County > Gaotai County > Sunan County > Ejina Banner. Temporally, from 1995 to 2020, the WLR matching level showed a decreasing trend, with decreasing differences among districts. The upper and middle reaches had higher matching levels from 1995 to 2010, while the lower reaches remained relatively stable (Figure 4). This can be attributed to differences in agricultural WLR, climatic conditions, and regional factors such as agricultural structure, economic development, and urbanization. In recent years, high-efficiency water conservation measures have reduced agricultural water consumption, decreasing WLR matching.

The Western development strategy, launched in 2000, led to large-scale land exploitation and intensified problems like groundwater over-extraction and land degradation. Initial policies aimed at expanding irrigation for economic development resulted in excessive water use, failing to improve WLR matching since 2000. Qilian County in the upper HRB maintained a high WLR matching. However, it has decreased due to its low development level and the burden of providing resources to downstream areas. In the middle reaches, areas like Jiayuguan City, Suzhou District, Ganzhou District, and Linze County have higher matching levels due to economic development and advanced agricultural technology. In the lower reaches, characterized by arid conditions and land degradation, areas like Ejina Banner and Jinta County show low matching levels. The water distribution policy has helped reduce differences in matching levels across districts.

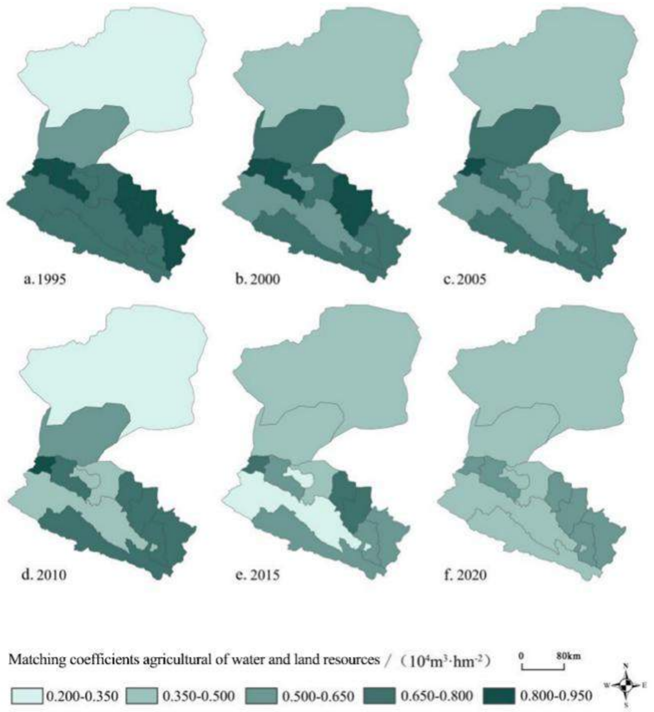

Figure 4. Matching coefficients agricultural of WLR of districts and counties in HRB by time

3.4 Relationship between land ecological risk and matching coefficient

The regression analysis of the change of WLR matching coefficient and the change of agricultural WLR ecological risk in each district and county of HRB showed that the change of WLR matching coefficient was significantly correlated with the ecological risk of agricultural water resources utilization. The coefficient of determination was 0.777(P<.05) (Table 3). This shows that the change of the WLR matching coefficient in HRB is positively correlated with the change in ecological risk of agricultural WLR utilization. After comparison, it is found that the effect is significant after adding the control variable of population density (POP), and the matching coefficient has a certain correlation with the population. With the increase of the matching coefficient of WLR, the ecological risk of water resources increases, while with the decrease of the matching coefficient of WLR, the ecological risk of resources decreases.

Table 3 Regression Equation between Matching Coefficient of WLR and Ecological Risk of Agricultural Water Resources

Variable	Coefficient	Std. Error	t-Statistic	Prob.
PPXS	0.777446	0.382514	2.032464	0.0485
POP	0.012473	0.005439	2.293113	0.0269
C	-0.171040	0.416966	-0.410200	0.6837
R-squared	0.208699	Mean dependent var		0.907343
Adjusted R-squared	-0.017387	S.D. dependent var		0.265581
S.E. of regression	0.267880	Sum squared resid		0.406507
F-statistic	0.923096	Durbin-Watson stat		1.959130
Prob(F-statistic)	0.533238			

4. Discussion

4.1 Impact of agricultural policies on water and land ecological risks

In assessing agricultural water resources in the HRB, we found that technical efficiency, technological progress, and improved management in downstream and midstream areas, such as the Suizhou District, helped reduce ecological risks. However, uneven water distribution, unbalanced supply and demand (Cheng et al., 2011), and the Heihe River water diversion policy led to rising groundwater levels downstream and falling levels midstream, damaging riparian vegetation and raising ecological risks in some midstream areas (Zhang et al., 2018). 1995–2005, population growth and artificial oasis irrigation increased water demand and ecological risks. By 2005, advances in water-saving technologies and scheduling measures reduced risks, particularly in Ganzhou District.

4.2 Relationship between water and land matching and water and land risk

For agricultural land resources, limited scale efficiency and technology hindered risk reduction. Urbanization fragmented grasslands, while water shortages, climate aridification, overgrazing, and improper irrigation accelerated soil salinization and oasis fragmentation (Du et al., 2004). From 2005–2010, the land degradation index surged, increasing risks. Since 2000, programs like grassland management and forest restoration improved woodland and grassland conditions, though some areas have experienced degradation due to low rainfall (Liu et al., 2006). Land degradation showed improvement by 2020.

5. Conclusions and Recommendations

This study analyzes the evolution and spatial correlation of agricultural WLR ecological risk in the HRB using input-output and coupling models at the county scale. From 1995 to 2020, the ecological risk of agricultural water resources increased by 33.7% from 1995 to 2005 but decreased by 52.9% from 2005 to 2020, with a spatial pattern of midstream > downstream > upstream. Agricultural land resource risk decreased by 16.8% from 1995 to 2005, increased by 25.5% from 2005 to 2010, and decreased by 7.7% from 2015 to 2020, with a spatial distribution of midstream > upstream > downstream. Ecological risk coupling and coordination increased by 42.0% upstream but decreased by 22.8% midstream and 12.0% downstream over 25 years. Changes in the WLR matching coefficient were positively correlated with ecological risk, driven mainly by population dynamics. The study recommends promoting water-saving irrigation and modernizing agricultural infrastructure in the midstream, enhancing water source protection and grassland ecology in the upstream, and strengthening resource management across the basin. Additionally, it calls for the restoration of vegetation and sustainable management of water and land resources through coordinated projects in the downstream and across the HRB.

Prior Source:
Yu, J.; Zhou, J.; Zhao, J.; Chen, R.; Yao, X.; Luo, X.; Jiang, S.; Wang, Z. Agroecological Risk Assessment Based on Coupling of Water and Land Resources - A Case of Heihe River Basin. Land 2023, 12, 794. https://doi.org/10.3390/land12040794

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Impacts of Future Land Use/Cover Change on Ecosystem Services in Sichuan-Chongqing Region, China

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Abstract

To improve the environment of the ecosystem, China has implemented the Green-for-Grain Program for two decades, which has resulted in an imbalance among ecology, economy and food. This study focuses on the "ecology-food" imbalance problem, taking Sichuan-Chongqing Region as an example, to set up future scenarios to predicate the distribution of ESs. We first forecast land use/cover change in 2050 under four different scenarios: Natural Development Scenarios; Arable Land Conservation Scenarios; Ecological Priority Scenarios; Ecology-Arable Land Harmonization Scenarios. Then, we assess changes in five ESs: habitat quality, crop production, soil conservation, water yield, and carbon storage from 1990 to 2020 and 2050. Finally, we reveal the spacial distribution of ESs. The following conclusions are obtained: (1) From 1990-2020, CS, SC, and HQ reveal an increasing trend with growth rates of 1.68%, 0.08%, and 0.46%; CP reveals a reduce rate of 2.75%. (2) S4 has an increase in arable land, and CP has increased by 7.56% compared to S1, reversing the trend of reduced CP under S1. (3) The high-high anomalies area of CP under S4 is basically the same as that under S2, which proves that S4 is a scenario policy that can be referred to for future development.

Keywords: Ecosystem services, PLUS-InVEST model, land use/cover change, Sichuan-Chongqing region

1. Introduction

Food is the most fundamental material for the survival of mankind and epochmaking for ensuring the safe and stable development of the country and society However, to improve the quality of the environment in ecosystem, China implemented a policy of Green-for-grain project (GFGP) in 1999 (T. Chen et al., 2022; Geng et al., 2019; Wang et al., 2011). The implementation of this policy has changed the way land is utilized. By 2020, a large amount of arable land in the Sichuan and Chongqing regions (SCR) and across China will have been converted to forest and construction land, leading to a significant drop in food production.

D'Amour predicted that 25% of the total global arable land loss in 2030 will occur in China (D'Amour, C.B. et al., 2017). However, most of the ecosystem service research in SCR focuses on ecological indicators (Cui et al., 2022), and few people pay attention to the contradiction between "ecology-economy", "ecology-food". This is a research gap that cannot be ignored.

Ecosystem services (ES) are the functions of various ecosystems that are relevant for the survival and activities of mankind. The current study concluded that there is a nonlinear relation between different ecosystem services (Li et al., 2022). Food production and ecological protection are not a matter of extreme trade-offs, but two aspects of a complete ES system that can only be considered comprehensively by focusing on multiple indicators of ecosystem service trade-offs. As a vast grain production and reserve base in western China, The SCR has severe soil erosion, and high ecological sensitivity. Therefore, this study will provide a comprehensive assessment of CP, SC, HQ, WY and CS ecosystem services in Sichuan and Chongqing to reconcile ecological conservation with food production.

Land use and land cover change (LULC) gets a large effect on ecosystems, and it is an important way in which human activities affect ecosystems (Wang et al., 2022). Studying the effects of LULC on ES is an indispensable process for analyzing ES changes (Wang et al., 2019; Zhao et al., 2022a). To better assess and simulate LULC, researchers have developed a number of studying models. After validation, the PLUS has been shown to be a superior model to CA and FLUS. In addition, ecological models are constantly updated and improved, among which the Integrated Valuation of Ecosystem Services and Trade-offs (InVEST) model shows better integration of ecological procedures , good spatial presentation, with high accuracy, and the model rationality is well verified (Li et al., 2021).

Currently, few studies have moved from a single ecological or food perspective to a coordinated "eco-food" perspective. Considering future ES projections from the perspective of balancing food production and ecological conservation is an important research gap. Therefore, we built a framework to predict future ES from the perspective of balancing food production and ecological conservation. (1). This study will use the InVEST to comprehensively evaluate the historical transformations in crop production (CP), water yield (WY), soil conversation (SC), habitat quality (HQ) and carbon storage (CS) in the study area, and to offer a preliminary understanding of some of the problems that exist in the development of the SCR. (2). On this basis, four future scenarios were constructed based on the two perspectives of "ecology-food" using the PLUS model to predict the future ES distribution. (3). We use spatial autocorrelation analysis to assess and discuss future changes in ES indicators.

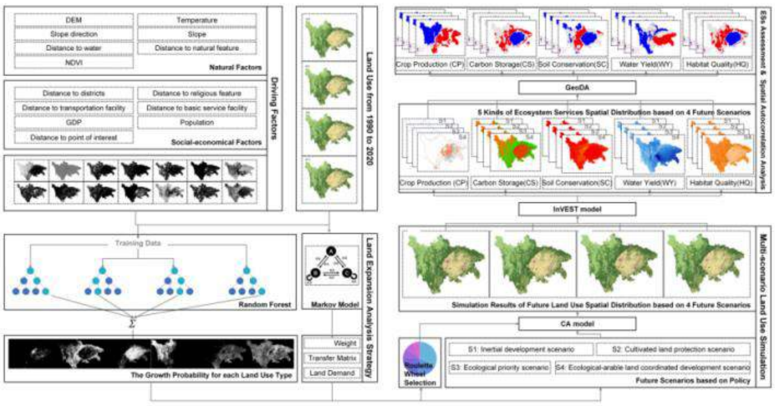

Figure 1. Research Framework

2. Study regions and data sources

2.1 Study area

The Sichuan-Chongqing area, covering 56.84×10^4 km² (97°21'34°19'N), includes varied terrain: an alpine plateau in the west, mountains in the southwest, and a basin in the east. The climate ranges from dry, cold in the west (2–8°C, 600–800 mm precipitation) to warmer, wetter conditions in the east (16–18°C, 1000–1200 mm precipitation). Soil types include purple, red, yellow, and alpine meadow soils, with vegetation ranging from subtropical forests to alpine meadows.

Figure 2. Location map and topography of Sichuan-Chongqing area

2.2 Data sources

LULC change is a complicated dynamic procedure driven by multitude of factors like natural factors, economic factors, social factors, policy factors, etc. Concerning the relevant research on land use simulation, this article chooses 14 driving factors from three aspects: natural (NDVI, Temperature, slope, etc.), economy (population, GDP), society (distance to transportation facility, etc.), and divides the land into six types (Liu et al., 2023): arable land (AL), forestland (FL), water area (WA), grassland (GL), construction land (CL), and unused land (UL).

3. Methodology

Incorporating three main aspects is the proposal presented in this study for the integrated system. (1) Through the study of space and space evolution of five regions from 1990 to 2020, some problems in the regional development of Sichuan and Chongqing are preliminarily understood. (2) The PLUS model is used to simulate and forecast four scenes respectively, and the results are compared. (3) The study used the InVEST model to evaluate changes in five significant ecosystems in 2050, and spatial autocorrelation analysis was used to analyze and discuss.

According to the PLUS model, 14 selected driving factors were input, and the LULC in 1990 ~ 2020 was studied by LEAS model, and the land use in 30 years was obtained. On this basis, Markov chain is applied to anticipate the natural development in 2050, and finally, CARS model is used to simulate the LULC change in 2050.

(1) Natural factors, elevation and others are the significant factors impacting the change of land use; economic factors: GDP and other factors; social factors: natural land, water resources, administrative units, transportation sites, public service agencies, religious land and public land.

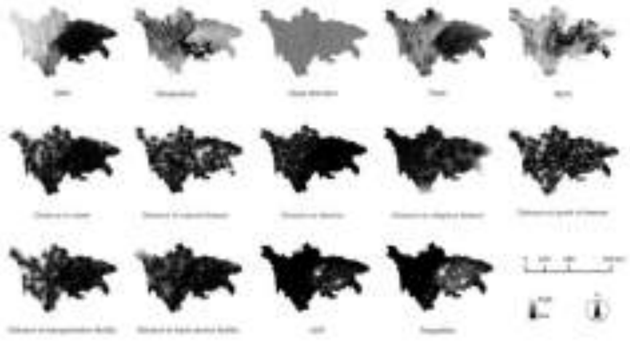

Figure 3. Driving factors affecting LULC

(2) Neighborhood weight setting:

The neighborhood weight was determined according to the proportion and the research experience of predecessors in this area. The final values are as follows (Table 1).

Table 1. Neighborhood factor parameters

The type of land use	A	B	C	D	E	F
The neighborhood factor parameter	0.4	0.6	0.4	0.4	0.9	0.8

A-AL; B-WL; C-GL; D-WA; E-CL; F-UL

(3) Scenario setting:

In this paper, we set up a conversion cost matrix based on four development scenarios (Table 2) for the simulation prediction of land use.

Table 2. Scenario setting

Scenario Design	Scenario description
Natural development scenarios	The future land change pattern is consistent with the change from 1990 to 2020, and the demand for land is simulated using Markov model, and all lands are set to be interconvertible.
Arable land conservation scenarios	Set AL is strictly prohibited to transfer out, other land types can be converted to AL except for CL.
Ecological Priority Scenario	Set up FL and WA is strictly forbidden to be transferred out, GL can only be transferred out to FL and WA, and AL can be converted to any land type.
Ecology - Arable Land Harmonization Scenario	The land types are ranked according to their ecological benefits: FL, GL, WA, UL, AL, and CL (Li et al., 2022c); it is set that AL and Fl can only be converted to each other, and land types with lower ecological benefits than FL can be converted to AL.

4. Results

4.1 LULC and ES changes from 1990 to 2020

4.1.1 LULC change from 1990 to 2020

In terms of quantitative changes, from 1990 to 2020 (Table 3), the proportion of AL decreased the most, and the proportion of FL increased the most among all types of LULC in Sichuan and Chongqing. The region of AL and GL decreased significantly, the proportion of AL decreased from 28.10% to 25.77%, and the proportion of GL decreased from 29.98% to 28.20%, decreasing by 1,783,800 ha and 1,360,500 ha respectively. The proportion of FL increased from 40.16% to 43.10%, the proportion of WA increased from 0.82% to 0.93%, the proportion of CL increased from 0.28% to 1.08%, and the proportion of UL increased from 0.66% to 0.91%, increasing by 2,254,900 ha,843,000 ha, 614,900 ha, and 190,300 ha, respectively.

Table 3. Share and rate of change of different types of LULC in 1990 and 2020

The type of land use	1990	2020	Change ratio
A	28.10%	25.77%	-2.33%
B	40.16%	43.10%	2.94%
C	29.98%	28.20%	-1.77%
D	0.82%	0.93%	0.11%
E	0.28%	1.08%	0.80%
F	0.66%	0.91%	0.25%

A-AL; B-FL; C-GL; D-WA; E-CL; F-UL

From the spatial layout (Figure 4), by 2020, the size of site type in Sichuan and Chongqing will be FL> GL > AL > CL> WA > UL. CL is primarily expanded in the AL area, which is clustered and spread over the Chengdu-Chongqing urban agglomeration within the Sichuan basin, mainly in 16 cities such as Chongqing and Chengdu; the FL is distributed around the Sichuan basin, mainly in Liangshan Yi Autonomous Prefecture and Ya'an City; the GL is chiefly distributed plateau area of high mountains in the northwestern Sichuan-Chongqing region, specifically in Ganzi region. The primary reasons for rapid urban development and population inflow are the vast urban land expansion in Chengdu and Chongqing throughout the previous three decades, leading to the depletion of vast amounts of AL. Additionally, the initiative of "returning farmland to the forest" has accelerated the reduce in AL and the increase in FL. This has resulted in the embezzlement of a good deal of Al in these cities.

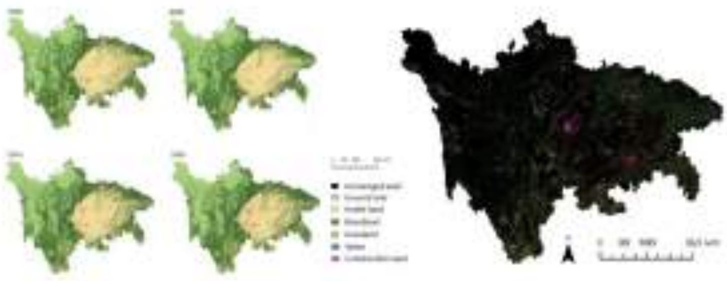

Figure 4. LULC change from 1990-2020 (the left graph shows the distribution of land types; the right graph shows the expansion distribution of each land type from 1990 to 2020)

4.1.2 Dimensional and time variation in ESs from 1990 to 2020

Regarding quantity change (Figure 5), CS, SC, and HQ were constantly on the rise, with an equilibrium growth rate of 1.68%,0.08%, and 0.46%, respectively. CP gradually decreased, with an average decreasing rate of 2.75%. WY decreased first and then increased, with a decrease rate of 0.11% averagely.

Figure 5. A histogram of changes in the number of ESs from 1990 to 2020

From the spatial layout (Figure 6), the high-value CS, SC, and HQ areas are concentrated in the Sichuan basin's WL areas. The WL areas have the most significant contribution to ecology, mainly in Aba, Ya'an City, Liangshan Yi Autonomous Prefecture, and some areas in Guangyuan City and Chongqing City, and the expansion trend of CS, SC, and HQ in these areas gradually increases due to the expansion of WL; the low-value areas are mainly in the Sichuan basin. The median value of CS and HQ is located in the GL area, mainly in Ganzi and Aba, and the change over time is small, while the SC in most areas is at a low value. The high value of WY is located in the area's east, mainly in the CL and AL in Meishan, Leshan, and the eastern area of Chongqing; the middle value is principally in the AL in the Chengdu-Chongqing urban agglomeration and the northern area of Aba; the low value is principally in the FL and GL areas in the high mountain plateau in the west; the distinction in WY is related to the land type and the topography of the Sichuan and Chongqing regions.CL and FL expansion in Chengdu, Meishan and Neijiang has led to a decrease in plowland in these areas. The trend of CP shrinkage is more pronounced in these areas. Low-value areas are principally located in the forest-field interval in the southeast of the AL area.

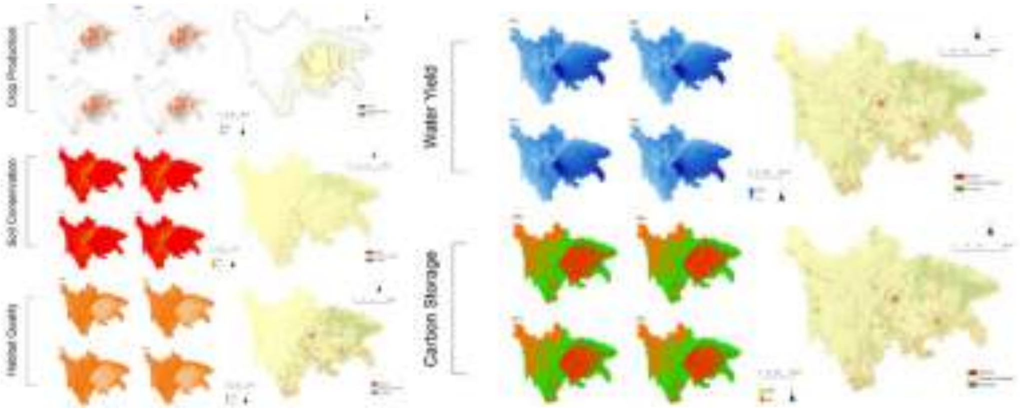

Figure 6. Spatial and temporal changes in ecosystem services from 1990-2020 (left panel shows the spatial distribution of ecosystem services for four years; right panel shows the spatial distribution of changes in ecosystem services from 1990-2020)

4.2 Impacts of LULC change on ESs under different future scenarios in 2050

4.2.1 LULC change under different future scenarios in 2050

In terms of quantitative changes (Table 4), CL was enlarged in all three scenarios, except for the S4 scenario, with 0.57%, 0.21%, and 0.37% expansion, respectively; the maximum ratio of CL is 1.65% in the S1 scenario, which is due to the development of urbanization in the realistic scenario. In scenarios S2 and S4, there is a slight expansion of the AL area, 0.74% and 0.08%, respectively; in scenarios S1 and S3, the decreased AL area is more significant, 1.72% and 2.93%, respectively. Since S2 is the scenario of arable land protection, the acreage of the AL area is the biggest, 26.52%. Under all four scenarios, the FL area expanded by 2.71%, 0.29%, 4.22%, and 1.41%, respectively; Under the S3 scenario, which aims at ecological conservation, the maximum acreage of FL area is 47.32%. Under all four scenarios, the GL area was reduced by 1.70%, 1.29%, 1.92%, and 1.59%, respectively. Out of the S1 scenario, the WA increased in the other three scenarios by 0.08%, 0.30%, and 0.16%, respectively; under the S3, the most significant proportion of WA was 1.23%.

Table 4. LULC volume changes in 2050 for the four scenarios (Rate of change for 2050 versus 2020)

Scenario	**S1**			**S2**			**S3**			**S4**		
	Land area	Proportion	Change rate	Land area	Proportion	Change rate	Land area	Proportion	Change rate	Land area	Proportion	Change rate
A	18439673	24.05 %	-1.72 %	20331563	26.52 %	0.74 %	17512408	22.84 %	-2.93 %	19822000	25.85 %	0.08 %
B	35128200	45.81 %	2.71 %	33272795	43.39 %	0.29 %	36280739	47.32 %	4.22 %	34132000	44.51 %	1.41 %
C	20323993	26.51 %	-1.70 %	20639191	26.92 %	-1.29 %	20153993	26.28 %	-1.92 %	20405490	26.61 %	-1.59 %
D	689675	0.90%	-0.03 %	781000	1.02%	0.08 %	945083	1.23%	0.30 %	841732	1.10%	0.16 %
E	1266092	1.65%	0.57 %	993183	1.30%	0.21 %	1116096	1.46%	0.37 %	831016	1.08%	0.00 %
F	830099	1.08%	0.17 %	660000	0.86%	-0.05 %	669413	0.87%	-0.04 %	645494	0.84%	-0.07 %

A-AL; B-FL; C-GL; D-WA; E-CL; F-UL

Regarding spatial layout (Figure 7), under scenarios S1 and S3, CL encroaches heavily on AL within the Chengdu-Chongqing urban agglomeration in the Sichuan Basin, achieving a large area of expansion; under scenarios S2 and S4, CL extension is not apparent. AL expands significantly in S2 and S4 scenarios in the Sichuan Basin, mainly on unused and ecological land. S2 also includes expansion in FL surrounding the basin. S4 focuses on protecting original high-quality contiguous land use. In scenarios S1, S3 and S4, there is a significant expansion of FL around the Sichuan Basin, mainly encroaching on UL and GL, which follows historical land use patterns and ecological priority scenario. The WA of the Yalong and Dadu Rivers in the western alpine plateau grass area increases significantly in scenarios S2 and S4. The UL around the WA also increases significantly, and these unused lands may be swamps around the rivers, etc. In scenario S3, because the AL area can be converted to ecological land, the Yangtze, Min, and Pei Rivers in the AL area of the Sichuan Basin expand significant.

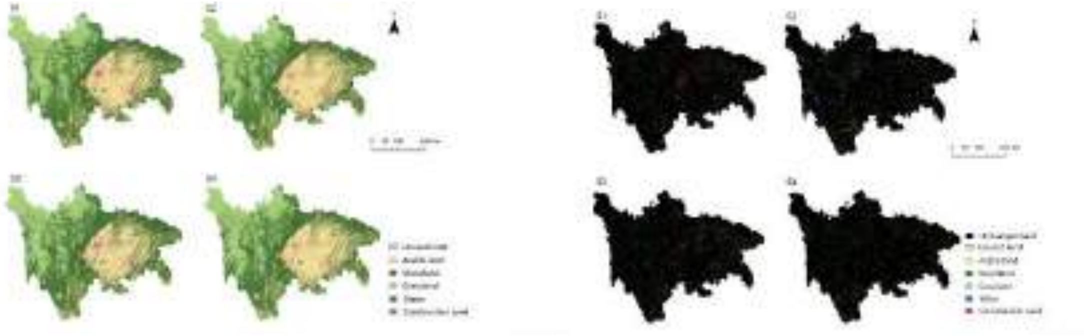

Figure 7. LULC change in 2050 under four scenarios (the left figure presents the land types distribution in the four cases; the right figure presents the distribution of expansion of each land type under each scenario with respect to 2020)

4.2.2 ESs changes under different future scenarios in 2050

The spatial distribution of ecosystem services in 2050 under the four scenarios is shown in Figure 8, Figure A, and the change curve of ecosystem services in 2050 under the four scenarios is shown in Figure B. The change curve of ecosystem services in 2050 under the four scenarios is shown in Table 5. From Table 5, the numerical changes in the conversion rate of ecosystem services from 2020 to 2050 can be obtained. The predicted results of virous scenarios show that the trend of all ecosystem service indicators in the S4 scenario is between S2 and S3. 4.22% expansion of FL in S3, and the expansion of LULC for ecology increases SC, HQ, and CS by 0.38%, 3.41%, and 7.44%, respectively. The expansion of forestlands and grasslands will increase plant transpiration to some extent, which will be shown in changes in ecosystem services as a reduction in WY. Scenarios S2 and S4 focus on conserving AL. These two scenarios result in an increase in AL area and an increase CP by 2.25% and 0.35% respectively, compared to S1. This reverses the trend of decreasing food production under S1. This highlights the significance of AL conservation in addressing the global food crisis. However, focusing on AL conservation will make in S2 scenario SC and WY decrease by 0.17% and 0.21%, respectively. Comprehensive analysis shows that the change of indicators under the S4 scenario is more balanced and meets the requirements of long-term development in the setting of the global food crisis.

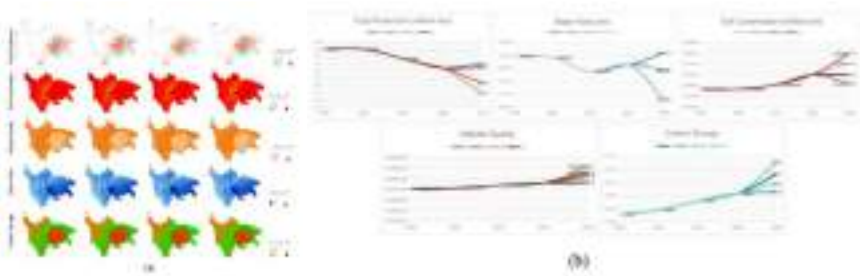

Figure 8. Spatial distribution of ecosystem services in 2050 under four scenarios (a) and ecosystem service change curves (b)

Table 5. Conversion rate of ecosystem services 2020-2050

		2020	2050	conversion rate
S1	CP	60.86	50.78	-16.56%
	WY	1066.45	1071.13	0.44%
	SC	5259988.72	5270817.00	0.21%
	HQ	456656441.4	462703846.2	1.32%
	CS	16069	16817	4.65%
S2	CP	60.86	62.23	2.25%
	WY	1066.45	1064.26	-0.21%
	SC	5259988.72	5251030.68	-0.17%
	HQ	456656441.4	456988032.5	0.07%
	CS	16069	16124	0.34%
S3	CP	60.86	53.91	-11.42%
	WY	1066.45	1052.84	-1.28%
	SC	5259988.72	5280069.73	0.38%
	HQ	456656441.4	472234181.7	3.41%
	CS	16069	17265	7.44%
S4	CP	60.86	61.07	0.35%
	WY	1066.45	1064.08	-0.22%
	SC	5259988.72	5260143.14	0.00%
	HQ	456656441.4	466395590.9	2.13%
	CS	16069	16450	2.37%

4.3 Spatial autocorrelation analysis of ESs in 2050

The Moran's I index reflected the spatial distribution of high or low ES functions in the Sichuan-Chongqing region. Fig.9 shows a local auto-correlation of the future ESs.

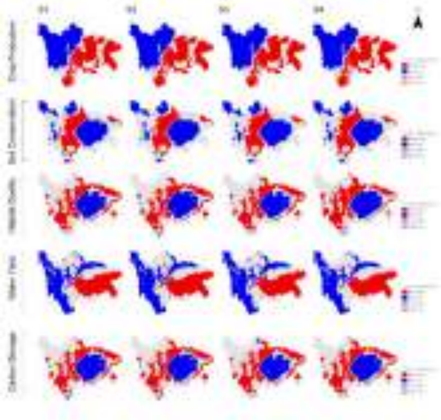

Fig. 9. Local spatial auto-correlation analysis of ecosystem services under four scenarios in 2050

The relative distribution of the areas with high-high autocorrelations (HH) and the areas with low-low autocorrelations (LL) in each scene shows a certain regularity. In the area of concentrated distribution of low-altitude administrative regions in the southeast, SC, HQ, and CS all show concentrated distribution of LL, and CP shows a concentrated distribution of HH. In the sparse distribution area of high-altitude administrative regions in the northwest, LL is concentrated under CP and WY, and HH is concentrated under HQ and CS. Meanwhile, HQ and SC show high similarity in HH, LL, the areas with low-low autocorrelations (HL), and the areas with low-high autocorrelations (LH), and SC and WY show some complementary distributions in the northwest region.

For CP, HH and LL mainly thrives in northern and southern Sichuan-Chongqing areas. In the southern region, LL has the lowest value under the S3 scenario; in the northern region, HH has the highest value under the S4 scenario. Regarding SC, HH, LL, and in the S2 scenario, LH anomalies can be found dispersed throughout both central and marginal regions. The LL and HH anomalies in HQ are concentrated in the central part. In this region, the highest value of the S4 distribution and the lowest value of the S3 distribution was found for the LL distribution. For the HH distribution, the S4 distribution is the lowest, and the S3 distribution is the highest. Regarding FL, the HH anomalies are scattered, and they all show a trend in which the HH values of S4 are between those of S2 and S3. Regarding CS, the pattern exhibited between scenarios in the southeast direction was consistent with the HQ. At the same time, LL anomalies were observed on the northern side, where the LL values of S3 were higher than those of S4.

5. Discussion

5.1 Impact of LULC conversion of ESs

Based on Figure 4, the land use types in SCR have more significantly conversed during the last three decades, which is caused by the combined effect of many factors, such as urban development, changes in environmental conditions, and policy adjustments.

The impact of land use changes on the ecosystem performs much better than that of other natural elements (Li et al., 2003). The low-cost areas in CS, HQ, and SC are all located in the arable land area of the Sichuan Basin. the same conclusions have been drawn by Hu(A. Hu et al.,

2022) and Bai(Bai et al., 2018). On this distribution of ecosystem services in this region. This also indicates that forestlands drive more ecosystem services in Sichuan and Chongqing, like SC, HQ and CS, which is in harmony with the conclusions obtained from the research conducted in Sichuan Province. The high-cost area in CP is situated in the cultivated area of the Sichuan Basin. Moreover, the high-cost region governed by cultivated and construction land of WY is mainly positioned in the Sichuan Basin area.

In contrast, the low-cost region is mainly positioned in the FL and GL territories in the western alpine plateau region. This is in harmony with the research results of Bai et al. (Bai et al., 2017) on water containment in Sichuan. Additionally, the annual water supply of CL and AL is greater than that of FL and GL, which is the same finding as Hu et al. (W. Hu et al., 2022).

5.2. Scenario-driven ESs

In different development contexts and policy orientations, ecosystem services are bound to change in time and space, with Sichuan Province taking the lead in "returning farmland to the forest" as a pilot project in 1999, mainly leading to a decrease in AL and CP from 2000 onwards. Green development focuses on energy conservation, emission reduction, reforestation and combating desertification. These measures have led to increased carbon storage and improved soil and habitat quality. This contributes to ecological restoration and sustainable development. However, in the absence of other policy influences, the extreme ecological priority can make the expansion of representative ecosystems like forests, grasslands, and water encroach on arable land and thus lead to lower food production. In the S4 scenario set up in this paper, a certain balance between arable land conservation and ecological development is achieved, and the balanced development of all ecosystem services is better than the other three scenarios.

5.3 Limitations and future prospects

However, this study has some shortcomings, and future studies need further consider the mechanisms of action and adaptation strategies of climate change., population growth and other factors on the impacts of LULC and its ESs, In addition, future studies should also examine the synergistic or trade-off relationships between different ecosystem services, as well as the mechanisms of action and adaptation strategies of climate change, in order to enhance the accuracy and applicability of the model.

6. Conclusion

Our study builds a framework to assess the historical changes of ESs in the SCR from the perspective of balancing food production and ecological conservation, and to anticipate the SCR future ESs. The subsequent conclusions are derived:

(1) The analysis of historical LULC showed that during the 30-year period from 1990 to 2020, the proportion of AL in each type of LULC in the SCR decreased the most. By analyzing the historical data of ecosystem services, CS, SC, and HQ all showed an increasing trend. WY showed a decreasing and then increasing trend. CP decreased more significantly. In the case of a large expansion of ecological land, the decline in food production is much larger than the rise in ecological indicators.

(2) By calculating the ESs under different future scenarios in 2050, under S1 scenario, CP is negatively correlated with other ecological indicators. In the S4 scenario, the negative correlation between CP and other ecological indicators is alleviated.

(3) The projections under different scenarios showed that the ecosystem services developed in a balanced manner in the S4 scenario, which was better than the other three scenarios.

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Rehabilitation of landfills in Thessaloniki: from landscape destruction to recovery

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Abstract

In Greece, landfills take the form of either uncontrolled or controlled waste disposal sites, while in recent years there has been a rise in the development of sanitary landfills. Here, we present two applied examples of landfill rehabilitation in Thermi (80.000m^2) and Derveni (132.000m^2), located in the outskirts of the city of Thessaloniki (northern Greece), which today are used as environmental parks by the citizens. The implemented rehabilitation scheme in each site, was designed to comply with the relevant provisions of the EU Waste Framework Directive 75/442/EEC and the Greek regulation defined in the Joint Ministerial Decision 114218/1997 "Establishment of a framework of specifications and general waste management programs". In addition, the evolution of their aftercare over the years was based on the aforementioned framework. Both sites demonstrate successful case studies, where the rehabilitation was not treated solely on a technical level but was analyzed and designed according to environmental and socio-cultural criteria, factoring-in the character of the landscape and its uses. Ultimately, these spaces were upgraded as locations of great value for the quality of life in a city with limited open spaces and were integrated in the environmental units of Thessaloniki.

Keywords: Landfill rehabilitation, wasteland reclamation, environmental park

1. Introduction

The term "restoration" has become widely accepted to describe the overall process of taking all necessary measures and making the corresponding efforts to minimize the negative environmental impacts of an activity, whether that activity has ceased or continues, while simultaneously restoring the values and functions of the ecosystem as much as possible and establishing a new state of equilibrium for it (Kougionis, 2007).

According to Brofa (2012), the term landscape restoration does not imply returning the area to its pre-exploitation state. Moreover, in most cases, such a strong disturbance of ecological conditions occurs that it is impossible to restore the original state and use. However, often such a project is not cost-effective due to very high costs.

In general, restoration means creating conditions that will allow similar animals and plants to live there in the future. This means that other types of plants and animals, besides those that were originally there, can also be used. Similarly, restoration, broadly speaking, is creating a stable situation and deciding what the land will be used for in the future.

More and more, people are turning to landfill reclamation to solve environmental issues and make new green areas. This method has changed empty areas into thriving spaces across the globe. It shows us the power of using landfills differently (https://esoftskills.ie/from-landfill-to-landscape-restoring-ecosystems-and-protecting-biodiversity/).

But we sould see the closure of landfills as an opportunity not only for the enviroment, but also for society. From this perspective, we can distinguish three categories to explain the concept of landscape restoration (Bonnicksen, 1990 & Hatzistathis, 1997):

Restoration**:** This is the process through which the conditions of an area before disturbance are returned to an identical state after the disturbance.

Reclamation**:** This implies that the area will become habitable by living organisms (plants and animals) in the same composition and density once the reclamation work is completed.

Rehabilitation**:** This implies that land uses will be different from those before the disturbance. Landscape rehabilitation suggests that the chosen land use should be ecologically stable and have high value for the local community.

So, in this paper we talk about rehabilitation of landfills and this is the approach that The Regional Association of Solid Waste Management Agencies for Central Macedonia (FODSAK) managed the closure of Thermi and Derveni landfills in Thessaloniki, Greece.

2. Material and Method

To study and define rehabilitation of landfills, such as the case stydies of Thessaloniki presented here, primary and secondary sources, data, and materials were used. These were obtained through a review of the literature and archival material, as well as through field research and on-site observations.

3. Findings and Discussion

The Regional Association of Solid Waste Management Agencies for Central Macedonia (FODSAKM) is a public entity responsible for the integrated solid waste management in the Central Macedonia region of Greece. It consists of 38 municipalities and is tasked with:

- Developing and implementing a regional waste management plan
- Operating and maintaining waste management facilities
- Promoting waste reduction and evaluating reuse and recycling programs
- Educating the public about waste management
- Enforcing waste management regulations

Its main vısıon is to create a Zero Waste Society which utilizes municipal waste for sustainable development goals (https://fodsakm.gr/).

The country has a long history of landfill disposal, but, in recent years, various techniques have been utilized for their recovery. The main managment includes closure and landfill capping, gas management, and soil remediation. Until recently, the final cover of landfills and the resulting restoration were based solely on ecological and environmental parameters, achieved through low-level planting aimed at erosion control (Figure 1).

Figure 1. Landfill site at Kastoria(before and after the restoration) (http://www.diadyma.gr/Website/Apokatastaseis/Apokatastaseis.html)

In this paper we present two applied examples of landfill rehabilitation in Thermi (80.000m^2) and Derveni (132.000m^2), located in the outskirts of the city of Thessaloniki (Figure 2). Both are being used as environmental parks by the citizens.

Figure 2. Locations of the two Enviromental Parks in Derveni and Thermi, Thessaloniki, Greece, after rehabilitation of prespective landfill site. (Photos by Google map).

The technical restoration work, particularly in leachate, biogas management, and soil cover, was carried out in accordance with European and Greek regulatory standards. The same restoration process was applied to both parks. It should be noted that the final surface cover layer has a minimum thickness of 2.5 meters, enabling support for tree planting and the installation of numerous structures. The differnce in these rehabilitations lies in the landscape approach, which refers to a holistic framework for managing land and natural resources that considers the interconnectedness of social, economic, and environmental factors within a specific geographic area.

The landscape design of the Environmental Park of Derveni aimed to harmonize and integrate the space with the surrounding landscape, characterized by a peri-urban forest. Native conifers, evergreen oaks, and pines were selected to create a natural and sustainable landscape that complements the existing peri-urban forest.

The design aims to link the park with adjacent green spaces, forming a green corridor that penetrates the urban core of western Thessaloniki (Figure 3).To the east, the park is bounded by Filiro and 'Mylos' streams. It adjoins a green forest to the southwest, which is being redeveloped by the Municipality of Pavlos Melas. This green corridor extends to the verdant 'Agiazma' location and concludes at the Evkarpia open-air theater.

Figure 3. The Network of green spaces adjoining the Enviromental Park of Derveni.(Photos and map by Google map)

The Environmental Park of Derveni is a popular destination for residents of western Thessaloniki, providing recreational and sports facilities, including playgrounds, sports fields, and walking trails (Figure 4 & 5).

Consistent maintenance and ongoing development, including the introduction of features that complement its character (such as plant labyrinths), connections to the surrounding landscape, and environmental education initiatives, have established the park as a popular destination with a regional appeal as a peri-urban green space (Figure 6).

Figure 4. The first stage of rehabilitation with soil cover at Environmental Park of Derveni.(Photos from FODSAKM archive)

Figure 5. Aerial photos of the Enviromental Park of Derveni show the outline and indicate key elements of the park the final land form and (FODSAKM archive).

Figure 6. Photos of the Enviromental Park of Derveni were selected from visitors' upload social media.

The Environmental Park of Thermi is Greece's first example of the rehabilitation of a landfill into a recreational area, fully recovering the damaged landscape and creating a location that is useful for citizens and beneficial to the environment. A network of designated trails, sports fields, fitness stations, and outdoor recreational areas, including chess and children's play areas, are adorned with aesthetically pleasing ornamental plant beds.

The design capitalizes on the elevation difference resulting from the landfill, incorporating openings that frame views, especially towards the Thermi Dam, which is a significant landmark of the area (Figure 7).

Figure 7. Aerial photos of the Enviromental Park of Thermi (FODSAKM archive).

The park was repurposed as an environmental information hub for local schools. The FODSA's Environmental awareness program, combining theoretical and practical learning, promotes the values of recycling, reuse, and environmental stewardship. It is noteworthy that the environmental awareness program was attended by 15,000 children and adolescents in 2023 (Figure 8).

Figure 8. Photos of the Enviromental Park of Thermi selected from visitors' uploads on social media.

4. Conclusion

Landfills are vital to public health, society and the environment, with considerable impact on the landscape. The locations of landfills tend to be marginalized, degraded areas on the outskirts of a city. Due to their size, they have a local and supra-local character. This is a factor that should be considered when designing their rehabilitation and integration into the environmental, social and cultural landscape of the wider area in which they are located. Indeed, landfill rehabilitation should not be seen as a purely technical or engineering challenge, but rather as an opportunity to upgrade the social and environmental value at a local and regional scale. By reclaiming and redefining the use of such sites, landfills can be transformed into parks, green spaces, or other development projects that can benefit the community**.** It is thus obvious that landfill rehabilitation should not be seen as an expenditure, but rather as an investment towards a sustainable future for urban areas.

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Evolution and Movement of Urban Voids in Antakya: From Existence to Nothingness

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Abstract

Antakya, with its unique cultural heritage, heterogeneous structure, and historically vibrant spaces, holds the essence of its identity within distinctive social and spatial voids. Unlike typical modern cities, Antakya's multifaceted, adaptable, and meaning-generating voids—courtyards, streets, squares, and shores—transcend the conventional dichotomy of urban solids and voids. These "Meaningful Voids," once integral to the city's ancient and contemporary life, were profoundly altered by last year's earthquake, transforming into involuntary, deep voids. This study examines the earthquake's impact by analyzing changes in historical streets and urban voids, which bear traces of past civilizations. Central to the research is the concept of void, framed by Parmenides as "Being" and Einstein as "A being beyond nothingness with mass." The study draws on data from the "Antakya Köprübaşı City Square and Its Surrounding Urban Design Project Competition," which received a Purchase award. The research explores how the meaningful voids that shaped Antakya's development were reduced to nothingness post-earthquake. It proposes strategies to rehabilitate these voids, reintegrating them into daily urban life. Ultimately, it aims to provide tools to transform "Urban Nothingness into Existence," addressing environmental degradation and fostering sustainable urban recovery.

Keywords: Antakya, Urban voids, Earthquake, Existence, Nothingness

1. Introduction

The concept of emptiness has been a subject that has been intensively discussed and addressed in various disciplines for many years. This concept, which first emerged in social sciences such as philosophy and psychology, has continued to be examined in quantitative sciences such as physics and space, and then gained an interdisciplinary character with the contributions of art disciplines such as painting, sculpture and music. In philosophy, emptiness is defined in the context of "Existence and Nonexistence, Infinity and Limitation" and for philosophers such as Aristotle and Plato, "Emptiness does not exist" (Cevizci, 1999). On the other hand, atomist philosophers such as Democritus and Epicurus saw emptiness as "an inseparable part of matter". Einstein's general theory of relativity, on the other hand, asserts that space and time have a dynamic structure and that space is a "Field Shaped by Mass and Energy". In the context of quantum mechanics, the vacuum is defined as "a vacuum in which energy fluctuations occur and virtual particles are constantly created and destroyed".

In the field of architecture, the void becomes visible, palpable and inhabitable as a result of the act of delimitation, and this special void becomes integrated with the concept of "space" (Kuban, 2018). The void transforms into space as value is attached to it. Space, with all its dimensions and forms, is both a conceptual and a real phenomenon and carries a social structure; it is a whole of relationships and forms (Lefebvre, 1991). Emptiness is not a lack, but a "Complex and Active Space"; beyond its physical dimension, it is an "Existential State" (Cevizci, 1999). Moreover, emptiness means "freedom and liberty". Urban voids are the embodiment of human and social freedom. While these voids contribute to the shaping of the urban form as part of the physical structure of the city, they have also become spaces where social memory is represented, collective memory is formed and kept alive with the meanings they have acquired.

The city of Antakya has been home to many civilizations due to its strategic location and constitutes an important area of existence with its historical past, natural structure and multicultural social structure. This city, where people of different religions and sects live together, offers a free and dynamic life. This quality can be observed in the city's urban spaces rather than its built environment. This study focuses on Antakya's urban gaps, which are its assets. In particular, the designs that came to the agenda and won awards with the "Antakya Köprübaşı City Square and its Vicinity Urban Design Project Competition" organized by Hatay Metropolitan Municipality in 2021 and the urban voids that were largely destroyed in the earthquake of February 6, 2023 are examined. In this context, the study aims to draw attention to the importance of space beyond structural elements in the reorganization of these earthquake-destroyed assets by questioning the "Existing/Productive (Designed) and Destroyed" urban spaces.

2. Antakya City

Antakya is one of the oldest settlements in Anatolia. Located at the intersection of the roads connecting Northern Mesopotamia to Anatolia, this important trade center draws attention as the intersection of eastern and western cultures (Figure 1). In antiquity, it was named "Queen of the East" and became a holy center for the Christian world like Jerusalem and Rome. St. Piyer Church, located on the Antakya-Reyhanlı road, is considered one of the first important religious buildings of Christianity as the place where St. Peter the Apostle preached when he came to the city. For this reason, it was declared a pilgrimage site by the Papacy in 1963 (Akın et al., 2005). Climatically, Antakya is under the influence of the Mediterranean climate, with hot and dry summers and mild and rainy winters. The region is influenced by the prevailing winds blowing from the southwest direction (Demir, 1996).

Figure 1. Urban context (ECO.laud, 2021)

Antakya is one of the oldest cities in Turkey and a well-established ancient city dating back to 300 BC. Its location on important trade routes since 2200 BC reinforced the strategic importance of the city. At the same time, its favorable climate and fertile soils made Antakya a center where communities of different religions and nationalities lived together. This city, which changed hands many times between the Seleucids, Romans, Byzantines, Arabs, Seljuks, Latins and Mamluks, came under Ottoman rule in 1517. Antakya, which remained under the rule of the Ottoman Empire for 400 years, passed to French rule in the 19th century after World War I. In 1938, the city declared its independence and established the State of Hatay, which lasted for one year before joining the Republic of Turkey in 1939 (Temiz, 2002).

Antakya was founded by Seleucus Nicator I in the 4th century BC, replacing the city of Antigonia. This city, called Antiokheia, became the center of the Seleucid State and the ruins of Antigonia, which was destroyed during the construction of the settlement, were used as building material for the new city (Akın et al., 2005). Antakya, which joined the Roman Empire in 64 BC, became the capital of the Syrian province. With the Roman rule, Antakya started to experience the golden age of its history. During the reign of Augustus (31 B.C. - 14 A.D.), the Olympic Games, which were regularly repeated every four years, were started here. Many new public buildings were constructed in the city during this period. One of the most important reconstruction activities of the period was the construction of the famous colonnaded street, which crossed the city and was two Roman miles (one Roman mile = 1.478 m) long. With the construction of this street, the city grew and its population gradually increased thanks to the neighborhoods that developed on both sides of the street. During the Sokullu period, construction activities in Antakya gained momentum. The social structural changes that began with the Tanzimat period contributed to the spatial development of the city (Akın et al., 2005). In this process that Antakya has undergone since its foundation, the spatial development of the city, the squares, streets and buildings that make up the urban fabric have played an important role in the formation of the city's identity. The grid system inherited from the ancient period blended with the organic urban texture to form the unique character of Antakya (Figure 2).

Figure 2. Traces of civilizations - Protected axes/ textures (a) Tseleukos period, (b) Roman period, (c) French mandate, (d) Present (2021) (6)

Antakya is home to Nusayri Arabs (Arab Alevis), Sunni Turks, Alevi Turks, Sunni Arabs, Christian Orthodox, Catholics, Protestants, Armenians, Jews and many other ethnic groups. Although there are similarities in the social and cultural spheres, there are distinct differences in terms of lifestyles and religious practices. These individuals are able to keep their identities alive and live together in line with common values (Başeymez, 2009).

In addition to social activities such as weddings organized according to different cultural values, celebrations of festivals of various religions, birth and death ceremonies, Antakya people continue their lives with important social activities such as picnics, golden days and bathhouse entertainments. Food culture plays a unifying role in social life and shows that gathering around a table and eating a meal expresses the sharing of common values, although it differs from culture to culture.

Antakya'nın Akdeniz iklimine sahip olması çeşitli sebze ve meyvelerin yetişmesine olanak sağlamış; önemli ticaret yolları üzerinde bulunması ve tarih boyunca farklı kültürlerden etkilenmesi yemek kültürünün ve çeşitliliğinin zenginleşmesine katkıda bulunmuştur. Antakya'da yemek kültürünün yaşatılmasında fırıncılar, kasaplar, tatlıcılar ve lokantacılar önemli rol oynamaktadır. Bu zengin mutfak kültürü şehrin ayrı bir kimliğini oluşturmakta ve geçmişten gelen yemeklerin hala Antakya sokaklarında bulunması bölgeyi gastronomi turizmi açısından daha da cazip hale getirmektedir. Antakya, 2017 yılında Birleşmiş Milletler Eğitim, Bilim ve Kültür Örgütü (UNESCO) tarafından "Dünyanın 26. Gastronomi Şehri" olarak kabul edilmiştir. Günümüzde kahvehanelerin yerini kafeler almış olsa da bu mekânlar kentte önemli bir sosyal alan olarak varlığını sürdürmektedir (Nesipoğlu, 2019).

3. Existing Voids

Habib-i Neccar Mountain is an important part of the historical fabric of Antakya and has become a symbol of the city. There are many historical buildings and old streets on the slopes and summit of the mountain. Excavations in this region have uncovered remains from the Hellenistic, Roman and Byzantine periods. It is known that the mountain was an important settlement in ancient times. In addition, Habib-i Neccar Mountain is considered a holy place for Christians, Muslims and Jews.

The most important surface water source of the city of Antakya is the Asi River passing through the center of the city. This river, which underwent many changes in different periods, was called "Orontes" in Antiquity. During the draining of the Amik Plain, the part of the Asi River passing through the city was rehabilitated and turned into a smooth channel (Anonim, 1998).

There are a total of seven bridges over the Asi River, five of which are used for vehicles and two for pedestrians. The cut-stone "Roman Bridge", once the symbol of Antakya and built by Emperor Diocletianus in 300, was demolished by the state in 1972 in order to dry Lake Amik and speed up the flow of water by widening the river bed, and a concrete bridge was built in its place (Salıcı et al., 2015).

In historical periods, the Asi River was of great importance. According to travelogues, ships engaged in maritime trade on the river could reach from the ancient port city of Seleucia Pieria on the coast of Samandağ to today's Antakya city center. However, over time, the river has lost this importance and has become an area that causes serious environmental and visual pollution in the city due to increasing pollution.

Following the construction of the government house and the establishment of the district governor's office, families of civil servants began to settle in Antakya in the second half of the nineteenth century. The road extending from the barracks to the newly built government mansion widened over time and was named "Saray Street"; thanks to the new buildings, shops, casinos and restaurants built on this street, this neighborhood became the most modern district of Antakya (Akın et al., 2005). Today, Saray Street remains one of the busiest commercial streets in Antakya.

One of the most important construction activities brought to Antioch during the Roman period was the famous Colonnaded Street, which was located outside the city during the Seleucid period and was 3 km long, covered and surrounded by 10 meter wide colonnades on both sides. This street, adorned with ornamented marble paving and sculptures, became the busiest street in Rome after its construction (Özalp, 2008). According to the sources, street lighting was applied for the first time in the world on this Colonnaded Street (today's Kurtuluş Street), which passes through the center of Antakya and is surrounded by marble columns on both sides. During the Roman Empire, what distinguished Antakya from other cities and made it modern was the illumination of this street, known as the Colonnaded Street, at night. Even in the heyday of the Roman Empire, this street was different from the streets and avenues of other cities, which remained pitch black at night, and where bandits and vagabonds roamed.

A public square, Cumhuriyet Square, was designed at the intersection of the İskenderun (Alexandretta) and Samandağ (Seleucia Pieria) roads, directly connected to the Roman Bridge over the Asi River. This square houses the Archaeology Museum (now the Ethnography Museum, 1939), the Ziraat Bank (1942), the Municipality Building (1923), the Gündüz Cinema (1936) and the Post Office (1935) (Rifaioğlu, 2018).

The archaeological finds were initially exhibited in the Sultani School on the corner of the square, where the museum is located today, but due to the large number of finds, the school was demolished and the Antiquities Service commissioned architect Michel Ecochard to design a new museum. The Antakya Archaeological Museum is recognized as the second largest mosaic museum in the world. However, the museum became inadequate over time and was moved to its new location on the Reyhanlı road in 2014. Today, this building serves as the Ethnography Museum.

On the west bank of the Asi River, in Cumhuriyet Square, opened in 1936 as the “Empire Cinema Hall” where the French organized balls between 1936 and 1939, it was named “Gündüz Cinema” after 1939 in reference to General Asım Gündüz. This building was also used as the parliament building for a period (Temiz, 2002).

Antakya's Municipal Park on the west bank of the Asi River was built during the French period (1920-1938). Today the park includes tea gardens, a gymnasium, a swimming pool and a children's playground (Mersinligil & Erişen, 1996).

Uzun Bazaar and its surroundings, which is defined as a traditional trade centre today, has existed functionally, if not physically, with various changes since 300 BC. However, the actual shaping of today's Uzun Bazaar area took place with the beginning of the Arab domination around 700 AD. Arabisation and Islamisation processes started in the city, which was under the influence of Christianisation until this period. The present identity of Uzun Bazaar was formed when the Ottoman Empire shaped the city and its centre (Turgut, 1986). Uzun Bazaar and its surroundings developed in connection with the Habib-i Neccar Mosque in the southeast and Mahremiye Mosque in the northeast, starting from the Grand Mosque. However, the new road system built over time has broken this relationship.

The urban texture of Antakya was initially planned with a grid system, and in time it gained a unique character by integrating with the organic street structure. Along Kurtuluş Street and Saray Street, there are architectural structures in a contiguous order. The settlement texture in the neighbourhoods located in the southwest and northeast directions of Kurtuluş Street mainly consists of dead-end streets integrated with the grid system, two-storey buildings built in the masonry and timber building system in adjacent order, as well as inward-oriented courtyard buildings with high walls on the facades facing the road. In the courtyard houses of Antakya, there are narrow streets and dead-end streets called ‘zokmak’.

The streets were planned and shaped under the influence of natural structure and climatic factors. The width of the streets generally varies between 2-4 metres, but sometimes they narrow down to 80 cm width. These streets are designed to ensure that the prevailing wind blowing from the south-west direction is effective throughout the city. These streets, laid out with cobblestone paving, have water channels called ‘arık’, which are 10-15 cm deep and 50-120 cm wide, with cut stones on the edges. The streets of Antakya form a unity with their stone walls and stone floors that provide privacy (Yüzer, 2021).

The concept of 'courtyard as a socio-spatial expression', which constitutes the ancient and contemporary urban life model of the local people, includes many common values that constitute the physical, human and social identity of the city of Antakya. In Antakya, the house system with courtyard, which is determined by climatic conditions, is common. The lifestyle is predominantly introverted and courtyards are at the centre of this lifestyle. It is possible to see this characteristic both on the urban scale and on the housing scale. In Antakya houses, the courtyard is the most used and most important space of the house. It functions as the main place where family members come together, spend time, host guests, do household chores, eat and sit. Rooms and other closed spaces are arranged around the courtyard and form the shape of the courtyard (Figure 3).

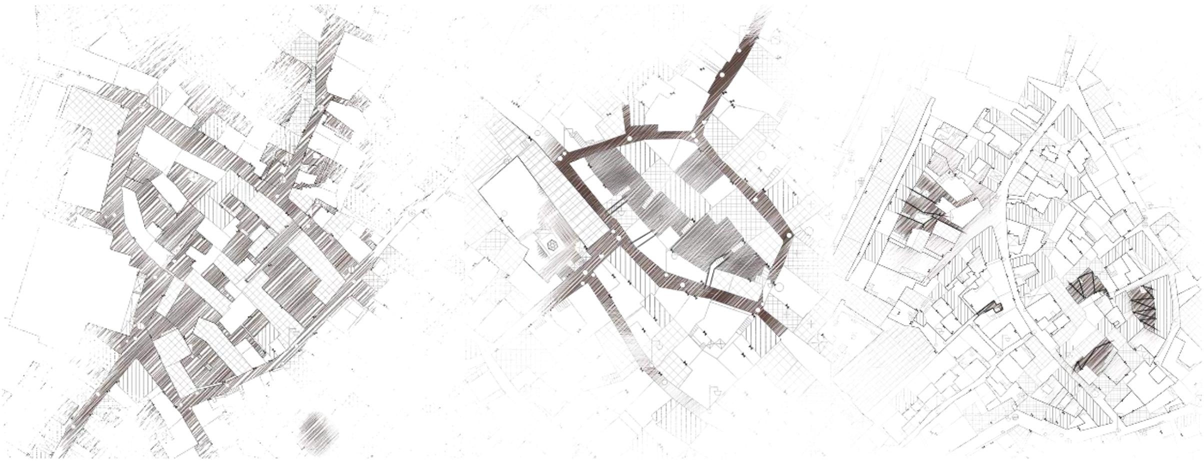

Figure 3. (a) Urban texture formation (equal solid-cavity balance and ıntroverted structure in urban texture), (b) Spatial grading (street-passage-court-housing/ public-semi public-semi private-private spaces), (c) Urban void typologies (back-back mourned, common walled/ surface, ındependent courtyards) (Okumuş et al., 2024)

4. Produced (Designed) Voids

Organised in 2021 by Hatay Metropolitan Municipality, the 'Antakya Koprubasi City Square and Near Surroundings Urban Design Project Competition' targeted the area east of Atatürk Bridge, which is located in the city centre on the Asi River with the historical urban texture of Antakya district. The aim of the competition is to create a living urban open space with a high quality of life that is socially, physically and visually compatible with the natural and cultural living environments in the city centre by evaluating the multifaceted and layered potentials of this area. In the competition, ECO.laud's design was awarded the purchase prize, and in the project, the city was read through 'Voids with Meaning' instead of occupancy (Figure 4).

It has been seen that it is important to grasp the traces of civilisations that fill the meaningful gaps shaped in the formation and development processes of the city. It is aimed to focus on the effects of space on life rather than seeing it only as a physical structure, to aim to allow space to express itself freely, to read the spatial codes of a city with a high level of experience, to hold on to these codes and to protect them. Understanding emptiness means understanding the city's structure that expands and contracts, full of surprising perspectives and surrounded by dead-end streets; courtyards and squares as spaces for people. It is to understand the connections of the society with the place and experiences that make the void of Antakya exist. In short, the void of Antakya is a place filled with its unique social structure and surrounded by spatial structures with identity. This void, as a unifying and reconciling force between different spaces, is a phenomenon that carries the traces of social lives and requires a deep understanding.

Figure 4. Produced voids (ECO.laud, 2021)

5. An Evacuated City-Absence-Earthquake

“Earthquake”, as a phenomenon with devastating effects on the structural and social environment, has been threatening life in Turkey, as in many parts of the world, since the early ages of history. The recent earthquakes, the epicenter of which was Kahramanmaras, can be given as an example, which can be seen very few in the history of the country and which occurred consecutively and directly affected 11 provinces.

Antakya, the “ancient memory of Anatolia”, which has been destroyed many times throughout history and has been home to many civilizations, has also faced the destructive effect of these earthquakes, and the “meaning and life-laden gaps” in the city have turned into a “deep nothingness” (Figure 5).

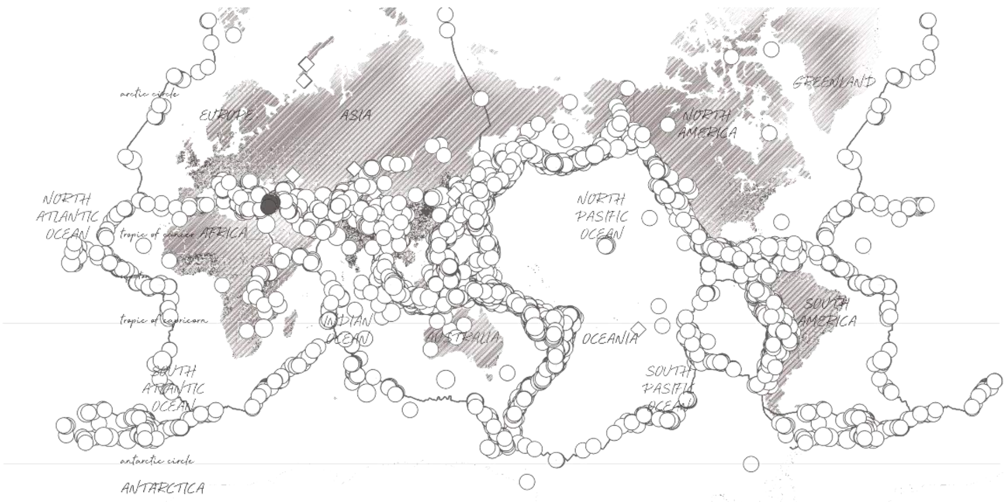

Figure 5. The most destructive and deadliest 2.,3. earthquakes in human history; 2. Antakya, Turkey, 115 (year), 260,000 deaths, magnitude 7.5 earthquake, 3. Antakya, Turkey, 525 (year), 250,000 deaths, magnitude 7 earthquake (Okumuş et al., 2024)

Historically, Antakya has experienced many devastating earthquakes. The city was repeatedly destroyed and rebuilt. Especially the earthquakes in the years 115, 458, 526, 588, 848, 1114, 1170, 1407, 1759, 1822 and 1872 were of magnitude 7 and above (Kaya & Kıyılı, 2009). More recently, 8 earthquakes of mild intensity occurred between 1921 and 1940 and 7 undamaged earthquakes between 1951 and 1981. However, the Hatay earthquake on January 22, 1997 caused significant cracks in the buildings. In addition, technical reports and articles by scientists have been published that the January 22, 1997 Hatay earthquake and the June 27, 1998 Ceyhan-Misis earthquake may represent the preparatory phase of a possible earthquake series. In 2021, the Earthquake Advisory Board of the Chamber of Geological Engineers published “Our Cities Living on Faults: Hatay Report”, warned that the city was located on a live fault. However, these studies and the earthquakes in the city's history have been ignored in recent years. Horizontal and vertical development, incompatible with the culture and physical environment of Antakya, has rapidly spread to the peripheries of the city with the increase in population. On February 6, 2023, the Kahramanmaras earthquake hit Antakya the hardest and caused a major devastation in the city. This was followed by the Hatay earthquake on February 20, 2023, which increased the devastation; human and building losses reached great dimensions (Figure 6).

Figure 6. Detection of destroyed buildings using before (22.12.2022) and after (03.03.2024) earthquake aereal photographs (Okumuş et al., 2024)

6. Conclusion

Today in Antakya, the structural freedom of the city shaped by human life has been transformed into a deep and meaningless void by the earthquake. This physical emptiness should not mean being defenseless and unprotected, on the contrary, it should not be considered as a blank slate on which new meanings can be constructed. Starting from the existence of the city, it is necessary to emphasize the character of the place and the existing voids. Cultural continuity between layers has not been interrupted throughout history in Antakya. The people of Antakya have always protected their city and culture. This social power should be used to repair the destruction of the city and urban gaps where urban life is dense should be repaired with priority.

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Exploring the Driving Mechanism of Differences in Coordination of Urban Resilience Coupling Based on Random Forests-Taking Chengdu-Chongqing Economic Circle as an Example

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Abstract

This study examines the coordination of multidimensional urban resilience subsystems (economic, social, ecological, and infrastructural) in the Chengdu-Chongqing Economic Circle (CCEC), using data from 16 cities between 2005 and 2020. The entropy-weighted TOPSIS model and linkage coordination degree (CCD) model analyze the coordination between resilience subsystems, while the Random Forest model quantifies the contribution of 12 indicators to urban resilience coupling and coordination. Key findings include: (1) High sustainability in economic, social, ecological, and infrastructural resilience is concentrated in Chengdu and Chongqing, with other cities showing lower resilience values. (2) Ecological resilience predominates in most cities, including Dazhou, Deyang, and Guang'an, while economic resilience is lowest, with Chengdu leading in 2005. (3) CCD results reveal significant regional heterogeneity, with Chengdu and Chongqing being the most coordinated cities. Other cities like Dazhou, Neijiang, and Ya'an are highly uncoordinated. (4) Social and economic indicators contribute most to urban resilience coordination, while a few cities, such as Mianyang, Dazhou, and Guang'an, show higher contributions from ecological and infrastructure indicators.

Keywords: Urban resilience, subsystem resilience, coupling coordination degree, entropy weight-TOPSIS method, CCD model, Chengdu-Chongqing Economic Circle(CCEC).

1. Introduction

Natural disasters, exacerbated by global climate change and public health events, have caused significant losses worldwide, threatening socio-economic development. Since 1970, global losses have exceeded $3.7 trillion, with over 2.4 million deaths (Smith, 2021). As urbanization and climate change intensify, disaster frequency and severity are expected to rise (Wang et al., 2023). Enhancing urban resilience can reduce disaster losses and aid recovery (Xia & Zhai , 2022). The "14th Five-Year Plan" of China highlights the importance of improving urban resilience (Wu et al., 2023). Urban resilience refers to cities' ability to withstand and recover from disruptions through effective planning and coordination (Sara & Joshua, 2016). Increasing focus on multi-dimensional urban resilience has emerged, incorporating economic, social, ecological, and infrastructural dimensions (Cui et al., 2023). While the role of infrastructure in resilience is widely recognized, there is a lack of consensus on the dimensions that define resilience. This paper adopts infrastructure as a fourth dimension and builds a coupling coordination model to evaluate urban resilience comprehensively.

Most studies have explored spatio-temporal evolution, with few addressing the driving factors behind coupling coordination. Economic, social, ecological, and infrastructure factors significantly impact urban resilience (Huang et al., 2022), but existing research often focuses on individual aspects. A comprehensive analysis is needed to understand the combined effects of multiple factors (Liu, 2021). Random Forest, due to its robustness and precision, is well-suited for identifying the driving mechanisms of urban resilience (Abhijit et al., 2020).

The Chengdu-Chongqing Economic Circle (CCEC) represents a key western region of China, experiencing significant losses from natural disasters. Future climate change will intensify these challenges, yet existing research on urban resilience in the CCEC is limited. This paper proposes a comprehensive framework using the TOPSIS, CCD, and RF models to explore the driving mechanisms of urban resilience coupling. The objectives are to analyze the coupling coordination degree and establish relationships between resilience indicators and coordination, providing insights into enhancing urban resilience and emergency response.

2. Methodology and Materials

2.1 Study area

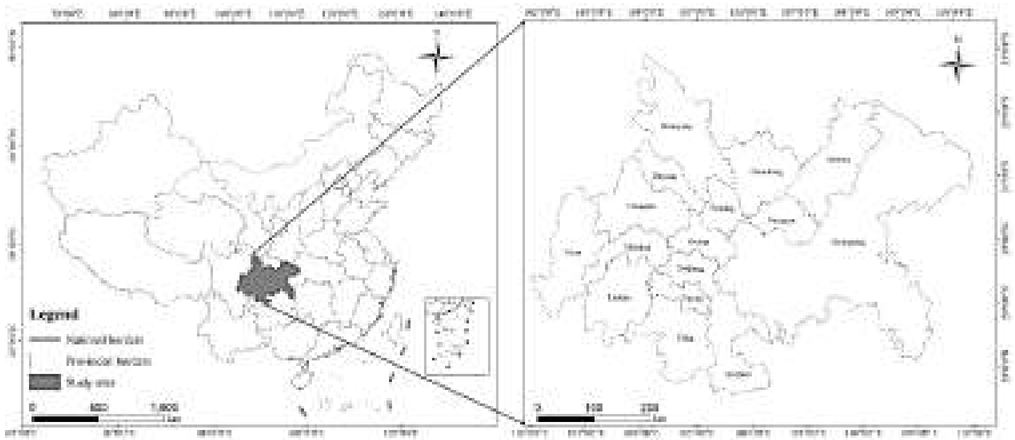

Figure 1. Study Area

CCEC covers 185,000 square kilometers, including Chongqing and 16 Sichuan cities, or about 1.92% of China's land area. Located in the Sichuan Basin on the Yangtze River's upper reaches, it is a key development hub in western China and a major node in the "One Belt, One Road" and Yangtze River Economic Belt. With Chengdu and Chongqing as its core cities, CCEC plays a vital role in central and western China's growth. The region’s mix of plain cities (Chengdu) and mountain cities (Chongqing) highlights the importance of studying their coordination for sustainable development. CCEC is analyzed in three regions: Western, Southern, and Northern Sichuan, with Chengdu and Chongqing’s separate development reflecting this distinction.

Table 1. Contains city

Region	Contains city
Chengdu	Chengdu
Southern Sichuan	Zigong, Luzhou, Neijiang, Yibin, Ziyang, Deyang
Western Sichuan	Leshan. Meishan. Ya'an
Northern Sichuan	Mianyang, Suining, Nanchong. Guang'an. Dazhou
Chongqing	Chongqing

2.2 Research framework

Based on the data of 16 cities in CCEC from 2005 to 2020, the entropy-weighted TOPSIS model and Coupling Coordination Degree (CCD) model are first used to analyze the coupling coordination degree among the four resilience subsystems of economy, society, ecology, and infrastructure in cities. Subsequently, the Random Forest model is used to quantify the contribution rate of 12 economic, social, ecological, and infrastructure indicators in the coupling coordination of urban resilience.

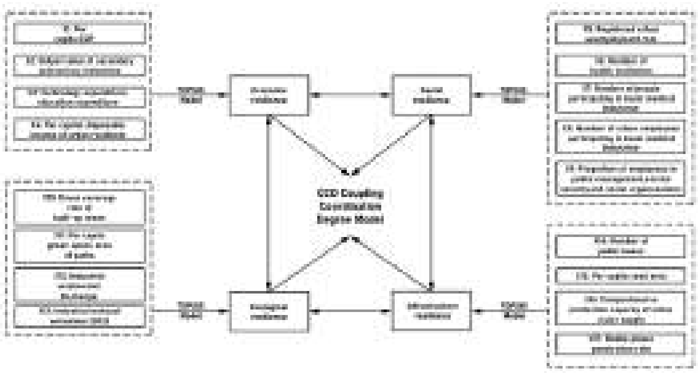

Figure 2. Research Framework

3. Research Results

Table 2. Statistical analysis of the data results by region

Statistical analysis of the data results by region																				
	Economic resilience				Social resilience				Ecological resilience				infrastructure resilience				coupling coordinationleve			
YEAR	2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020	2005	2010	2015	2020
Chengdu	0.8614	0.5016	0.5008	0.5344	0.6943	0.8545	0.7551	0.8089	0.5529	0.7437	0.4954	0.2120	0.4574	0.4900	0.5095	0.6090	0.9240	0.8532	0.8148	0.8128
Southern Sichuan	0.1124	0.1047	0.0995	0.1048	0.1162	0.1569	0.1154	0.1448	0.2357	0.4054	0.2313	0.2905	0.1694	0.1377	0.1152	0.1295	0.2742	0.2470	0.3631	0.2512
Western Sichuan	0.0980	0.0898	0.0791	0.0947	0.1119	0.0902	0.0752	0.1254	0.2598	0.5517	0.2651	0.4582	2589.0000	0.1895	0.1451	0.1810	0.4050	3311.0000	2882.0000	0.3616
Northern Sichuan	0.1058	0.0800	0.0755	0.0957	0.1204	0.1769	0.1577	0.1575	0.2676	0.5732	0.5675	0.2123	0.1754	0.1546	0.1294	0.2020	3515.0000	0.3743	0.2976	0.2713
Chongqing	0.6958	0.7511	0.7472	0.7509	0.6852	0.5815	0.6376	0.7054	0.5828	0.7099	0.5500	0.4757	0.7727	0.8014	0.8690	0.5997	0.9662	0.9014	0.9148	0.8990

3.1 Characteristics of the spatial and temporal distribution of economic-social-ecological-infrastructural resilience

3.1.1 Economic resilience

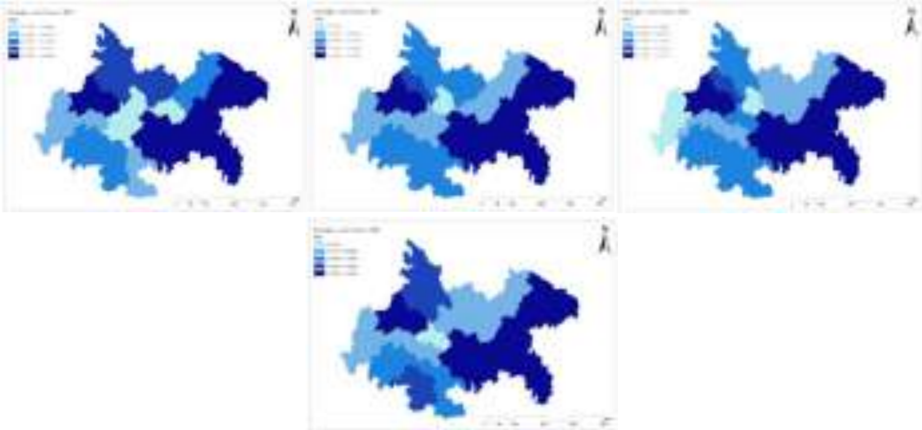

Figure 3. Economic resilience

The average EnR index values in 2005, 2010, 2015, and 2020 were 0.1910, 0.1594, 0.1538, and 0.1645, respectively, showing a decreasing trend followed by a rebound. The rate of EnR index decline from 2005 to 2010 was 16.5%, while the decline rate from 2010 to 2015 was 3.5%, and the growth rate from 2015 to 2020 was 1.1%. Values of ER in each region are shown in Table 2. Chongqing has the highest average ER value, followed by Chengdu, while the other regions tend to have lower average ER values. Regarding space, the average EnR values of Guang'an, Suining, and Ziyang in CCEC are generally low. In 2005, the high EnR average values were mainly concentrated in Chengdu and Chongqing, and there was a significant difference in the EnR average values within CCEC. By 2020, the number of cities with high EnR values will increase significantly, forming a cluster with Chongqing and Chengdu in the middle.

3.1.2 Social resilience（SR）

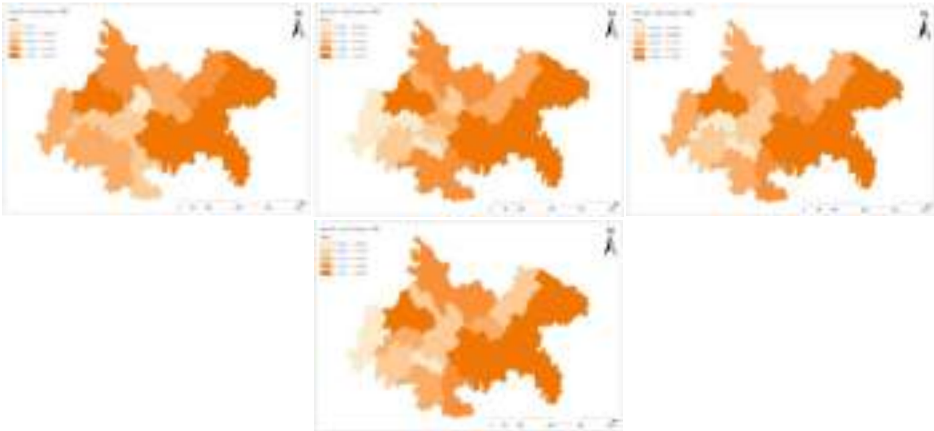

Figure 4. Social resilience

The average values of the SR index in 2005, 2010, 2015, and 2020 were 0.1884, 0.2214, 0.1942, and 0.2248, respectively, showing a fluctuating trend of growth-decline-rebound. From 2005 to 2010, the SR index increased by 17.5%. However, from 2010 to 2015, the SR index decreased by 12.3%. From 2015 to 2020, the SR index increased by 15.7%. Values of SR in each region are shown in Table 2. The SR average value is highest in Chengdu, followed by Chongqing. The gap between other areas and Chengdu and Chongqing is large. Spatially, the average SR values of Suining, Zigong, and Meishan in the Chengdu-Chongqing urban cluster are generally low. From 2005 to 2020, the high values of SR in the Chengdu-Chongqing urban cluster were mainly concentrated in Chengdu and Chongqing, and the difference in SR between high and low was significant. Cities with low SR values were mainly concentrated in the western part of Sichuan.

3.1.3 Infrastructure resilience（IR）

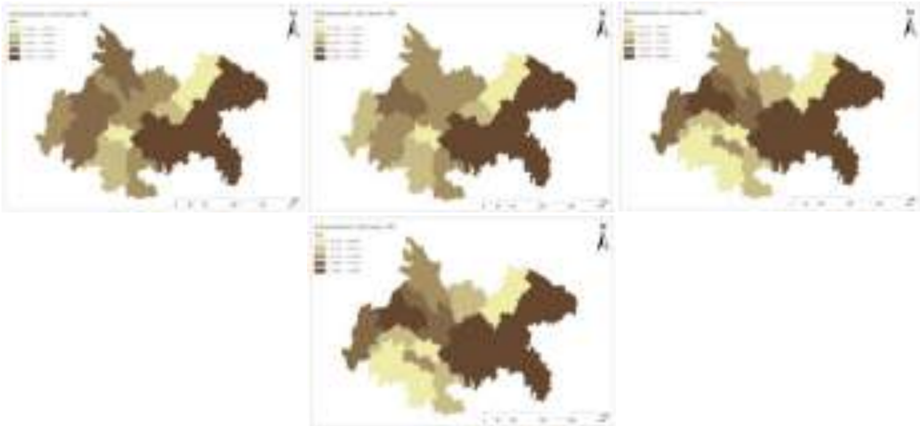

Figure 5. Infrastructure resilience

The average values of the IR index in 2005, 2010, 2015, and 2020 were 0.2466, 0.2193, 0.2010, and 0.2252, respectively, showing a trend of first decline and then rebound. From 2005 to 2010, the decrease rate of the IR index was 11.1%. From 2010 to 2015, the decrease rate was 8.4%. From 2015 to 2020, the growth rate was 12.1%. Values of IR in each region are shown in Table 2. Therefore, the average IR value is highest in Chongqing, followed by Chengdu. The southern region of Sichuan is relatively lower. Spatially, the average IR values of Jiang and Dazhou in the Chengdu-Chongqing urban cluster are generally lower. In 2005, the high values of IR were mainly concentrated in Chongqing. Until 2020, the difference in IR values between cities has decreased.

3.1.4 Ecological resilience（ElR）

Figure 6. Ecological resilience

The average values of the ElR index in 2005, 2010, 2015, and 2020 were 0.2918, 0.5255, 0.4160, and 0.3403, respectively, showing a trend of first increasing and then decreasing. The ElR index increased from 2005 to 2010, with a growth rate of 8.0%, while from 2010 to 2020, the ElR index steadily decreased. The decrease rate from 2010 to 2015 was 20.8%, and from 2015 to 2020, the decrease rate was 18.2%. Values of EIR in each region are shown in Table 2.

Therefore, the ElR average value is highest in Chongqing, followed by Chengdu, and relatively low in southern Sichuan. Spatially, the ElR average values of Neijiang, Suining, and Zigong in CCEC are generally low. In 2005, the high values of the ElR average were mainly concentrated in Chengdu and Chongqing. With the help of these two cities, the gap between other regions and the two cities was significantly reduced. From 2015 to 2020, the ElR average value in the northern region of Sichuan exceeded that of Chengdu.

3.1.5 Analysis of the evolution of resilience

Figure 7. Analysis of the evolution of resilience

The EnR, SR, IR, and ElR values for each city were ranked from highest to lowest, and the results were grouped into four categories: EnR dominant, SR dominant, IR dominant, and ElR dominant (Table 3). Specifically, fewer cities are EnR dominant, with Chengdu and Yibin being EnR dominant in 2005 and Chongqing being EnR dominant in 2020. The proportion of SR dominant cities is relatively low, with 1, 2, 1, and 3 in the four years, respectively. There were 5 IR dominant cities in 2005, accounting for 31.2% of the total cities. From 2010 to 2020, the number of IR dominant cities was 2, appearing in Ziyang, Chongqing, Ya'an, and Deyang, respectively. ElR dominance is the primary resilience mode in CCEC, with 8, 12, 13, and 10 in the four years, accounting for 50%, 75%, 81.3%, and 62.5% of the total number of cities.

Table 3. The number of cities dominated by EnR, SR, IR and ElR

Year	EnR-led Number of cities	SR-led Number of cities	IR-led Number of cities	EIR-led Number of cities
2005	2	1	5	8
2010	0	2	2	12
2015	0	1	2	13
2020	1	3	2	10

3.2 Coupled economic-social-ecological-infrastructure resilience coordination

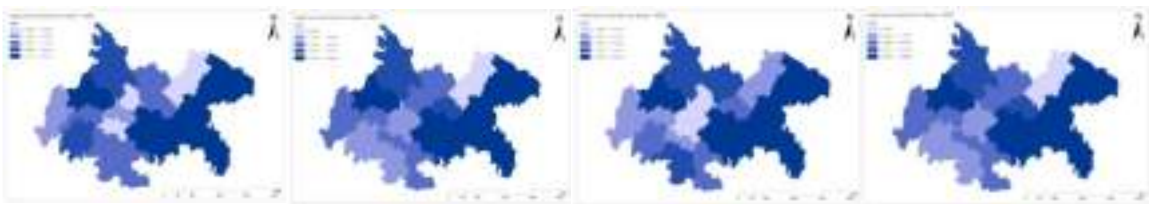

Figure 8. Coupling coordination degree

The mean value of coupling coordination was 0.4444, 0.4189, 0.4225, and 0.4225 in 2005, 2010, 2015, and 2020, respectively, which was relatively stable. The number of highly uncoordinated cities (below 0.25) decreased from 3 in 2005 to 1 in 2020, accounting for 18.8% and 6.3% of the total, respectively, with a significant difference.

(1) Extremely uncoordinated (0-0.25): The number of highly uncoordinated cities in 2005, 2010, 2015, and 2020 was 3, 1, 2, and 1, respectively, accounting for 18.8%, 6.3%, 12.5%, and 6.3% of the total cities. They fluctuated, mainly distributed in Dazhou, Neijiang, Suining, and Ya'an.

(2) Relatively uncoordinated (0.25-0.5): In 2005, 2010, 2015, and 2020, the number of relatively uncoordinated cities mainly was 10, 13, 12, and 13, respectively, accounting for 62.5%, 81.3%, 75%, and 81.3% of the total cities. They were concentrated in all directions.

(3) Relatively coordinated (0.5-0.75): The number of relatively coordinated cities was relatively small in 2005, 2010, 2015, and 2020. Only Mianyang City was at a relatively coordinated level in 2005, located in the north of Sichuan Province.

(4) Extremely coordinated (0.75-1): Only Chengdu and Chongqing had extremely coordinated cities in 2005, 2010, 2015, and 2020, with Chongqing's coupling coordination slightly higher than that of Chengdu, and the coupling coordination of both cities showed a decreasing trend.

3.3 Economic-social-ecological-infrastructure resilience index contribution rate

Table 4. Economic-social-ecological-infrastructure resilience index contribution rate

	top1	top2	top3	top4	top5
Overall economic zone of Twin Cities	X5:Registered urban unemployment rate	X2-1:Output value of secondary industry	X10:green coverage rate of the built-up area	X11:per capita park green space area	X8:number of insurance participants
Southern Sichuan	X5:Registered urban unemployment rate	X7:number of unemployment insurance participants	X3-1:science and technology expenditure	X11:per capita park green space area	X6:Number of health institutions
Northern Sichuan	X5:Registered urban unemployment rate	X10:green coverage rate of the built-up area	X16:comprehensive production capacity f urban water supply	X8:number of insurance participants、X2-1:Output value of secondary industry	
western Sichuan	X5:Registered urban unemployment rate、X2-1:Output value of secondary industry		X1: per capita GDP	X10:green coverage rate of the built-up area∧X11:per capita park green space area	
Chengdu	X6:Number of health institutions	X2-1:Output value of secondary industry	X2-2:value added of the tertiary industry	X10:green coverage rate of the built-up area	X8:number of insurance participants
Chongqing	X5:Registered urban unemployment. rate	X2-1:Output value of secondary industry	X16:comprehensive production capacity of urban water supply	X8:number of insurance participants、X2-1:Output value of secondary industry	X10:green coverage rate of the built-up area

To prevent the data quantity from influencing the calculation of the contribution rate, 12 indicators were ultimately selected (X1: per capita GDP, X5: urban registered unemployment rate, X6: number of health institutions, X7: number of unemployment insurance participants, X8: number of participants, X10: coverage of green areas in built-up areas, X11: per capita park green area, X16: per capita road area, X16: comprehensive production capacity of urban water supply, X2-1: output value of secondary industry, X2-2: output value of tertiary industry, X3-

1: science and technology expenditure) for further analysis. According to the results of the random forest model calculation, the top five indicators with the highest contribution rate for the overall urban resilience of CCEC are X5, X2-1, X10, X11 and X8, covering the economic, social, and ecological aspects, in descending order of contribution rate.

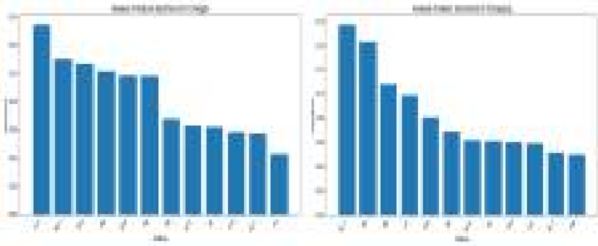

Figure 9. Analysis of feature importance for cities

In terms of space, the top five contributing indicators of Chengdu are X6, X2-1, X2-2, X10 and X8, with contribution ratios of 14.2%, 11.4%, 11.1%, 10.8%, and 8.3%, respectively. The top five contributing indicators of Chongqing are X5, X2-1, X16, X8 and X10, with contribution ratios of 19.3%, 12.9%, 10.2%, 8.0%, and 8.0%, respectively. X2-1, X8 and X10 in the built-up area significantly impact the coupling and coordination of the two major cities.

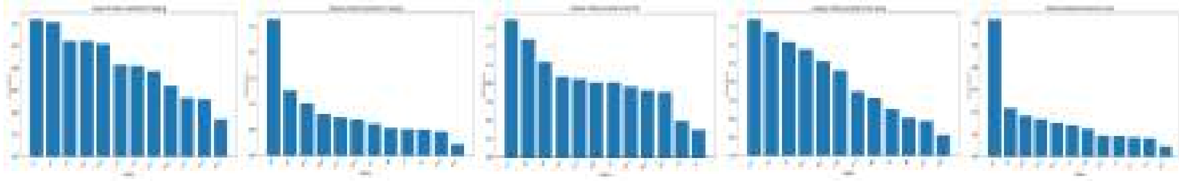

Figure 10. Analysis of feature importance for cities

The three indicators with the highest contribution rate to the cities in southern Sichuan are X5, X7 and X3-1, focusing on the social and economic sectors. Yibin and Deyang have the highest contribution rate for X5, accounting for 15.3% and 26.2%, respectively. Neijiang and Ziyang have the highest contribution rate for X3-1, accounting for 12.7% and 15.4%, respectively.

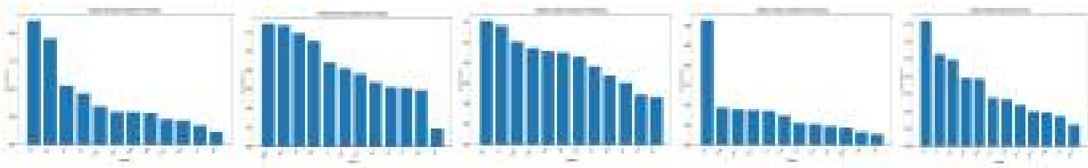

Figure 11. Analysis of feature importance for cities

The three indicators with the highest contribution rate to the cities in northern Sichuan are X5, X10 and X16. Among them, Suining City and Nanchong City have the highest contribution rate for X5, accounting for 16.9% and 30.9%, respectively; the highest contribution rate of Mianyang City and Dazhou City is reflected in the ecological aspect; the highest contribution rate of Guang'an City is X16, accounting for 13.0%.

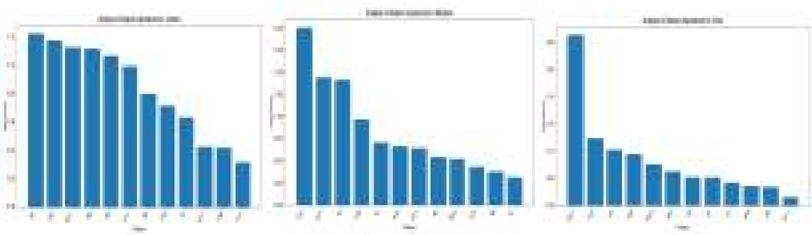

Figure 12. Analysis of feature importance for cities

The two highest contribution indicators in western Sichuan are X5 and X2-1, followed by X1. Leshan and Ya'an have the highest contribution rate for X2-1, reaching 14.6% and 29.1%, respectively, while Meishan has the highest contribution rate for X5, accounting for 18.1%.

Overall, the indicators with high contribution rates for urban resilience coupling coordination in CCEC are primarily concentrated in the social and economic sectors. A few cities with high contribution rates for the indicators are from the ecology and infrastructure aspects, including Mianyang, Dazhou, and Guangan. These cities are mainly distributed in northern Sichuan.

4. Discussion

4.1 Urban resilience fluctuates with the needs of urban development

Urban resilience evolves with urban development needs. This study examines the resilience of four subsystems within the CCEC framework and their interactions. From 2005 to 2020, EnR, IR, EIR, and SR showed fluctuations. After 2015, EnR and IR initially declined but later rebounded, aligning with findings from He Wei et al. (He et al., 2023) and Yi Pingtao et al. (Yi et al., 2023). Improved transportation infrastructure, such as the Western Land-Sea Corridor and new railways, played a key role, boosting economic growth and infrastructure (Wang et al., 2020) Policies like the 2016 Chengdu-Chongqing urban cluster plan and the 2020 dual-city economic circle further enhanced economic development, supporting the region’s role as a transportation hub. However, balancing economic growth and ecological resilience remains challenging. Studies (Han et al., 2023) indicate limited synergy between EIR and EnR, often causing conflicts. From 2010 to 2015, ecological resilience declined due to climate change, natural disasters, and industrial impacts, but recovery followed from 2015 to 2020, aided by initiatives like urban gardens. While southern Sichuan’s ecological resilience remains low, development efforts have improved EnR and EIR. Rapid urbanization in the Chengdu-Chongqing region prioritized economic gains, sometimes at the expense of ecology. Future planning must better balance economic growth with ecological protection.

4.2 Spatial distribution characteristics of urban resilience indicators

Urban resilience in the Chengdu-Chongqing Economic Circle exhibits distinct spatial patterns. Chengdu leads in social resilience, driven by urban-rural planning, a robust service sector, and cultural development. Its infrastructure resilience is twice the regional average, supported by substantial investments in public facilities. In contrast, Chongqing excels in infrastructure resilience due to significant transportation investments addressing its challenging terrain and dense population. The city’s efforts in urbanization and logistics development have reinforced its role as a regional hub. Northern Sichuan shows strong ecological resilience, leveraging natural resources, but city-level development varies. Western Sichuan, influenced by Chengdu’s "Park City" initiative, has seen moderate ecological resilience growth. Southern Sichuan, despite high economic resilience due to "core" cities like Chengdu and Chongqing, struggles with lower ecological resilience, reflecting uneven urbanization and resource exploitation.

4.3 Spatial-temporal distribution characterization of coupling and coordination

From 2005 to 2020, the Chengdu-Chongqing Economic Circle (CCEC) displayed fluctuating but relatively uncoordinated development (CCD index: 0.25–0.5). This aligns with Shi and Yang's (Shi et al., 2020) findings, which identified lagging economic growth and spatial disparities in central and western regions reliant on resource-intensive industries, resulting in environmental degradation. Liu Nana et al. (Liu et al., 2018) also noted similar regional imbalances caused by insufficient modern industries and technical labor in the west compared to the east and northeast.

Spatially, Chengdu and Chongqing demonstrated higher coupling and coordination, solidifying their core positions. Northern Sichuan showed steady progress except for Dazhou, while Western Sichuan remained stable despite Leshan's decline. Southern Sichuan faced challenges due to natural barriers, consistent with Han Shan et al.'s (Han et al., 2023) observations of terrain-induced developmental disparities.

4.4 Contributions driven by coupling and coordination

In the Chengdu-Chongqing Economic Corridor (CCEC), the urban registered unemployment rate is the most significant contributor to coupling and coordination, reflecting urban economic and social conditions. High or low unemployment rates indicate imbalances in population structure, reducing coupling between population and other systems, consistent with findings by Zhang and Qiu (Zhang et al., 2023). In Chengdu, however, the number of medical institutions ranks highest, driven by an aging population and increased demand for healthcare services (Wang et al., 2021). By 2020, those aged 60 and above constituted 17.98% of Chengdu's population, up 3.08 percentage points from 2010, underscoring healthcare's role in urban resilience. Additionally, the secondary industry's output value is a key factor for Chongqing, Chengdu, and Western Sichuan, emphasizing economic resilience as a central element, aligning with Wang Bo et al. (Wang et al., 2022). Future urban planning should address employment, industrial balance, and elderly care to enhance sustainable development in the CCEC.

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Analyzing the Representation of 'Code Red' Theme in Postgraduate Theses in Türkiye: A Landscape Architecture Perspective

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Abstract

*The Earth is undergoing unprecedented changes, marked by a state of emergency encapsulated in the theme **'Code Red'**. This theme underscores the urgent need to address environmental crises that are severely damaging ecosystems—land, air, and water—while threatening the survival of all living beings and their habitats. Climate change and natural disasters exacerbate these issues by disrupting lives, altering land use patterns, encroaching on natural habitats, and accelerating biodiversity loss.*

This paper examines how these critical issues are represented in postgraduate education in landscape architecture in Türkiye. Specifically, it analyzes the extent to which the keywords associated with the 'Code Red' theme are addressed in postgraduate theses, with a focus on resilience, climate adaptation, and disaster management. The study also explores opportunities for interdisciplinary collaboration with other fields. Additionally, it investigates research trends over time, assessing whether studies on these themes have increased or decreased.

To achieve this, a comprehensive analysis of the YÖK Thesis Database, which includes postgraduate theses from across Türkiye, was conducted. A total of 164 theses were reviewed, focusing on 9 key terms related to the 'Code Red' theme. This analysis provides valuable insights into research trends within the Turkish academic landscape, highlighting strengths and identifying underexplored areas that require further attention. Addressing these gaps will enhance the contribution of landscape architecture to mitigating the environmental challenges of our time.

Keywords: Code red, postgraduate theses, Environmental crises, Türkiye

1. Introduction

The International Federation of Landscape Architects (IFLA) World Congress 2024 highlights the urgent need to address escalating global ecological crises through its theme, 'Code Red for Earth.' This overarching theme is structured around seven interrelated sub-themes: Codifying Code Red, Sustaining Life, Cultivating Resilience, Acting for All, Engaging with the Digital, Projecting the Process, and Building Bridges, Breaking Barriers. Each sub-theme offers a distinct perspective on addressing contemporary environmental and societal challenges while fostering collaboration and innovation. This study focuses specifically on the sub-theme 'Codifying Code Red: Eco-Emergency, Global Solidarity,' which emphasizes the urgent need to codify responses to global ecological emergencies.

The sub-theme 'Codifying Code Red' encompasses critical topics such as Natural Processes and Disasters, Ecological or Environmental Degradation, Climate Crises and Impacts, Urbanization and Sprawl, and Human Factors and Impacts. Together, these topics provide a comprehensive framework for understanding and addressing the interconnected impacts of climate change, natural disasters, and anthropogenic pressures on landscapes. The sub-theme aims to promote global solidarity and actionable strategies among landscape architects, urban planners, and policymakers, creating a foundation for sustainable and resilient urban and ecological futures.

This study aligns with the 'Codifying Code Red' initiative by focusing on its application within the field of landscape architecture in Türkiye. Positioned at the crossroads of Europe and Asia, Türkiye faces unique environmental challenges, ranging from the impacts of climate change to significant earthquake risks associated with active tectonic zones such as the North Anatolian Fault (Şengör et al., 2005). Poor construction quality and inadequate enforcement of building regulations further exacerbate these vulnerabilities (AFAD, 2021). Additionally, Türkiye is increasingly experiencing the effects of climate change, including rising temperatures, prolonged droughts, and extreme weather events, which threaten biodiversity, water resources, and urban resilience (World Bank, 2024).

As an example, Istanbul, which is also the host city of the congress, is identified as one of Europe's most climate-vulnerable coastal cities (Abadie et al., 2016). It faces heightened risks of flooding and heat stress due to its rapid urbanization and proximity to active fault lines. Efforts such as the Provincial Risk Reduction Plans, developed for provinces across Türkiye, represent considerable progress in systematically addressing these vulnerabilities (Republic of Türkiye Ministry of Internal Affairs Disaster and Emergency Management Presidency, 2024). These plans identify province-specific risks, from earthquakes, floods, landslides, and wildfires to industrial accidents, and propose targeted disaster risk reduction strategies. However, a key question remains: to what extent are landscape architects in higher education engaging with these critical themes?

This study investigates postgraduate research trends in landscape architecture in Türkiye to assess the extent to which these themes are being addressed in academia. By analyzing research priorities and gaps, the study contributes to the broader goals of the 'Codifying Code Red' initiative, aiming to bridge academic efforts with practical, on-the-ground solutions. Furthermore, the study explores the interdisciplinary potential of landscape architecture in addressing these urgent global ecological crises and evaluates the role of landscape architects in shaping resilient, sustainable urban and rural landscapes in Türkiye. It also seeks to identify opportunities for stronger collaboration between academic institutions, local governments, and other stakeholders to enhance the effectiveness of disaster risk reduction and climate adaptation strategies.

2. Material and Method

This study evaluates the extent to which postgraduate research in landscape architecture in Türkiye aligns with the *Code Red for Earth* themes of the IFLA World Congress. To ensure thematic consistency, the analysis utilized the following keywords: *Natural Processes/Natural Process, Disasters/Disaster/Crisis/Earthquake/Flood/Fire, Ecological Degradation/ Environmental Degradation/Degradation, Climate Crises/Climate Impacts, Climate, Urban Sprawl, Human Factors/Human Impacts/ Anthropogenic/ Anthropocene, Urbanization, and Resilience/ Resilient/ Resiliency*. These keywords were carefully selected to capture the multifaceted dimensions of the Code Red initiative and to reflect the scope of challenges addressed within the sub-theme 'Codifying Code Red: Eco-Emergency, Global Solidarity'. The inclusion of Earthquake, Flood, and Fire under the disaster category reflects their prominence in the postgraduate research examined, as these risks are frequently addressed within the context of disasters in Türkiye.

The data were collected from the Presidency of the Council of Higher Education of the Republic of Türkiye's National Thesis Center (YÖK, 2024), encompassing postgraduate theses published from 1993 to 2024. The year 1993 was selected as the starting point, based on the availability of the earliest relevant thesis in the database. To refine the dataset, additional filters were applied to include only theses explicitly categorized under the field of landscape architecture, ensuring a focused examination of academic contributions within the discipline. Some of the theses were tagged with more than one field, we also included those into our analyses.

A mixed-methods approach was adopted to analyze the data. Quantitative methods included statistical evaluations of keyword frequencies, temporal trends, and geographical distribution across academic institutions. Graphical representations were employed to illustrate these findings. Qualitative analysis involved an in-depth review of thesis abstracts and titles to identify recurring themes, research questions, and methodological approaches. This dual approach provided a comprehensive understanding of how landscape architecture research in Türkiye engages with Code Red for Earth priorities.

Theses were analyzed by searching for the selected keywords in their titles, abstracts, and keywords sections. Only theses directly relevant to the themes were included in the analysis. For theses containing multiple keywords, categorization was made based on the primary theme identified as the central focus of the study.

3. Findings and Discussion

This study analyzed postgraduate theses in landscape architecture in Türkiye to evaluate their alignment with the Code Red for Earth themes. Using nine carefully selected keywords, the research identified total 164 theses published between 1993 and 2024, reflecting the academic engagement with ecological and societal challenges. The distribution of these theses over time highlights a growing awareness of the themes prioritized under Codifying Code Red: Eco-Emergency, Global Solidarity.

3.1. Temporal trends in research

The temporal analysis revealed that while research activity in landscape architecture related to Code Red for Earth themes began in 1993, significant academic engagement only emerged after 2018 (Figure 1). The majority of the 164 theses were concentrated between the years 2018 and 2024, collectively accounting for over half of the total publications. These peaks in activity align with global and national shifts in recognizing climate crises, urban resilience, and disaster risk reduction as critical areas for academic inquiry. Notably, 2024 alone contributed 30 theses, underscoring an intensified focus on addressing ecological and societal challenges within the discipline.

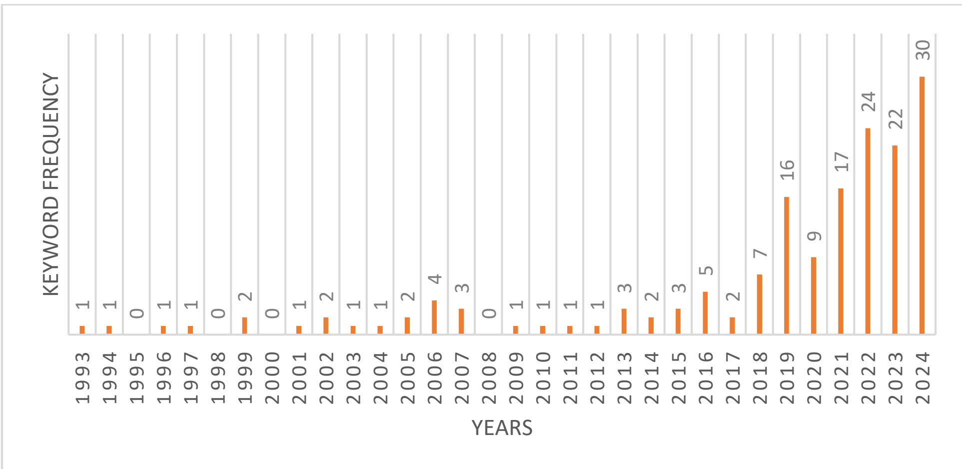

Figure 1. Keyword frequency across all categories in theses between the years 1993-2024.

In contrast, the earlier years, particularly the 90s and 2000s, saw limited contributions, indicating that the themes encapsulated under *Codifying Code Red* gained prominence in Turkish academic discourse only in recent years. This trend suggests an evolving recognition of the role of landscape architecture in tackling complex environmental and urban challenges.

3.2. Institutional and regional contributions

Leading institutions such as Ankara University, İstanbul Teknik University, and Ege University have played pivotal roles in advancing research related to Code Red themes. Universities like Çukurova University, Karadeniz Teknik University, and Akdeniz University have also contributed significantly, reflecting their engagement with these critical topics. Additionally, institutions such as Düzce University, Bursa Teknik University, and İstanbul University-Cerrahpaşa have participated with moderate frequency, while universities like Yeditepe University, Van Yüzüncü Yıl University, and Çanakkale Onsekiz Mart University have made occasional contributions. This distribution underscores the collaborative efforts of a wide range of universities in addressing ecological crises and urban resilience within the context of Code Red themes.

From the reviewed theses, it is evident that regional case studies constitute a dominant methodological approach within the analyzed research. Cities such as Ankara, İstanbul, Düzce, and İzmir frequently emerge as focal points, reflecting their prominence in addressing key challenges like disaster resilience, urban transformation, and environmental management. The central role of Ankara and Istanbul as academic and urban hubs highlights their importance, while the vulnerability of İstanbul and Düzce to earthquakes underscores the urgency of disaster preparedness and resilience in these regions.

Additionally, cities such as Adana, Bursa, Van, and Kastamonu appear in the theses, albeit with slightly less frequency, underscoring their importance as case studies in addressing specific regional issues. For instance, Adana and Van often serve as examples for climate resilience and disaster preparedness, given their vulnerability to flooding and earthquakes, respectively. Meanwhile, the inclusion of smaller urban centers like Kastamonu signifies an attempt to diversify the research focus, incorporating local perspectives on ecological and urban challenges.

This geographic distribution of research emphasizes the localized nature of many environmental and urban issues in Türkiye. The findings highlight a growing recognition of the need for context-sensitive solutions, particularly in regions prone to natural disasters or experiencing rapid urbanization. However, the absence or limited representation of some regions in the analyzed theses points to a potential gap in addressing the diverse challenges across Türkiye's varied ecological and urban landscapes. Expanding research to underrepresented regions would ensure a more comprehensive academic response to the country's pressing environmental challenges.

3.3. Thematic distribution

Among the nine keywords analyzed, **Disasters**, **Climate**, and **Urbanization** emerged as the dominant themes (Table 1). Of the 164 theses reviewed, **Disasters** were the most extensively researched area, addressed in 67 theses (20.9% PhD, 79.1% Master's). These studies predominantly focused on earthquakes, floods, and fires, exploring their impacts on urban planning, landscape resilience, and risk mitigation strategies. **Climate**, encompassing topics like climate-sensitive urban planning and green infrastructure, was the second most frequent theme, featured in 43 theses (23.26% PhD, 76.74% Master's). However, despite its critical importance, **Urbanization**, with 14 theses (7.1% PhD, 92.9% Master's), was comparatively underexplored. Research on this theme focused on urban identity, rural-urban transitions, and the effects of urbanization on landscapes. Similarly, **Resilience**, a vital aspect of ecological and societal adaptation, was investigated in only 14 theses (28.6% PhD, 71.4% Master's), highlighting a significant gap in academic focus. This underscores the need for further research to address resilience comprehensively, ensuring effective strategies for future challenges.

In contrast, keywords like **Human Factors**, **Urban Sprawl**, and **Ecological Degradation** are underrepresented, highlighting areas that warrant further investigation. Interestingly, while **Climate Crises/Impacts** did not feature in any theses, the broader keyword **Climate** was addressed in 43 studies, reflecting an emphasis on climate-sensitive planning and adaptation strategies. The variations in keyword prevalence underline a need to balance research efforts across emerging and critical issues in landscape architecture.

Among the additional fields, Urban and Regional Planning emerges as the most frequently recurring, particularly in studies on urbanization, resilience, and climate. Other fields such as Architecture, Agriculture, Forestry and Forest Engineering, and Geodesy and Photogrammetry also contribute, particularly in studies related to disasters and climate. This interdisciplinary scene can be attributed to the inherently multidimensional profession of landscape architecture. Additionally, the presence of landscape architecture programs within faculties of architecture, art, agriculture, and forestry further reinforces this multidisciplinarity, encouraging diverse thematic explorations.

The analysis highlights a regional concentration of research in disaster-prone areas such as Istanbul, Düzce, and Elazığ, where localized strategies for disaster management are prioritized. Institutions like İstanbul Technical University, Ankara University, and Düzce University are prominent contributors, addressing key topics such as emergency assembly areas, urban resilience, and the adaptive use of open and green spaces in disaster contexts.

This thematic focus underscores the essential role of landscape architecture in disaster mitigation, with a particular emphasis on enhancing urban and ecological resilience. However, broader regional representation and strengthened interdisciplinary collaborations could further expand the scope and impact of future research, addressing Türkiye's diverse and urgent disaster challenges more comprehensively.

Theses addressing **Natural Processes** have been a part of Turkish landscape architecture research for nearly three decades, with the earliest study dating back to 1996. Over the years, research in this field has evolved from foundational assessments to incorporating advanced methods like remote sensing and GIS. Studies frequently focus on *ecological risk assessment, green infrastructure,* and *integrating natural processes into urban design*, highlighting the discipline's commitment to bridging ecology and urbanism. The distribution of these studies reveals steady engagement, with a noticeable increase in recent years as climate adaptation and disaster resilience gained prominence. Universities such as Ankara University, Ege University, and Istanbul Technical University have been key contributors to this theme, reflecting their strong academic presence in ecological and environmental research. The trend demonstrates a growing recognition of natural processes as a critical area for addressing urban and ecological challenges in Türkiye.

Table 1. Distribution of Postgraduate Theses in Türkiye Based on *Code Red* Themes

Keywords	Total Thesis Count	PhD (Count/%)	Master's (Count/%)	Fields	Universities
Natural Processes /Natural Process	13	8 (62%)	5 (38%)	Landscape Architecture, Urban and Regional Planning	Ankara U, Ege U, Akdeniz U, Anadolu U, Istanbul Technical U, Karadeniz Technical U, Çukurova U, Işık University
Disasters/ Disaster/ Crisis/	67	14 (20.9%)	53 (79.1%)	Landscape Architecture, Urban and Regional	ITU, Düzce University, Namık Kemal University, Abant İzzet Baysal University, Karadeniz

Earthquake/ Flood/ Fire				Planning, Architecture, Geodesy and Photogrammetry, Agriculture	Technical University, Akdeniz University, Ankara University, Inonu University, Kastamonu University
Ecological Degradation/ Environmental Degradation/ Degradation	4	2 (50%)	2 (50%)	Landscape Architecture	Ege University, Kahramanmaraş Sütçü İmam University, Istanbul University-Cerrahpaşa, Ankara University
Climate Crises /Climate Impacts	0	0	0	None	None
Climate	43	10 (23.26%)	33 (76.74%)	Landscape A., Urban and Regional Planning, Environmental Eng., Forestry and Forest Engineering, Geodesy and Photogrammetry, Agriculture, Architecture	Akdeniz U, Ankara U, Aydın Adnan Menderes U, Bartın U, Bursa Technical U, Çanakkale Onsekiz Mart U, Düzce U, Ege U, İnönü U, ITU, IU-C, İzmir Democracy U, KTU, Kastamonu U, Selçuk U, Süleyman Demirel U, Tekirdağ Namık Kemal U, Van Yüzüncü Yıl U, Yeditepe U
Urban Sprawl	6	3 (50%)	3 (50%)	Landscape Architecture, Urban and Regional Planning	Dokuz Eylül U, Bartın U, Tekirdağ Namık Kemal U, Ankara U, Akdeniz U
Human Factors/ Human Impacts/ Anthropogenic/ Anthropocene	3	2 (66.7%)	1 (33.3%)	Landscape Architecture	Ege University, İstanbul Teknichal University
Urbanization/ Urbanisation	14	1 (7.1%)	13 (92.9%)	Landscape Architecture, Urban and Regional Planning, Agriculture, Architecture	İstanbul Teknik U, Ege U, Çukurova U, Zonguldak Karaelmas U, İstanbul U-Cerrahpaşa, Bartın U, Çanakkale Onsekiz Mart U
Resilience/ Resilient/ Resiliency	14	4 (28.6%)	10 (71.4%)	Landscape Architecture, Urban and Regional Planning, Architecture, Public Administration	İstanbul Teknik U, Ankara U, Düzce U, Yeditepe U, Bursa Teknik U, Atatürk U, Çanakkale Onsekiz Mart U, İstanbul U-Cerrahpaşa, Mersin U

The **Disaster**-focused postgraduate theses provide a substantial and evolving body of research within landscape architecture in Türkiye. This thematic category has been a consistent focus since the early 2000s, mirroring the country's high disaster risk and the growing academic attention to mitigation and resilience strategies. Earthquake, flood, and fire risks emerge as dominant topics, with studies emphasizing innovative approaches such as nature-based solutions, green-blue infrastructure, and spatial analyses for risk assessment and recovery planning.

The thesis addressing **Ecological and Environmental Degradation** in landscape architecture remain relatively limited, spanning only a few studies from 2009 to 2024. These works primarily explore the impacts of land-use changes and urban transformation on ecosystems and habitat connectivity. Key themes include remote sensing techniques for ecosystem degradation analysis, landscape restoration in urban renewal areas, and the effects of land-use changes on urban water resources. Institutions like Ege University and Ankara University have contributed significantly, highlighting localized challenges such as the Gediz Delta and North-West Anatolia. This limited yet focused body of work underscores the importance of expanding research on degradation, particularly in the context of urbanization and climate change.

The **Climate**-focused postgraduate theses reveal a substantial body of research in landscape architecture in Türkiye, spanning from 1994 to 2024. These studies reflect the increasing importance of climate considerations in both theoretical and practical applications. Key themes include climate-sensitive urban planning, the relationship between climate change and vegetation, and the microclimatic effects of urban green spaces. The theses also address innovative approaches, such as bioclimatic comfort modeling, green and blue infrastructure, and climate adaptation strategies for urban and rural settings. Ege University, Süleyman Demirel University, and Atatürk University have emerged as leading contributors, producing studies that explore diverse aspects of climate impacts and adaptation. These theses emphasize localized approaches, with a notable focus on regions such as Erzurum, İzmir, and Samsun. While the academic contributions in this category are extensive, there remains potential for further interdisciplinary collaboration and integration of advanced modeling techniques to address climate-related challenges in urban and ecological landscapes.

The exploration of **Urban Sprawl** in landscape architecture postgraduate theses has been a significant theme in Türkiye since the early 1990s. Research in this area predominantly focuses on the impact of urban growth on surrounding rural landscapes, land-use changes, and the effects of urban expansion on agricultural areas. Recent studies also examine the dynamic models of urban growth and propose conceptual landscape planning models for rural areas affected by urban sprawl. Key topics in these theses include the legal, managerial, and spatial aspects of urbanization, especially in the context of peripheral regions such as İzmir, Antalya, and Denizli. Notable contributors include universities like Dokuz Eylül University, Bartın University, and Akdeniz University, which have focused on urban-rural interactions and the challenges posed by urban sprawl in rapidly expanding cities like Ankara and Istanbul. This body of research emphasizes the need for sustainable planning strategies to manage the growth of urban areas while maintaining ecological balance and protecting rural landscapes.

Urbanization focused postgraduate theses in Türkiye explore the evolving relationship between urban development and landscape architecture, with a focus on the impact of rapid urbanization on rural landscapes, green spaces, and urban identity. The research spans from the late 1990s to the present, highlighting a growing academic interest in sustainable urban planning strategies, the integration of ecological principles, and the management of urban growth pressures. Notably, studies often emphasize the need for comprehensive planning to address the challenges posed by urban sprawl, including preserving agricultural areas, enhancing urban resilience, and integrating green infrastructure.

These studies are predominantly conducted in rapidly urbanizing cities such as Istanbul, Ankara, and Adana, with universities like Çukurova University, Bartın University, and Ege University leading the research. The research has broadened over the years, shifting from a focus on the impacts of urbanization on agriculture to more contemporary concerns such as the relationship between urban identity and green spaces, the pressures of rapid city growth on rural landscapes, and strategies for sustainable urban development.

The theme of **Human Impacts** on landscape architecture has been explored in a few studies focusing on anthropogenic influences on land use and the environment. These studies often utilize methods like Geographic Information Systems (GIS) and remote sensing to analyze the effects of human activity on landscapes. Research topics include land use changes, environmental impacts, and the integration of landscape memory and design codes into landscape architecture practices. Universities like Ege University and İstanbul Technical University have significantly contributed to this area of research, with work spanning from the mid-2000s to 2019.

The research related to **Resilience** in landscape architecture in Türkiye has grown significantly since the early 2010s. The focus of this body of work centers on strategies for enhancing urban and ecological resilience, especially in response to climate change and natural disasters. Studies from 2012 onward emphasize the role of resilient cities and urban adaptation strategies, with specific focus areas such as ecosystem services, urban transformation, and the regeneration of urban spaces.

A notable concentration of studies includes topics like climate resilience, disaster risk reduction, and urban planning, with universities such as İstanbul Technical University, Ankara University, İstanbul University-Cerrahpaşa, and Bursa Technical University leading contributions. Research explores areas like urban recreation spaces, flood risk management, and the potential use of green infrastructure in climate adaptation. Additionally, resilience strategies have been applied to various contexts, from urban transformation in Van and Erciş to climate adaptation models in Edirne and Mudanya. This theme highlights landscape architecture's role in disaster preparedness and resilience-building, with a growing emphasis on interdisciplinary approaches and practical, real-world applications.

3.4. Gaps and opportunities

While the analysis highlights the increasing academic focus on disaster-related topics, climate and resilience in landscape architecture, significant gaps remain in key areas such as human factors, urban sprawl, and ecological degradation. These themes, which have profound implications for urban and ecological systems, are still underexplored despite their interconnectedness with climate adaptation and resilience strategies. Research on how urban sprawl impacts resilience and the environment, along with a deeper investigation of human activities contributing to ecological degradation, is essential. Expanding the research agenda to better integrate these themes will provide more comprehensive insights into how landscapes and urban environments can adapt and thrive in the face of ecological challenges.

Moreover, the findings emphasize the need for further interdisciplinary collaboration in landscape architecture research, especially to address the complexities of human and environmental systems. The integration of social, technological, and ecological perspectives will foster more innovative solutions for climate change adaptation, resilience building, and urban planning. Encouraging collaborations between universities, governmental bodies, and local communities, especially in disaster-prone regions, will be critical in developing context-specific strategies.

The current research landscape in Türkiye shows notable strides in aligning with global environmental priorities, but further efforts are required to build a more inclusive and holistic approach to sustainability and disaster resilience. Strengthening ties between academia and other sectors, diversifying thematic focuses, and engaging more academic institutions particularly those located in regions most impacted by ecological crises will help bridge the existing gaps and pave the way for more effective, multifaceted solutions.

4. Conclusion

This study provides a comprehensive analysis of postgraduate theses in landscape architecture in Türkiye, examining their alignment with the critical themes of ecological resilience, climate adaptation, and disaster risk management. The findings indicate a growing academic interest in addressing ecological crises, particularly in climate-related topics and resilience strategies. However, notable gaps remain in areas such as human factors, urban sprawl, and the integration of ecological degradation into urban planning. These gaps highlight the urgent need for a broader, more inclusive research framework that incorporates these themes to fully address the interconnected challenges of ecological and societal crises.

Despite the increasing risks Türkiye faces from natural disasters such as earthquakes, floods, and droughts, the number of theses produced over recent decades remains limited. This underrepresentation underscores the critical need for intensified academic focus on Türkiye's pressing ecological and urban challenges. Landscape architects possess a unique ability to integrate resilience and sustainability into both urban and ecological design, making it essential that research expands to reflect these critical needs. While some studies highlight innovative approaches, including nature-based solutions and green infrastructure, the limited focus on resilience, particularly in the context of human impacts and urban sprawl, calls for more comprehensive and diverse research.

The study also highlights the multidisciplinary nature of landscape architecture, with contributions from fields such as urban planning, geography, and forestry. However, disparities in regional research contributions and institutional involvement persist. Expanding research efforts in underrepresented regions and fostering collaborations across universities will be crucial to ensuring that research reflects the diverse ecological and urban challenges faced across Türkiye. Additionally, engaging a broader range of stakeholders, including policymakers, local governments, and private sector actors, will enhance the applicability and impact of academic findings, particularly in addressing the needs of vulnerable regions.

Looking forward, Türkiye's academic community has a significant opportunity to position itself as a global contributor to addressing the "Code Red" priorities. Increasing the number of studies on critical resilience and climate adaptation themes, as well as enhancing interdisciplinary collaborations, will be vital to building a more robust research framework. This will require a concerted effort to include a diverse array of academic institutions, particularly those in regions most vulnerable to ecological and urban crises.

In conclusion, while initiatives by institutions such as the Ministry of Internal Affairs Disaster and Emergency Management Presidency are commendable, the current volume and scope of research in landscape architecture remain insufficient. By addressing underexplored themes, fostering collaborations across disciplines, and elevating the role of landscape architects in addressing ecological crises, Türkiye can make a substantial contribution to global ecological resilience and solidarity. Expanding both the quantity and quality of research in landscape architecture will ensure that the discipline plays a central role in tackling the pressing challenges of our time.

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Thinking About Landscape Architecture-Planet Relationship in Today's Multiple Crisis-Uncertainty Environment

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"We must think of the whole of mankind as being a single body and of each nation as constituting a part of that body. ... We must not say, 'If there is sickness in a certain place in the world, what does that matter to me?' ... If there is such sickness, we must be just as much concerned with it as though it happened right in our midst."

Kemal Atatürk was quoted as saying by Lord Kinross (1964)

Abstract

The 'Code Red', which constitutes the theme of the IFLA World Congress 2024, accounts for today's era of complex/multiple crisis-uncertainty resulting from pressing environmental and societal challenges at the global-local scale sequence. Emerging socio-ecological disasters, including climate change effects, Covid-19, particularly form the visible face of ecological, political, and socio-economic crises across the globe.

Instead of approaching the code red matter through some codes/tools of our current civilization, this paper quests for a paradigm shift grounded by two particular assumptions below:

- In the face of the 1929 world economic crisis, the struggle of the young Turkish Republic led by Kemal Atatürk and the United States of America (USA) should be a model for challenging the code red conditions of today.

- As the common ground of landscape, envisioning the present/future of the planet and life itself lies in the purview of landscape architecture and allied professions.

The (re)structuring of landscape architecture and its due relation with the code red conditions of the planet along with the 1930's experiences of the Turkish Republic and the USA are hereby interlinked, as the basement of the paradigm shift, in order to grapple with the circumstances of multiple crisis-uncertainty.

Keywords: Multiple crisis-uncertainty era, Anatolia and the Turkish Republic, Kemal Atatürk, Green New Deal, restructuring landscape architecture, landscape-based approach, landscape architecture-planet relationship

1. Introduction

The 'Code Red', which constitutes the theme of the IFLA World Congress 2024, highlights the era of complex/multiple crisis-uncertainty resulting from a multitude of environmental problems across the globe. Industrial revolution-led capitalism and its existing economic and political systems within the Anthropocene Epoch deepen the ongoing crises in politics, economy, science, pedagogy, and professional practices and, disseminate the chaos at the planetary, regional, national, and local scales.

The fact that the existing political, economic, and social mechanisms in daily life alongside our mindset, education, and scientific environments are far from comprehending the code red situations and, cannot foster new and comprehensive approaches -other than introducing a fragmentary/reductionist perspective- results in the inability to produce or is in lack of solutions in the face of crises and uncertainties. For instance, some efforts at the global and national levels to combat the climate crisis have long been proven ineffective.

In his ground-breaking book 'Collapse', Jared Diamond (2011) examined the collapse or survival success of various civilizations due to environmental crises, exponentially leading to socio-ecological and economic-political chaos worldwide. The existence of the collapse story at a planetary scale today presents a new situation for the future of life and humanity. Especially, ecological, political, and socio-economic crises resulting from climate change and Covid-19 form the visible face of global importance.

Unless delivering a well-thought-out action framework apart from the course of existing civilization, we cannot afford to cope with the 'code red' conditions only through a series of (inter)national pursuits in politics, science, education, etc. King and Jones (p. 26, 2021) pointed out that "actions that may provide the means to address the interlinked factors of climate change, carrying capacity, indigenous energy, and manufacturing capacity and the over-reliance on complexity might provide the greatest resilience against future 'de-complexification'."

Within the context of the paradigm shift, the paper;

-seeks to delve into the effects of existing civilization and its systems underpinned by global capitalism as the primary source of the 'Code Red'.

-aims to interweave the experiences of these two nations along with the bedrock of landscape architecture and its inherent engagement with the planet in order to grapple with the circumstances of multiple crises-uncertainties as well as to think over landscape-oriented civilization.

2. Planetary Collapse in the Multiple Crisis-Uncertainty Era?

The period of multiple crisis-uncertainty stemmed from the unprecedented ecological, socio-cultural, economic, and political problems (Yüzak, 2023) has laid down our planet on the code red. Diamond (2011) argued that the cumulative effects of these problems would further be experienced in the form of 'planetary collapse" and its subsequent impacts (Figure 1).

Marcia Bjornerud (2018) indicated the very nature of the collapse in time misconception "… few of us have any conception of the enormous timescales in our planet's long history, and this narrow perspective underlies many of the environmental problems we are creating for ourselves. The lifespan of Earth can seem unfathomable compared to the brevity of human existence, but this view of time denies our deep roots in Earth's history-and the magnitude of our effects on the planet" ("Princeton University Press", 2018, para. 1).

Global capitalist civilization and imperialism alike have brought about a period of multiple crisis-uncertainty with their socio-ecological and economic-political impacts on the world. Robinson (2014, pp. 1-2) explained the reach of a global crisis that is unprecedented in terms of its magnitude, the extent of ecological degradation and social deterioration, and the scale of the means of violence. So the global capitalism perspective offers a powerful explanatory framework for making sense of the crisis.

In the aftermath of the code red, chaos and collapse on a global scale, a new world war over water, energy, and food, and eventually, the 6th extinction become foreseeable. Elizabeth Kolbert (2014) thus evidenced this process in detail over living species in her work "The Sixth Extinction: An Unnatural History". Acknowledging this process, the main question raised by this paper is whether a new landscape-oriented paradigm would be able to determine the future of humanity and the world.

Figure 1. Flow chart of ‘Code Red’ and beyond

Instead of approaching the current situation with the codes/tools of our civilization, the anticipated paradigm shift is to be supported through two facts below;

-In the face of the 1929 world economic crisis, the approaches of the Young Turkish Republic led by Kemal Atatürk and the United States of America (USA) are the two obvious case studies addressing the code red challenges of the 1930’s and today at the planetary scale.

-It is the responsibility of landscape architecture and allied professions to envision the present and future of the planet and life on it. The planet itself becomes the common ground of landscape (architecture) in this context.

3. The Turkish Republic and the USA against the 1930’s World Economic Crisis

The period of multiple crisis-uncertainty brought by capitalist civilization and imperialism includes the effects of the financial crisis and climate change from 2008 on. To confront today’s conditions, Jared Diamond's "comparative analysis in history" method was used, and thus, the Turkish Republic and the USA were zoomed in on the 1930’s world economic crisis. It is envisaged that the crisis experienced in the past, along with how these two countries have addressed it, serves as a guide and provides lessons for this period. With regard to the code red, a comprehensive road map will be introduced as a basis for the conceptual framework and approach of this paper.

The Green New Deal program of the USA develops an approach for today and the contribution of landscape architecture is considerably increasing. The experience of the liberation and establishment of the Turkish Republic and its principles-policies under the leadership of Kemal Atatürk throughout 1920’s and 1930’s has built up the country in landscape (infrastructure) mindset, now stands as a road map against the code red conditions of today (Figure 2 and 3).

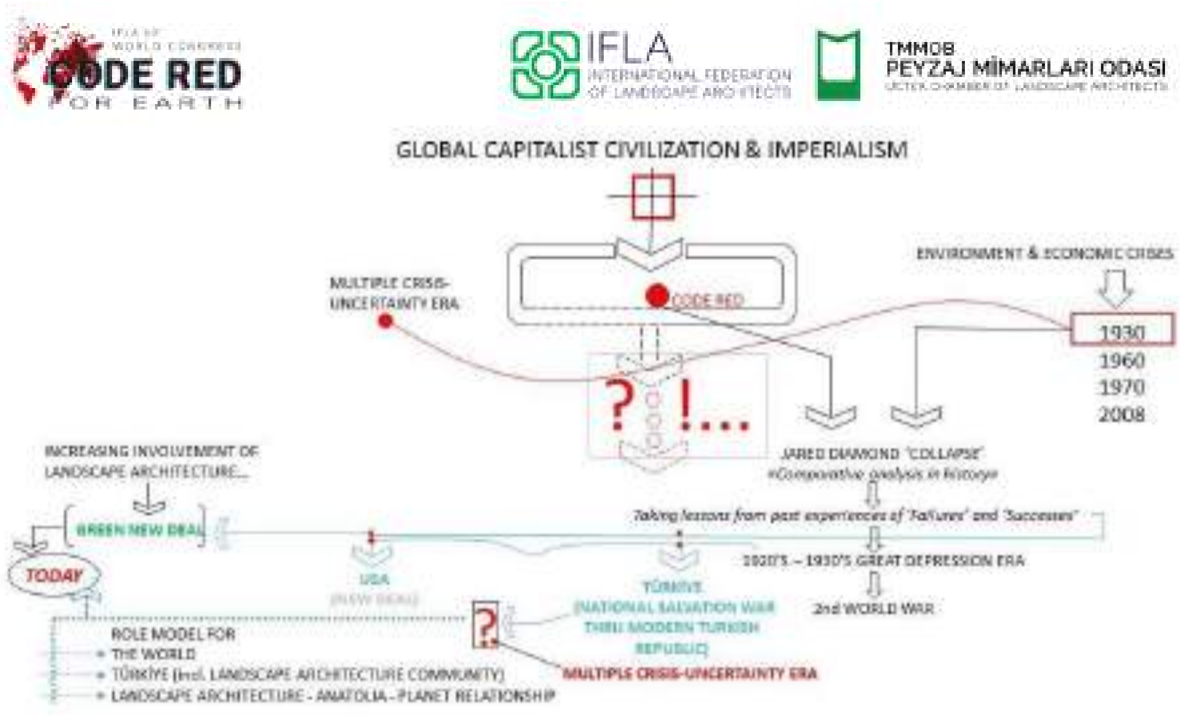

Figure 2. The road map of the Turkish Republic and the USA in both the 1930's and today's multiple crisis-uncertainty periods

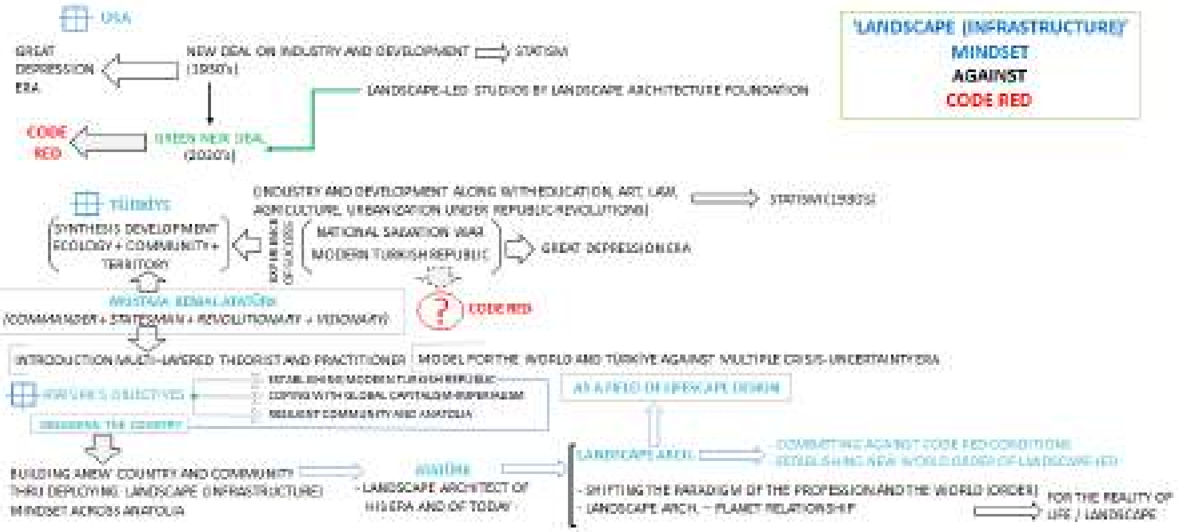

Figure 3. The road map of the Turkish Republic and the USA in both the 1930's and today's multiple crisis-uncertainty periods (extended)

From the 1929 world crisis on, it has been witnessed a thorough contraction and reliance on internal resources for self-sufficiency in the eco-political landscapes of our country and the USA to alleviate the pressing effects of the period. The USA attempted to overcome the era of multiple crisis-uncertainty by implementing the 'New Deal' program under statism policy, just like the way the Turkish Republic did, focusing on public policies/investments, and investing in large projects/infrastructures.

3.1. Green new deal superstudio-summit and landscape declaration (USA)

Today, in the USA, the concept of the 'Green New Deal ', guided by the struggle against the crises of 1930's, would lead the way in addressing crises at the national and global levels and developing new life scenarios, offering an important way out under the 'code red' conditions of today. The 'design world' does thus develop its limited scope according to the conditions of the current period. And landscape architecture-based "The Green New Deal Superstudio" and, "Design-Policy-Advocacy Summit" (2020-2022) under the leadership of the Landscape Architecture Foundation (LAF) have been realized (https://www.lafoundation.org/take-action/green-new-deal/superstudio).

The Superstudio was tailored to address the ongoing challenges such as climate crisis, fossil energy exploitation, conventional mass production, new urbanization and city-region relations, etc. through the "academy-practice-policy-implementation" joint-venture within 10 countries led by the USA. Thus students and practitioners delivered useful and innovative project proposals. Under the leadership of landscape architecture, the studio has gone beyond its defined boundaries and developed new life concepts/forms while tackling the issues of the code red in a wide range encompassing the planet-local. In this context, landscape architecture appreciated (re)defining itself in both disciplinary and inter/trans-disciplinary spheres.

Pevzner (2019, paras. 2, 3, 24) contended that "…the Green New Deal will represent a transformation of both the American economy and landscape… Although the Green New Deal agenda so far has been articulated through economic and social justice lenses, landscape architecture is well positioned to lead the remediation and land management conversation… Like the original New Deal, it is a call to redefine politics and establish a new social contract for America, in line with the economic and ecological realities of the 21st century."

The origin of the 'Superstudio' concept and its implementation originated at the University of Pennsylvania and, the New Landscape Declaration: A Call to Action for the Twenty-First Century (2016) was scheduled under the leadership of the same university and organized by LAF. The Declaration stated that landscape architects "give artistic physical form and integrated function to the ideals of equity, sustainability, resiliency, and democracy… As designers versed in both environmental and cultural systems, landscape architects are uniquely positioned to bring related professions together into new alliances to address complex social and ecological problems (Landscape Architecture Foundation (Eds.), 2017, pp. 33-34).

3.2. Anatolia and Young Turkish Republic – Kemal Atatürk

The Young Republic of Turkey, which went through the process of liberation and establishment in the 1920's and 1930's, transitioned to the statism policy through deep-seated public policies and hereby endeavored to spread out the development across the country through the well-defined web of industrial, agricultural, urbanization, transportation, infrastructure-logistics investments (Figure 4 and 5) in order to better cope with crises at both the global and national scales.

While the USA's New Deal Program focused on industry and development, the Turkish Republic created an integrated and cohesive network of education, art, law, urbanization, and rural development along with industry. According to Berkes (1978), this evolving network was labeled as the bedrock of Republican Revolutions. Turkey and the USA consistently applied their own introvert policies through the 'investment ecosystem' that stimulated the domestic market and encouraged job opportunities/investments for turning the wheels of the economy. Toprak (2020) also underlined that switching to a different phase in the 1930's, the "new man" of the Republic would be built with a series of cultural revolutions.

Figure 4. The Turkish Republic recorded the considerable achievements in industry and urbanization … (“Bir Millet Uyanıyor Sergisi”, 2024).

…

Figure 5. … Railway and infrastructure, education, rural development …

(“Bir Millet Uyanıyor Sergisi”, 2024).

The vision and initiatives led by Kemal Atatürk (Figure 6) are associated with landscape policies that distribute and share resources fairly and equitably across the country, resonating with the indicators of civilization, production, and public space construction in rural development and urbanization, reflecting the multi-layered, upper and lower scale consistency of landscape architecture. Thus, designing the country was done by taking into account the complex and unifying nature of diverse Anatolian geography, which, as the crossroad of many civilizations, has hosted many incoming/outgoing communities from/through east, west, north, and south axes. The story of unifying the natural and cultural dynamics of Anatolia under the identity of the Turkish Republic leads us to the synthesis or intersection of the different dynamics of landscape and landscape architecture. Therefore, the establishment of the Republic of Turkey is a laboratory for shaping both the current period and the future of the profession of landscape architecture. Hence Atatürk's multidimensional thought system and practices provide a rigorous road map today in terms of how to (re)conceptualize current landscape policies and landscape architecture itself.

Figure 6. Kemal Atatürk, The Founder of Modern Turkish Republic (Benazus, 2013)

(Re)structuring landscape architecture as the republic-democracy project requires understanding the founding philosophy of the Turkish Republic by Atatürk's principles and revolutions over Anatolian geography. Accordingly, understanding the landscape requires understanding natural and cultural dynamics as the ingredients of Anatolia and its genetic codes, collective memory in society, values, and ideals. The Turkish Republic has been conceptualized as the synthesis/fusion of all these diverse and complex relationships.

4. The Mechanism of Paradigm Shift …

The experiences of the Turkish Republic and the USA, exemplifying a suite of "landscape-oriented civilization - the planet" would be able to restructure landscape concept and landscape architecture in theory and practice through the paradigm shift against the period of multiple crisis-uncertainty (Figure 7). Otherwise, the code red situation during this period will take the planet and our life to the irreversible stage (i.e. 6th extinction).

To reposition landscape architecture within the context of Figure 7, Kelly Shannon claimed that landscape architecture must become the essential game changer in not only reshaping the earth's ecological systems in practice but also in transforming the fundamental habitation of the planet through broader systemic thinking whereas Kongjian Yu came up with the redefinition of it as the art of survival: to heal the earth and sustain humanity (Landscape Architecture Foundation (Eds.), 2017, pp. 79-80, 84).

The experiences of the Turkish Republic and the USA present promising avenues for the world and countries in the face of multiple crises and uncertainties. The professional discipline of landscape architecture, aiming for "resilient landscapes and societies" based on the reality of 'landscape', should focus on designing the future of the planet as a "life system/lifescape designer".

To sum up, providing the linkage of "Atatürk and his Turkish Republic – Green New Deal - landscape architecture and the planet" against the Code Red conditions, depicted as the paradigm shift mechanism (Figure 1, 2, 3, and 7) should be a model in order to establish a landscape-oriented civilization across the globe.

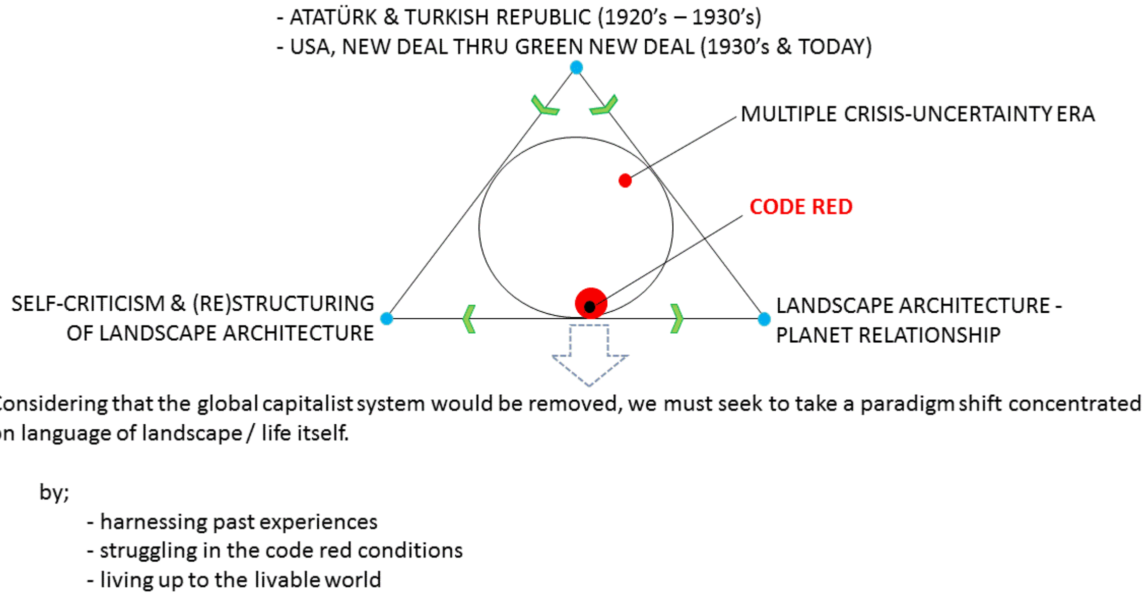

Figure 7. The paradigm shift in progress

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SUSTAINING LIFE

Economic Value Assessment of Recreation as Part of Ecosystem Services in Forest Park, Saint Louis, USA

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Abstract

Recreational services belong to cultural services, indicates recreational functions provided by recreational environments ecosystem context, including nonmaterial recreation and tourist activities that people implement on a specific site. As the ecosystem service has been emphasized in all types of ecosystems including urban parks, this paper focus on researching ecosystem values Forest Park in Saint Louis.

Keywords: Ecosystem service, urban park, Saint Louis

1. Introduction

Forest Park, 1.5 times the size of Central Park in New York City is shouldering significant opportunities for Saint Louis residents to explore. The park serves as a playscape for visitors as well as nonhuman creatures and delivers unlimited experiential educational opportunities for generations. Consisting of 1300 acres, Forest Park as a tremendous ecosystem contains native old-growth forest habitat, forests and woodlands, tall grass prairies, savannas, wetlands and two miles of reconstructed river system. Until today, it still provides great ecological services such as rainwater retention and filtration, carbon sequestration and plant pollination for all human and non-human creatures.

Ecosystem service value refers to the benefits accruing to humans from nature. Ecosystem not only provides sources for life and production, but also maintains life supporting systems that human rely on for existence. According to Millennium Ecosystem Assessment, ecosystem services include four major categories: provisioning, regulation and maintenance, cultural services and life supporting services. Recreational services belong to cultural services, indicates recreational functions provided by recreational environments ecosystem context, including nonmaterial recreation and tourist activities that people implement on a specific site.

Based on identification of recreational activities taking place in Forest Park including sports such as walking, running, driving, cycling, boating and yoga, temporary outdoor visiting such as camping, picnic, photography, and sightseeing, we can find out where free access for the public is. In addition to these, special provisions of facilities can also be provided, including golf carts, ice rink, tennis court and baseball fields etc. where activity sites are managed with labor and economic transactions to create recreational opportunities and visible economic contributions. Majority of ecosystems can create recreational service opportunities, for example, aside from general walking and sightseeing space, grasslands can provide space for open space sport activities while forests can be a great place for hiking.

Under the background of urbanization process and raising awareness of health benefits, Forest Park is being debated as a core site for outdoor recreation. In order to pursue a basic understanding of potential economic value, preservation and management importance, this study provides consideration on ecosystems recreational use monetary values which can possibly be referred for future value orientation towards environmental preservation and management policies.

2. Material and Method

Previous attempts of calculating recreational values can be found in the literature. Environmental protection has been a hot topic in interdisciplinary fields. However, in correlation with environmental protection actions, ecosystem service value was seldomly acknowledged, only development focused mindset defining our success or failure of ideas. Transferring invisible service values is helpful to explore the sustainable development of resources and economy to raise human's awareness of environmental protection.

From the perspective of ecology, it reveals core value of ecosystem service of natural landscape which can be comprehensively understood in the process of urbanization in the future. From the perspective of economy, it reveals the development intensity and disturbance intensity that the protection and development of ecosystems can bear under various conditions that the overall ecosystem services can be improved, which provides a method for reference for the investment budget of development in the process of urbanization. From the perspective of sociology, this can help evaluate impact of different development modes and living environment of stakeholders.

Under the background of rapid urbanization in the past decades, urbanization and commercialization made our landscapes "tourist attractions" which helps generate money rather than local culture and heritages. showing a big trend of emphasizing recreational services. Therefore, if we put a "price" on our natural assets, recognizing recreational values of Forest Park ecosystem services is one of effective educational ways to promote ecosystem conservation awareness and residential quality.

Major resource is Sam Fox Kranzburg Library Primo research with google scholar, methodologies used in my resources are (1) quantitative research: Authors agreed on using direct or replace market price approach, contingency valuation method, production cost method etc. to measure recreation service value. Travel cost method and consumer surplus method (value to a consumer of consumption of a good, minus the price paid) were most used. (2) Remote sensing satellite image and GIS as basic demographic data collection method (3) Sociological research methods including observational, interviewing, questionnaire methods. However, most of literature were based on regional or country scale by adopting various methods to calculate and map recreation services, levels of multiply and processing may increase the inaccuracy of value numbers. On a single case study base, we can come up with more accurate numbers separately and provide more experiences on doing and adding that on a country together for future investigations.

In Saint Louis Forest Park case, although regarded as a treasured asset with recreational services well-developed across the campus welcoming people of all ages to visit in the heart of city, little calculation of recreational service value was done in the past studies. Treating the park as a positive daily resource the same time, chances are that people have little knowledge on its wealth value regarding to the way it has been used. Therefore, this proposal seeks to get an overall estimation on potential recreational service values that Forest Park can generate each year by dividing sections to various sport and landscape ecosystems, to give advice for city designers and administrators to find out a better way of land using decision.

This recreational service value calculation will use mixed method including quantitative research using (I)TCM: (Individual) Travel Cost Method after questionnaire surveys to complete. This decision is made based on relevant literature reviews and site existing conditions by choosing the most suitable method to collect and process data.

Recreational service as a non-material service, the value is abstract and hard to define with an exact number. Therefore, method of alternative market pricing is a popular concept of valuing recreational non-market goods. According to The National Research Council of Washington D. C., the committee emphasized that the TCM was the first technique developed for valuing these commodities. TCM represents travel cost method, which implies the price that was paid by visitors to physically travel to the recreational site and the value of site existence.

From implemental perspective, the site-based recreation survey will be conducted on site following the travel cost method to process data. The calculation logic will start from knowing the number of visitors to Forest Park each year (more than 15 million) through GIS data or Forest Park Forever related organization documentations, followed by surveys to collect information on visitors' travelling method, distance and time, major stopping points and other subjective or objective economic factors that affected or made the trip possible to come up with estimated cost for each trip. After having enough amount of sample base collected, we can zoom out on the total amount of visitors and multiply them with individual travel cost then the total number of value can be calculated.

The survey will be designed to involve with random on-site visitors and surrounding neighborhood residents who tend to get easier access to the park. Time length of questionnaire completion will be controlled under 10 minutes to avoid disturbing their travel experience for site visitors or a lower response rate from neighborhood. Prepaid mail back envelopes will be provided to ensure response. To improve data reliability, weekdays and weekend surveys will both take place to guarantee interviewee diversity.

Questionnaire design:

(1) Where did you depart from? (This question will skip for nearby neighborhood people)

(2) Which places did you stop at or pass by? Which spot did you stop longer?

(3) How often do you usually visit Forest Park?

(4) Anyone you came here with? Which transportation did you take to reach here?

(5) How long did you spend on your way here?

(6) Think about related spending such as food or tickets, equipment, could you make a

general guessing on total cost of your trip?

(7) If you need to pay for Forest Park resources you used, how much are you willing to

pay seriously?

After going through the questions, local resident visits and visits will be divided by time consumption. Those who spent less than 20 minutes by car or 30 minutes by bike will belong to local visits, otherwise longer field trip visits. The cost of transport will be estimated based on time, round trips will multiply by 2. Then in these two groups, individual visits and group visits with family and friends will be divided and calculated separately because group visits need to divide by member numbers for individual cost.

Therefore 4 data groups are local and field trip groups with individual cost as well as group individual cost in each, based on total number of visitors, total local and field trip visitors can be computed out then multiplied by individual costs, will be followed by recreational service costs in the final.

3. Findings and Discussion

Through the survey, hot spots where people usually spend more time can be identified for further recreational service analysis and planning. It was hoped that aside from travel cost calculation, various survey findings can be revealed through people's response such as recreation service distribution, popularity mapping and service value ranking, Forest Park recreational service range analysis. TCM as an effective method can also provide helpful information on tracking people's travel preference and behavior habits across the site which has a positive assistance to optimize visitors' experience satisfaction.

4. Conclusion

Grassland is expected to have greater values comparing to other ecosystems as it shoulders more recreation activities. However, unit values may be different. If we jump out from park itself, its recreation service value not only relates to land use type and biodiversity, but has a close relation with neighborhood resource scarcity, regional conditions and so on.

However, this economic value calculation only comes from monetary cost behind each trip, the recreation value can also be measured through recreational emotion effects such as treatment and curing effects on people, which has no substance numbers to evaluate.

This study findings can also help with suggestions for other cities which have core city parks in the midtown area to integrate with city ecosystem management.

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Reexamining Green Infrastructure Quality for Creating Heat-Resilient Neighbourhoods

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Abstract

With an estimated global warming of 1.5°C to 2°C within this century as projected by the Intergovernmental Panel on Climate Change (IPCC), the frequency and intensity of extreme heat events have accelerated over past decades and intensified the urban heat island (UHI) effect in high-density cities such as Hong Kong. This exacerbates heat risks and threatens public health. Green infrastructure (GI), a nature-based solution can effectively cool down urban environment by regulating microclimate with provisioning ecosystem services. However, limited understanding of how to plan an effective GI system from climatological and spatial planning perspectives hinder its potential. Overemphasis on quantifiable measures over quality and omission of climate 'agency' are unfavourable to the development of quality GI and cooling efficacy. This study proposes a re-examination framework and optimization strategies to enhance the quality of GI, contributing to heat-resilient neighbourhoods in high-density cities. The framework evaluates GI's cooling efficiency and ecosystem health across six aspects, bridging the gap between planning and implementation of GI and challenging the misconception that green coverage equates ecological functionality. By laying the principle for sustainable, liveable and heat-resilient urban environment, the research aims to provide actionable insights for urban planners, designers and policymakers.

Keywords: Green infrastructure, urban heat island, thermal comfort, urban microclimate, ecosystem services

1. Introduction

1.1 Climate change, urbanization and extreme heat

The trend of global warming surges unprecedentedly in recent years due to human-induced climate change. According to the IPCC AR6 report (2021), global temperatures are expected to rise by 1.5°C to 2°C within this century if effective mitigation actions have not been implemented to curb greenhouse gas emissions. The rise in global temperature increases the risk of heat stress, with billions of people estimated at risk of extreme heat (World Meteorological Organization, 2024). The condition is further exacerbated by urban densification.

Urbanization has been accelerating speedily, with the urban share of the global population boosting from one-third in 1950 to two-thirds by 2050, according to the Population Division of the United Nations. The percentage of megacities has increased from 0.9% in 1950 to 7.6% in 2022, while rural areas have declined by nearly 30% during the same period (The Economist, 2015). To accommodate urban population growth, substantial amounts of natural land have been developed into industrial, commercial and residential zones. As urban areas have been dominated by heat-absorptive hard surfaces, it accumulates heat in compact urban fabric and intensifies the urban heat crisis (Figure 1).

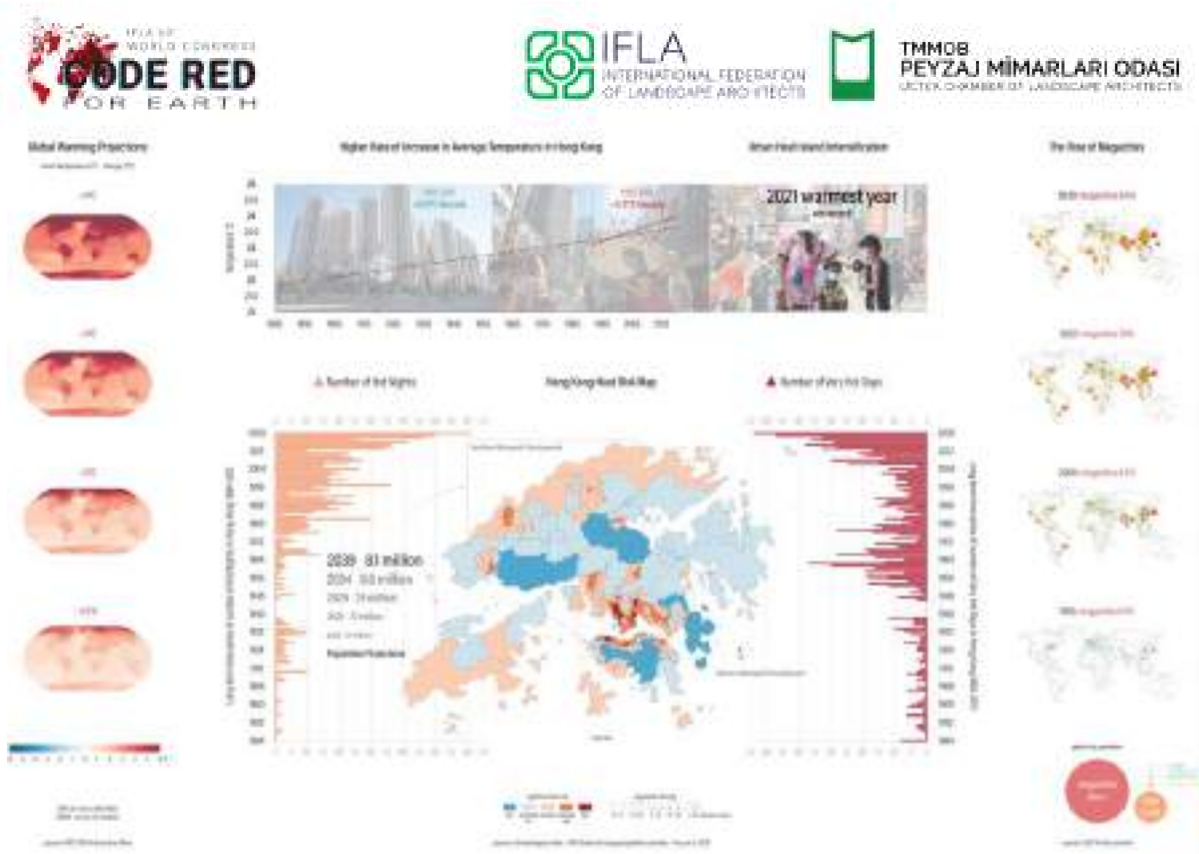

Figure 1. Global Warming Projections (IPCC WGI Interactive Atlas), Rise of Megacities (UN, The Economist) and Hong Kong Heat Risk Map (HKO; Hua et al., 2021)

At the city-level, global warming and urban densification amplify the UHI effect, further exacerbating heat risks locally. Hong Kong as a high-density city with a humid subtropical climate, dense urban fabric has intensified the UHI effect, where urban area is significantly warmer than surrounding rural areas. A tripling of the annual increase rate of average temperature since 1992 has been observed by the Hong Kong Observatory (HKO), with record-breaking high temperature events occurring annually in recent years. This rise of average temperature triggers urban heat risks and therefore poses a threat to public health, particularly among the vulnerable such as the elderly. A spatiotemporal assessment of extreme heat risks by Hua, Zhang, Ren, Shi and Lee (2021) identified that nighttime heat risks is concentrated in old towns in Kowloon Peninsula, the southern districts of Hong Kong Island and several new towns in New Territories. With projected population growth and government-initiated Northern Metropolis Development and Harbour Metropolis Development, it will undoubtedly densify urban areas, converting more natural land into built-up areas which will further reduce heat absorption and magnify heat accumulation.

Green infrastructure (GI) has been considered as an effective nature-based solution to adapt to the UHI effect and enhance thermal comfort. With the provision of multiple climate adaptation benefits in environmental, social and economic aspects, it can regulate microclimate through evapotranspiration and shading with provisioning ecosystem services. The American Society of Landscape Architects (ASLA) defines GI in three scales: 1) regional-scale: wildlife corridors or greenways; 2) local-scale: park systems and urban forests, constructed wetlands; and 3) site-scale: green streets, green roofs and walls. While GI can effectively reduce UHI effect by regulating microclimate, its cooling efficiency is often obstructed by challenges such as conceptual ambiguity, institutional fragmentation, technocratic management and neglect of climate agency. In an era of unprecedented climate crisis, cities have to be well equipped for climate emergency by building urban resilience under a changing climate.

2. Material and Method

2.1 Developing a quality evaluation framework

This research develops an evaluation framework for assessing GI quality from a climatological perspective, aiming to bridge the gap between GI planning and implementation. It challenges the misconception that green coverage equates ecological functionality.

The study utilises methodologies including a literature review of international and local studies and standards, case studies and toolkits to formulate a GI quality evaluation framework tailored to local context. City-level spatial mapping using GIS was conducted to spot high heat risk neighbourhoods for in-depth analysis and speculation. Fieldwork and community engagement facilitated the planning and design of quality GI from ecological and social perspectives.

The GI quality evaluation framework focuses on two major functions: cooling efficiency and ecosystem health. Cooling efficiency is assessed through site scale, vegetation size and plant species diversity, while ecosystem health is evaluated based on green coverage, structural complexity and biodiversity. Maintaining a healthy ecosystem is conducive to establishing long-lasting cooling performance. These six criteria are rated on a five-point rating scale from "very poor" to "excellent" based on site performance. This evaluation supports optimization strategies by identifying the strengths and weaknesses of GI quality at the site level (Figure 2).

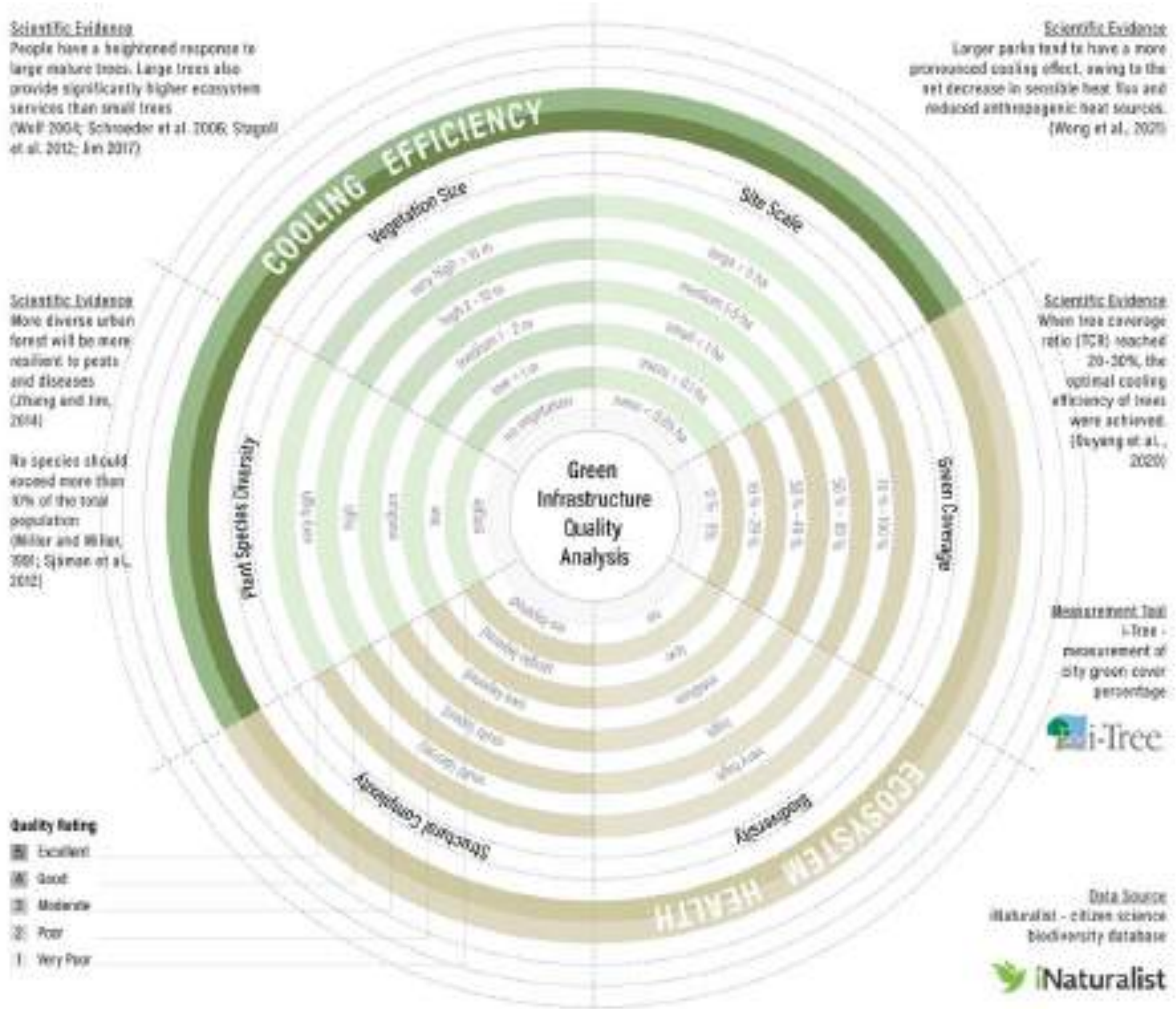

Figure 2. Green infrastructure quality evaluation framework

3. Findings and Discussion

3.1 Designing green infrastructure for extreme heat adaptation

Through city-level spatial mapping, Yau Ma Tei and Mong Kok neighbourhoods are identified as high heat risk areas. These neighbourhoods collectively referred to as “Yau Mong”, served as the study area. The study area is primarily dominated by compact high-rise (LCZ1) and mid-rise developments (LCZ2). The finding reveals unsatisfactory green coverage performance as indicated by low normalized difference vegetation index (NDVI) and low point-based green view factor (GVF). These conditions contribute to thermal discomfort and poorly performing microclimate for residents and pedestrians and raise the need for creating thermally comfortable neighbourhoods (Figure 3).

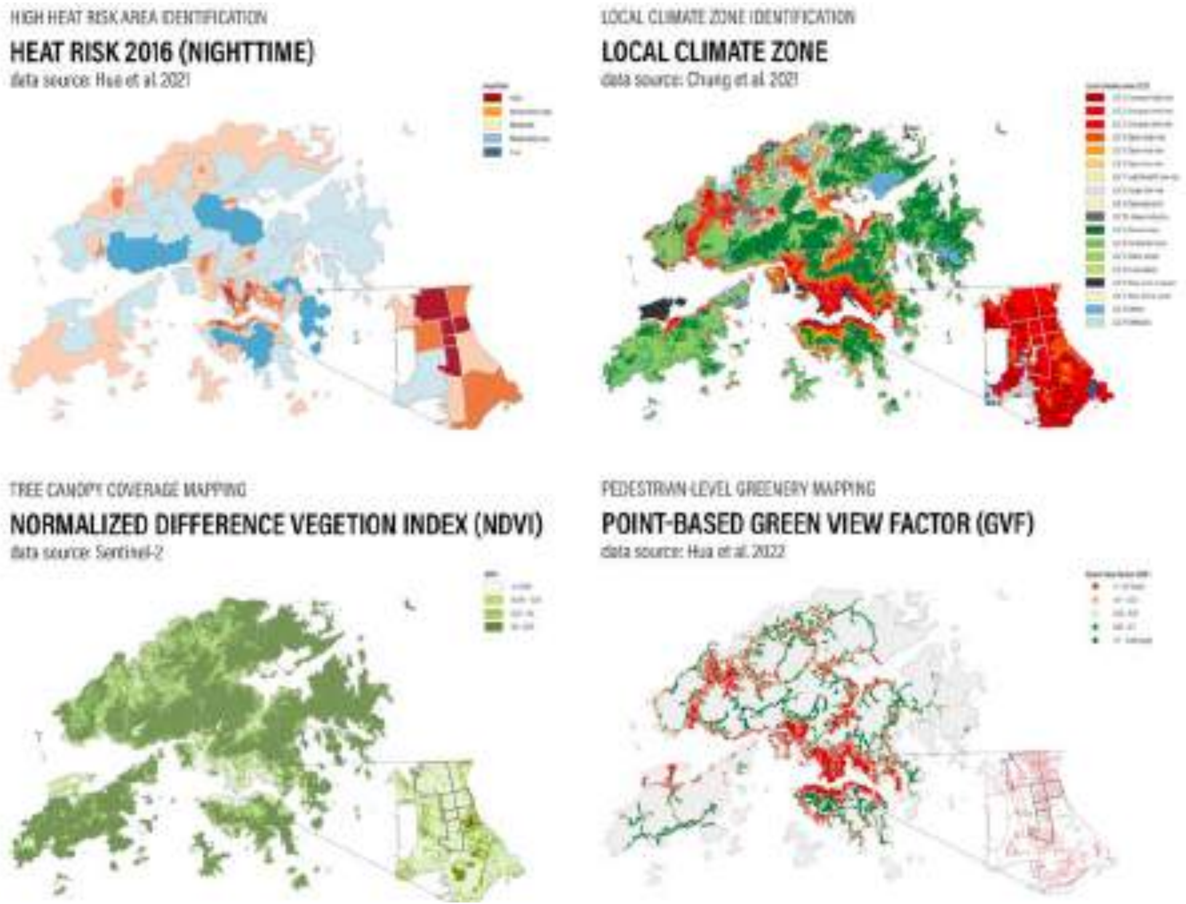

Figure 3. Heat Risk 2016 (Nightitme) (Hua et al., 2021), Local Climate Zone (Chung et al., 2021), Normalised Difference Vegetation Index (NDVI) (Sentinel-2), Point-based Green View Factor (GVF) (Hua et al., 2022)

Building on research by Shi et al. (2019) on spatial variability of extreme hot weather conditions and community-level UHI hotspots, the study spotted two significant extreme heat hotspots within the eastern Tai Kok Tsui area and central Mong Kok in the study area. These hotspots with a higher risk of extreme heat, were selected as focus areas for improving the thermal environment through GI optimization. Site analysis mapped the distribution of GI by size and ageing buildings in the study area. Approximately 65% of existing buildings are over 50 years old with 47% in marginal, varied or poor conditions (Urban Renewal Authority, 2022). These ageing buildings are often distributed densely, presenting an opportunity to systematically integrate GI system and enhance land use efficiency in urban renewal plans in the future.

Three focus areas representing distinct urban typologies were selected for GI design speculation.

1. Focus Area A - Green Pocket: Tai Kok Tsui Road / Larch Street Sitting-out Area and Tai Kok Tsui Road / Maple Street Garden

These nano-sized green spaces are adjacent but separated by a public toilet. Limited shade is provided by a few small trees, resulting in poor cooling performance. Proposed interventions include planting shade trees with broad leaves, diversifying tree species and layers and enhancing biodiversity to create a healthier ecosystem. Connecting these two green spaces will further unleash long-term cooling efficiency (Figure 4).

Figure 4. Focus area a Intervention: Green pocket

2. Focus Area B - Green Community Hub: Ivy Street Rest Garden

This micro-sized green space suffers from unhealthy small trees in confined tree pits, large extent of impermeable paving and limited species diversity. Proposed interventions include replacing hard surfaces with permeable paving or lawn, enlarging tree pits for tree root development and introducing diverse plant species to establish a healthy and sustainable urban ecosystem. It will evolve into a vibrant community hub adorned with seasonal flowering in the long run (Figure 5).

Figure 5. Focus area B intervention: Green community hub

3. Focus Area C - Multidimensional Green: Nathan Road and Fa Yuen Street

Nathan Road features a narrow strip of poorly maintained mono-species in confined concrete planters, while Fa Yuen Street has limited shade and is dominated by asphalt and concrete. Therefore, pedestrians often experience overheating during summertime in the street. Recommendations include diversifying street planting species, leveraging podium space for elevated quality greening and incorporating building setbacks for greenery in new developments under urban renewal (Figure 6).

Figure 6. Focus area C intervention: Multidimensional green

Design strategies for these focus areas integrate quality evaluation, green optimization and systematic planning to improve GI quality at the site, neighbourhood and city-levels. Proposed green optimization strategies comprise reserving large trees, enhancing biodiversity, maximising green coverage, optimising cooling experience, bringing nature closer and creating more open space. By optimising green quality, it is hypothesized it can effectively enhance cooling efficiency, contributing to heat-resilient neighbourhoods. Ouyang et al. (2020) researched that a 30% green coverage ratio can optimize cooling potential. The ultimate goal is to incrementally expand quality green coverage to 30% within 30 years by incorporating three-dimensional GI elements including at-grade greenery, green podiums, green roofs and vertical greenery, aiming to create a liveable and heat-resilient environment.

4. Conclusion

4.1 Building a heat-resilient future

The increasing frequency and intensity of extreme heat events with rapid urbanization, alert us to take immediate actions for heat adaptation. This research contributes to the emerging field of GI planning and design from a climatological perspective. The proposed evaluation framework and green optimization strategies align with local planning initiatives such as Hong Kong's Climate Action Plan 2050 and the Hong Kong 2030+ Planning Vision and Strategy. The Yau Mong neighbourhood study provides a representative model for systematically integrating quality GI into urban renewal plans for building heat-resilient neighbourhoods. It is also pivotal in incorporating local needs into prototype design. The community was engaged in the planning and design of quality GI in the study to create an inclusive and liveable environment.

Mainstreaming GI in urban planning policy and development is crucial and urgently needed, as it has been proved it can help us effectively adapt to extreme heat, improve thermal comfort and foster a healthy living environment. This research provides insights for policymakers, urban planners and landscape architects on the potential of developing systematic GI planning to create heat-resilient neighbourhoods in the face of climate emergency.

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Research on Spatial-Temporal Patterns and Influencing Factors of Cultural Heritages in Dongting Lake area, China

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Abstract

Cultural heritage area is an important part of China's territorial spatial pattern, and the protection of cultural heritage is an inevitable requirement of carrying forward the excellent traditional Chinese culture. Dongting Lake is an important lake in China. The region has formed a rich cultural heritage through thousands of years of continuous adaptation to the natural and social environment, with a long history and far-reaching cultural influence.

The paper studies the cultural heritage of Dongting Lake area by using the most adjacent point index, nuclear density analysis method and geographical detector. First of all, the number, category, formation time and protection level of cultural heritage are classified to form a regional cultural heritage database. Then, studying the temporal and spatial differentiation characteristics to show the multi-dimensional landscape characteristics of its space-time evolution. Finally, exploring the driving factors of temporal and spatial differentiation from the perspective of natural and humanistic elements. The findings contribute to enhancing the spatial comprehension and safeguarding of cultural heritage resources within the Dongting Lake area, with the aim of fostering sustainable development.

Keywords: Cultural heritage, Spatial-temporal pattern, Influencing factors, Dongting Lake area

1. Introduction

Cultural heritage represents the legacy of history to humanity (Vigneron, 2017), and its preservation is essential for promoting and sustaining the richness of China's traditional culture (Luo et al., 2019). Dongting Lake has cultivated a rich cultural heritage through its continuous adaptation to both the natural and social environments, boasting a long history and a profound cultural impact (He et al., 2024). The present research on cultural heritage mainly focuses on the spatial distribution (Dippon & Moskaliuk, 2020; Pang & Wu, 2023; Shen et al., 2024), the protection of cultural heritage (Yastikli, 2007; Fatoric & Seekamp, 2017), the development and utilization of cultural heritage (Garcia-Hernandez et al., 2017; Nocca, 2017), the value assessment of cultural heritage (Tengberg et al., 2012; Figueiredo et al., 2020) and other aspects. Additional, the research on Dongting Lake area mainly focuses on ecological protection (Hu et al., 2020; Yuan et al., 2021), water treatment (Wang et al., 2011; Wang et al., 2018), etc., and the excavation of its cultural attributes is not enough to provide a clear goal guidance for the rational protection and developing of cultural heritage in Dongting Lake area. The research findings enhance the spatial comprehension of cultural heritage resources in the Dongting Lake area. They provide valuable reference for the systematic organization, strategic development, and targeted conservation of cultural relics in the future.

2. Material and Method

2.1 Study area

Dongting Lake, plays a crucial role as a regulatory reservoir in the Yangtze River basin.(L. Yuan et al., 2024). This paper takes Dongting Lake area as the research scope, with Dongting Lake as the center, covering Yueyang, Changde and Yiyang cities. The geographical locations are 111 53 ′ to 113 05 ′ E and 28 44 ′ to 29 35 ′ N (Figure 1). The study subjects include the cultural heritage in the Dongting Lake area.

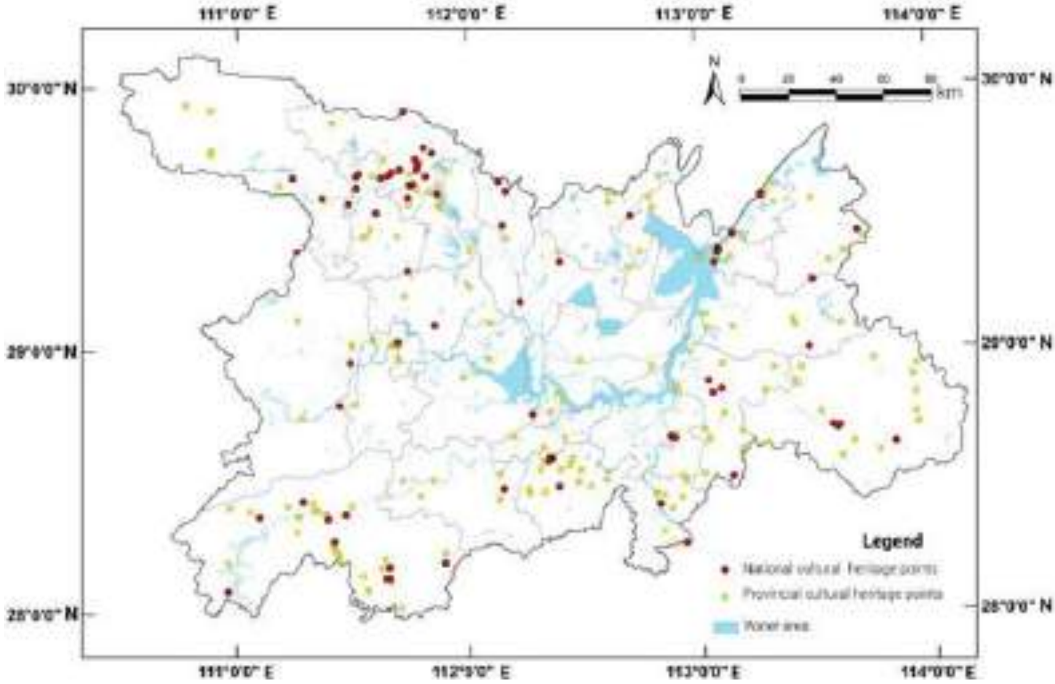

Figure 1. Dongting Lake Area in Hunan Province (Author self-painted).

2.2 Data

This study drew upon a diverse collection of cultural and geographic datasets as its primary data sources. For instance, it incorporated eight rounds of national key cultural heritage sites, along with eight batches of provincial key cultural heritage sites provided. Additionally, six sets of national traditional villages recognized. Administrative boundaries, river systems, and water networks were mapped using vector data extracted through Bigemap e-map downloads. This integration of cultural, administrative, and spatial data established a comprehensive and multidimensional foundation for the analysis, enhancing the depth and accuracy of the study.

Table 1. Data source

Data	Source
NDVI	The National Data Center for Earth System (http://www.geodata.cn）
Mean precipitation	
Average temperature	
GDP	The Center for Resource and Environmental Science and Data Research, Chinese Academy of Sciences (http://www.resdc.cn/)
Population spatial distribution	

National key cultural protection units	State Administration of Cultural Heritage
Key cultural protection unit of Human Province	Human Provincial Bureau of Cultural Heritage
DEM	Geospatial data Cloud (http://www.gscloud.cn/
Road	Bigemap Electronic map

2.3 Method

2.3.1 Nearest Neighbor Index (NNI)

NNI, which is calculated as the ratio of the observed nearest neighbor distance to the expected theoretical nearest neighbor distance. The formula is:

$$R = \frac{\bar{r}_1}{\bar{r}_E}$$

where $\bar{r}_1$ is the average value of the distance to the closest neighboring point and $\bar{r}_E$ is the theoretical closest neighboring distance. $\bar{r}_E$ is calculated by the formula.

$$\bar{r}_E = \frac{1}{2\sqrt{\frac{n}{A}}}$$

When R<1, it shows aggregated distribution; when R=1, it tends to be randomly distributed, and the closer R is to 1, the greater the chance of random distribution; when R>1, it shows discrete distribution.

2.3.2 Kernel Density (KD)

KD analysis effectively reveals the concentration of geospatial elements within a defined area. A higher kernel density indicates a more concentrated distribution of cultural heritage, while a lower kernel density reflects a more dispersed pattern.

$$f(x) = \frac{1}{nh}\sum_{i=1}^{n} k\left(\frac{x - x_i}{h}\right)$$

where n is the number of cultural heritage around Dongting Lake; $(x-x_i)$ is the distance from the valuation point x to the element x_i.

2.3.3 Optimal Parameter Geographic Detector (OPGD)

GeoDetector is a tool designed to analyze and explore spatial heterogeneity in geographic data, with the primary aim of identifying and quantifying the factors driving these variations. The Parametric Optimal GeoDetector (OPGD) overcomes the limitations and potential biases of traditional GeoDetector methods arising from subjective human delineation. By utilizing optimized discretization methods, OPGD achieves more accurate segmentation of continuous variables, enabling the determination of the optimal q-value and improving the reliability of the analysis. In this study, OPGD was employed to investigate the factors influencing cultural heritage patterns. This integrated approach not only uncovered the complex interactions among influencing factors but also offered valuable insights for cultural heritage conservation and management.

3. Findings and Discussion

3.1 Spatio-temporal database construction

To effectively illustrate the distribution characteristics of cultural heritage, the Dongting Lake is categorized into four distinct historical periods based on its significant historical stages: prehistoric to Six Dynasties, Sui, Tang to Song Dynasties, Yuan, Ming and Qing Dynasties, and modern times. The cultural heritage of each period is counted respectively to form a spatial-temporal database.

The results show that ancient sites were primarily concentrated in the Prehistoric to Six Dynasties period, with 43 records, gradually decreasing to 12, 5, and 0 in the subsequent periods. Ancient tombs were relatively scarce, with 14 and 1 recorded during the Prehistoric to Six Dynasties and Tang to Song Dynasties. Historic buildings were predominantly distributed in the Yuan, Ming, and Qing Dynasties, with 79 records, compared to 1 and 9 in earlier periods. Modern times were marked by 72 records of important historical traces, a category absent in earlier periods. Lastly, the "other" category contributed marginally to the dataset, with a total of 6 records. Overall, the spatio-temporal database comprised 261 entries, reflecting a dynamic evolution of cultural heritage across historical periods.

Table 2. Spatio-temporal database construction (Author self-painted)

Type	Prehistoric to Six Dynasties	Tang to Song Dynasties	Yuan Ming and Qing dynasties	Modern times	Total
Ancient sites	43	12	5	0	60
Ancient tombs	14	1	10	0	25
Historic building	1	9	79	0	89
Important historical traces of modern	0	0	9	72	81
Other	0	4	2	0	6
Total	58	26	105	72	261

3.2 Spatial and temporal pattern

According to NNI, the R value of the nearest ratio of cultural heritage in the four periods is small by 1, and they are all agglomeration type (Table 3). The spatial distribution map of cultural heritage across four historical periods, derived through kernel density analysis. In Period 1 (Prehistoric to Six Dynasties), the spatial distribution exhibited a northwest single-nucleus pattern, with high-density regions concentrated in the northwest. In Period 2 (Tang to Song Dynasties), the pattern shifted to a northeast-southwest dual-core distribution, characterized by two distinct high-density areas in the northeast and southwest regions. During Period 3 (Yuan, Ming, and Qing Dynasties), the distribution transformed into a southwest single-core pattern, with density concentrated primarily in the southwest region. In Period 4 (Modern Times), the spatial distribution evolved into a southern dual-core pattern, marked by two high-density regions in the southern area. These distinct spatial distribution patterns from different periods collectively contributed to the contemporary existing heritage pattern, which is characterized by a regional multi-core configuration (Figure 2).

Table 3. NNI of cultural heritages in Dongting Lake area at each historical period

Period	The average observation distance/m	Expected average distance/m	The nearest ratio R	Z	P	SST
Prehistoric to Six Dynasties	10923.08	12434.72	0.88	-1.77	0.076535	Clustered
Tang to Song Dynasties	14855.62	20244.11	0.73	-2.60	0.009418	Clustered
Yuan Ming and Qing dynasties	7242.95	12212.48	0.59	-7.98	0	Clustered
Modern times	10022.38	14460.47	0.69	-4.98	0.000001	Clustered
Total	4327.45	7891.57	0.55	-13.96	0	Clustered

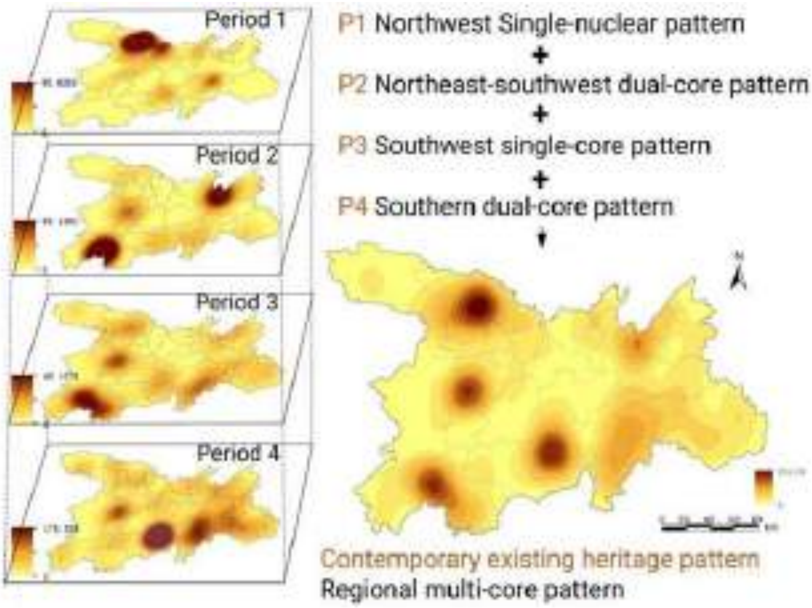

Figure 2. KD distribution pattern of cultural heritages in Dongting Lake area at each historical period.

3.3 Influencing factors

Research of the influence factors based on the OPGD. To analyze the correlation between cultural heritage distribution and influencing factors, eight key elements, encompassing both natural and humanistic aspects, were selected for examination. Based on the optimal discretization combination analysis, the parameter optimization results for eight independent variables (x1 to x8) were determined by evaluating the optimal q-values under five discretization methods: quantile, natural breaks, geometric, equal intervals, and standard deviation. The number of intervals for discretization was set between 4 and 6, with the Q- value serving as the evaluation metric to identify the best method for each variable. For instance, in the parameter optimization process for x1, the Q-value for the natural breaks method increased with the number of intervals, reaching its maximum at 6 intervals, making it the optimal method for this variable. In contrast, the geometric method consistently yielded the lowest Q-values across all interval numbers, indicating its unsuitability for x1. Similarly, for x2, the quantile method produced the highest Q-value when the number of intervals was set to 6, demonstrating its superiority for this variable. The parameter optimization process for the remaining variables followed a similar pattern (Figure 3).

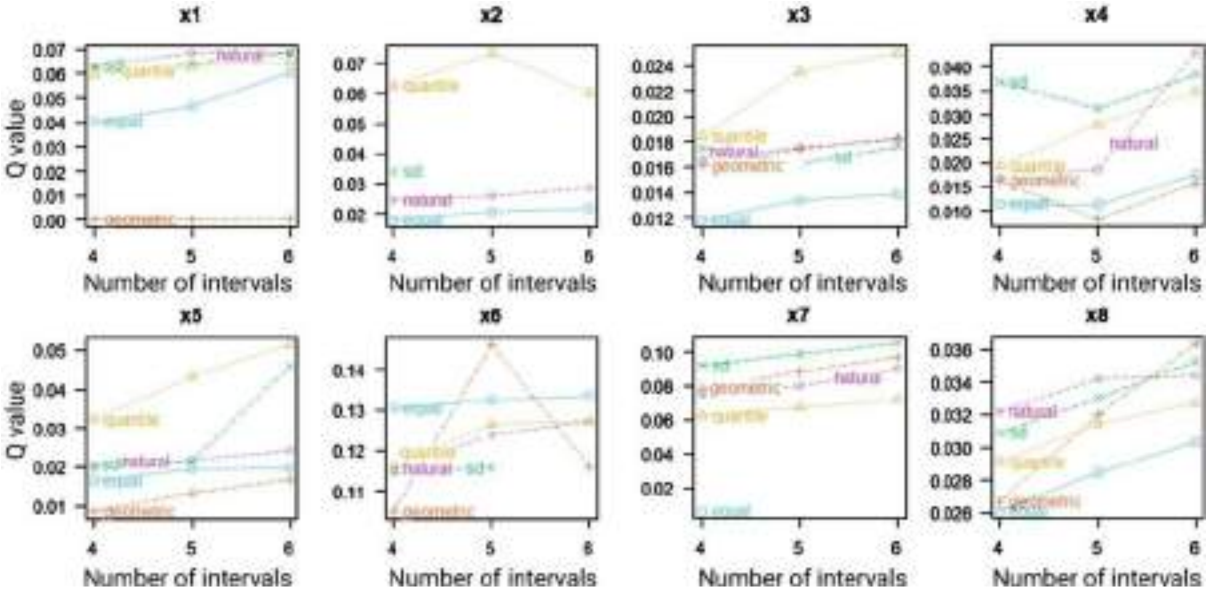

Figure 3. The Qvalue change plot of different factor discretization parameter combinations.Source: Author self-painted.

The detection results of driving factors (Table 4) and the interaction of driving factors (Figure 4) provide critical insights into the explanatory power of different indicators influencing cultural heritage distribution. The average explanatory power of individual factors followed the order: GDP > Population spatial distribution > DEM > NDVI > Annual average temperature > Precipitation > Distance to the road > Slope. Among these, GDP exhibited the highest explanatory power (q = 0.1567), while slope showed the lowest (q = 0.0250). Overall, the results indicated that the explanatory power of humanistic elements, such as GDP and population spatial distribution, was generally stronger than that of natural elements, such as NDVI, DEM, and climate variables.

Interaction of dual factors demonstrated a significantly stronger impact on cultural heritage distribution compared to single factors (Figure 4). For instance, the interaction between DEM and GDP reached the highest explanatory power (q = 0.2245), highlighting the synergistic effect of topographic and economic factors. Other notable interactions, such as GDP and population spatial distribution, also showed enhanced explanatory power compared to individual factors. This suggests that spatial distribution is not only shaped by isolated variables but is more significantly influenced by the complex interplay between natural and humanistic elements.

Table 4. Detection of driving factors. Source: Author self-painted

Indicator type	Indicator	q	Sort of q values
Natural elements	X1 NDVI	0.0687	4
	X2 DEM	0.0736	3
	X3 Slope	0.0250	8

	X4 Mean precipitation	0.0431	6
	X5 Average temperature	0.0516	5
Humanistic elements	X6 GDP	0.1567	1
	X7 Population spatial distribution	0.0970	2
	X8 Distance to the road	0.0364	7

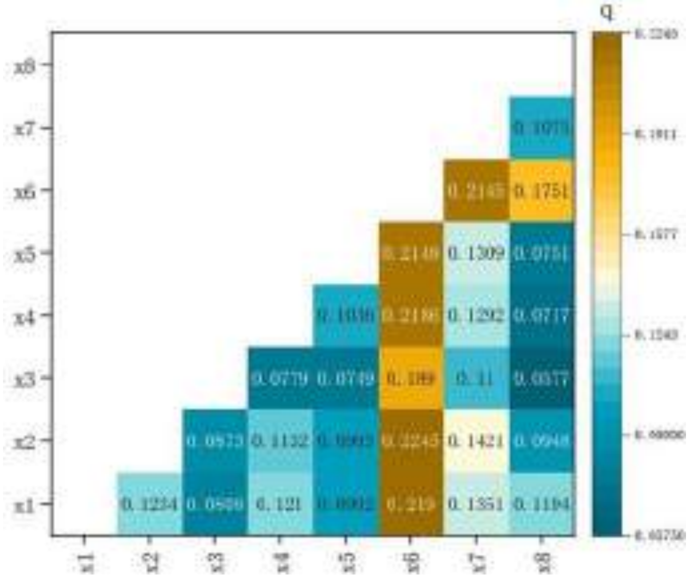

Figure 4. Interactive detection of driving factors. Source: Author self-painted.

4. Conclusion

The Dongting Lake area is renowned for its abundance of cultural heritage, which displays unique spatial distribution characteristics across various historical eras. Over time, the spatial layout of cultural heritage in the Dongting Lake region has gradually evolved from a single-nuclear aggregation pattern centered in the northwest to a more complex, multi-nuclear distribution pattern, reflecting the dynamic development of the region's cultural and socio-political landscape.

Analysis of the factors influencing indicates that human activities have a significantly greater impact than natural factors. Among these, GDP, population spatial distribution, and DEM (digital elevation model) have emerged as the most significant contributors to the current distribution patterns. Furthermore, the interaction between multiple driving factors plays a crucial role in shaping the spatial characteristics. Multidimensional interactions, particularly between human and natural elements, exhibit a more pronounced effect than single factors, underscoring the complexity of the pattern formation process of cultural heritages.

The study of spatial-temporal patterns and influencing factors in the Dongting Lake region holds significant academic and practical value. On one hand, this research provides a scientific basis for understanding the spatiotemporal evolution of cultural heritage across different historical periods. On the other hand, this research incorporates the multidimensional interplay between natural and humanistic factors, offering a deeper understanding of the mechanisms shaping the intricate spatial patterns of cultural heritage. The findings also provide valuable insights for heritage conservation planning in comparable regions. Additionally, the study supports the promotion of regional cultural transmission, strengthens local cultural confidence, and encourages the resilient development of cultural heritage.

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Impact of Landscape Pattern on Ecosystem Service Trade-Off in the South Taihang Area

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Abstract

Understanding the spatial temporal evolution and relationships of ecosystem services (ESs) and landscape pattern is vital for regional planning strategies in sustainable view. In this study, we assess the spatial distribution of four typical ESs across county scale in the South Taihang Mountains region. Using InVEST model, Fragstrats 4.2 and Spearman correlation analysis, we exam tradeoff and synergy relationship among ESs, as well as ESs and landscape pattern indices. Our findings revealed the following: (1) From 2000 to 2020, ESs of HQ and CS represented a downward trajectory, while SC experiences some fluctuations in the South Taihang Mountains area. And there was a high degree of synergies among ESs. (2) Landscape pattern indices indicated significant patches changes of diversity, fragmentation and simplification from 2000 to 2020. (3) Ecosystem services were closely correlated with landscape pattern indices, fragmentation indices were negatively correlated, and connectivity indices was positively correlated. These results could provide the basis for improvement of ecological environment and regional management in South Taihang Mountains area.

Keywords: Ecosystem services, tradeoff and synergy, landscape pattern; the South Taihang area

1. Introduction

Ecosystem services (ESs) can be understood as essential environmental conditions, resources and benefits that derived from ecosystems by directly or indirectly channel (Costanza et al., 1997). Interactions among ESs usually exist tradeoffs and synergies relationship, that is boosting one service increases or in others or the opposite, has scientific significance for decision-making of region ecology management (Du et al., 2024; Li & Luo, 2023). In recent years, because of urbanization and land use transform, landscape pattern produced change, driving the degradation of ecosystem function (Li et al., 2022 ; Li t al., 2023). Therefore, research on ESs tradeoffs and synergies, as well as relationship between landscape pattern index were highly necessary.

Many studies have been carried out concerning the synergy and tradeoff and inflecting factors of ESs (Zhang et al., 2020). In recent years, the InVEST model used to calculate ESs by multiple scientific validation (Li et al., 2024). And Pearson correlation or Spearman correlation coefficient has employed to examine the relation direction of ESs (Xu et al., 2017; Hua et al., 2024; Zhang et al., 2020). Other than understanding the relationships between ESs, landscape patterns also have significant impacts on the transformation of organisms and matters and indirectly in ESs (Dong et al., 2024). Several studies have used correlation analysis and linear regression to explore the relationship between landscape pattern and ESs (Tran et al., 2022; Chen et al., 2023). Considered the imbalanced distribution of natural or economic development resources, dividing the region as assessment scale is necessary (Fang et al., 2022). Therefore, finding the interaction in county scale of ESs and landscape pattern is still essential.

Considering data availability and existing research, the study choosed four indicators of ESs, applied the InVEST model to evaluate the ESs variation trend in the South Taihang Mountains area. The study aims to explore tradeoffs and synergies of ESs, and their correlation with landscape pattern, to provide significative ecological insights for the South Taihang Mountains area environment protection.

2. Material and Method

2.1 Study area

The Taihang Mountains are in the transition zone of the Loess Plateau and the North China Plain, which is divided into 3 regions as the North, West and South Taihang Mountains region (Qi et al., 2023). The study area was the South Taihang Mountains area (111°34′—114°27′E, 34°32′—37°4′N), including 28 counties of Shanxi and Henan Province (Figure 1). The altitude was in the range of 58 to 2009m above sea level. The overall terrain is high in the west area and low in the east. In recent decades, the area of green land has continued to decline with the rapid expansion of urban construction, which has a negative affect for the regional ESs and landscape pattern of the study area（Wang et al., 2024.

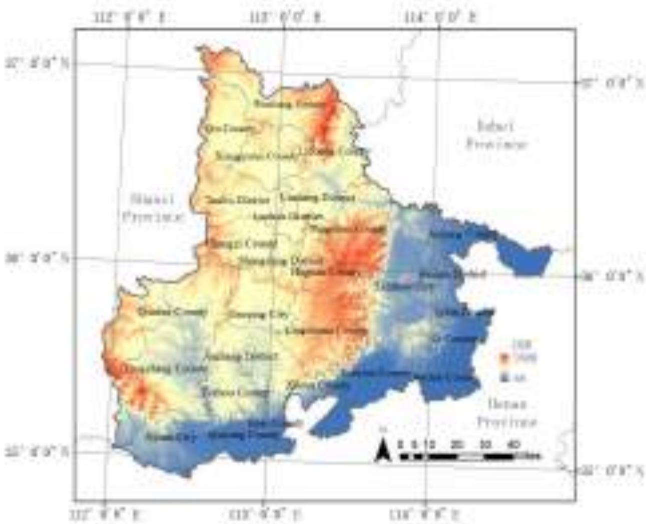

Figure 1. Location map and elevation of the South Taihang Mountains Area.

2.2 Data source and processing

Study periods included 2000, 2010 and 2020. The land use data and meteorological data came from the RESDP (https://www.resdc.cn/). DEM data at 30 m resolution came from the GDC (http://www.gscloud.cn/). Soil data comprised soil depth, soil organic carbon, soil type, and soil particle composition came from the HWSD (https://www.fao.org/soils-portal/en/). And all of these were defined as the same format of WGS 1984 and resampled to 1 km resolution to ensure consistency in spatial analysis, and research considered the county as the analysis research unit.

Our study employs the InVEST model and Fragstrats 4.2 to calculate ESs and landscape pattern indices spatio-temporal evolution, and Spearman correlation to explore tradeoffs or synergies of ESs and the influence relationship by landscape pattern.

2.3 Methods

2.3.1 Landscape pattern indices method

Quantitatively changes of four typical indices calculated by Fragstats4.2, such as PD, SHDI, CONTAG and LSI indicators. The detailed calculation steps of above indices were referred in the existing research (Zhang et al., 2024).

2.3.2 Ecosystem services

Four typical ESs referred to existing research and calculated by InVEST model, such as Habitat Quality (HQ), Water Yield (WY), Carbon Storage (CS), Soil Retention (SR). The detailed calculation steps were referred in the existing research (Du et al., 2024; Li & Luo, 2023; Zhang et al., 2020).

2.3.3 Trade-off and synergy analysis

Spearman correlation analysis required less raw data and applicabled widely, used to analyze the relationship direction, degree of ESs and landscape pattern indicators. The calculation formula is as follows and interpretation were referred in the existing research(Zhang et al., 2023):

$$\rho_s = 1 - \frac{6\sum d_i^2}{n(n^2-1)}$$

3. Findings and Discussion

3.1 Spatiotemporal changes and tradeoffs and synergies of ESs

The study area reflected an overall reginoal pattern of higher spatial distribution CS in the southwest and lower in the northeast. The HQ was decreased over the years, which was approximate with the distribution characteristics of CS, showed high quantitative value in the southwest area and low in the northeast. SR showed certain volatility in the study area, and WY fluctuated greatly and mainly along the dramatic terrain changes.

The result indicated a high degree of synergies between ESs in the study area, which are always closely linked to each other and the degree of synergies generally continued to rise from 2000 to 2020. The HQ has higher degree of synergies with CS and SR, and the degree of CS and SR has a rapid promotion in last 10 years, showed that there was a close interaction between these ESs at the county scale (Figure 2).

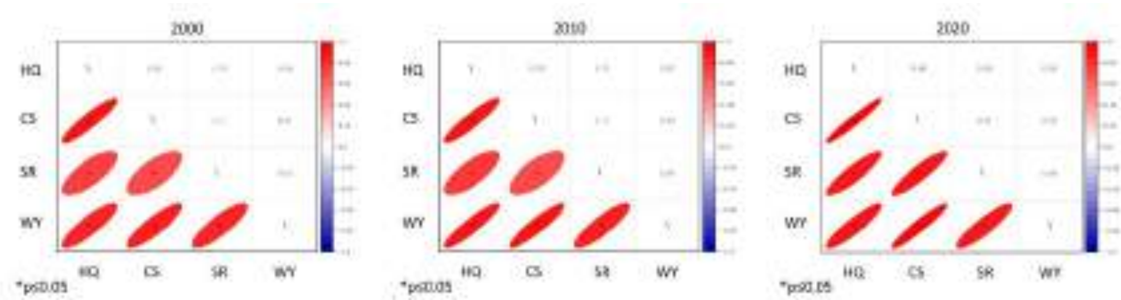

Figure 2. Correlation between ESs from 2000 to 2022.

3.2 Spatiotemporal changes of landscape pattern indices

From 2000 to 2020, landscape pattern indices indicated significant differences in county scale. Patch Density (PD) mainly increased in the first decade and large area decreased in the last decade, which indicated the intensity change of land use in study area. Shannon' s Diversity

Index (SHDI) showed similar spatial distribution to PD, while most areas have shown improvement from 2000 to 2020, meant that landscape patch diversity has been improved. Contagion (CONTAG) has a lower value in the central region, and declined continuously in the past 10 years. Landscape shape index (LSI) has a lower value in the south region, and most areas showed improvement trend, which represented the fragmentation and complexity patches transformation in study area.

3.3 The correlation between landscape pattern and ESs

ESs and landscape pattern indices were significantly correlated, especially the landscape pattern comprehensive index, indicate a close relationship between them at the county statistical scale. Indicators reflecting patches shape, density and diversity feature showed a positive correlation with ESs, while negatively correlated between ESs and CONTAG. SR and HQ compared the other two services, showed significant correlation with multiple landscape pattern indices in county scale (Figure 3).

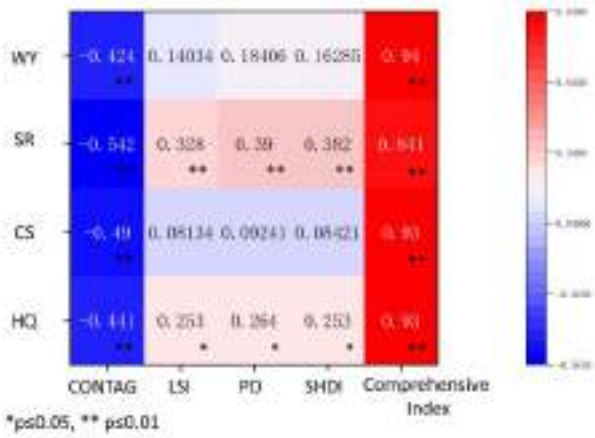

Figure 3. Correlation of ESs and landscape lattern indicators.

4. Conclusion

This study analysis spatiotemporal changes of ESs and landscape pattern in county scale, and the results revealed several key findings. The four ESs indicators in the South Taihang area showed a downward from 2000 to 2020, and the variation area overlapped with the topography. The relationship between ESs was represented by tight synergies. Landscape pattern indices displayed ecological changes and fragmentation and simplification of landscape spatial structure. And ESs and landscape pattern indicators had relatively significant correlation. This paper still has several limitations. For one thing, this study lacked driving factors by quantitative assessment due to data limitations. For the other thing, this study lacked the multi-scale analysis and took no account of topographical factors, which were not conducive to improve the research accuracy.

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Construction and Optimization of North-China Leopard Habitat Network in Jinzhong

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Abstract

This study focuses on the construction and optimization of habitat networks for the North-China leopard, using Jinzhong City, Shanxi Province, as a case study. Employing the MSPA-InVEST-MCR comprehensive model, the research yielded the following key findings: (1) Fifteen North-China leopard habitat source areas were identified, primarily located in the central and eastern mountainous regions, exhibiting significant fragmentation. (2) High-resistance areas were observed in the western plains and construction lands within the eastern mountainous regions. (3) Twenty significant ecological corridors were identified, predominantly situated in areas with favorable ecological conditions and nature reserves, though these corridors displayed low connectivity with peripheral habitat source areas, highlighting gaps in corridor coverage. (4) Nine optimized ecological corridors and 24 strategic ecological nodes were identified along key corridors, with an additional 19 artificial ecological nodes located at intersections with major highways and railways. (5) A habitat network comprising 15 source areas, 29 corridors, and 43 nodes was constructed, demonstrating a centralized core and dispersed periphery, with high network integrity. These findings provide a scientific basis for the restoration and optimization of habitat networks, key corridor planning, and regional biodiversity conservation.

Keywords: Habitat network, biodiversity, MSPA, MCR, InVEST

1. Introduction

The North-China leopard is under A-level state protection in China and serves as a top predator in the forest ecosystem food chain of the North China region. As an umbrella species, its habitat requirements encompass those of numerous other species (Roberge & Angelstam, 2004), underscoring its critical role in maintaining regional ecological balance (Zeng et al., 2022). However, over the past five decades, human activities have progressively degraded the leopard's habitat. Unsustainable development of current and potential habitats, coupled with the rapid expansion of road networks, has led to significant habitat reduction, isolation, and fragmentation (Zhu et al., 2021). These factors have resulted in the disappearance of migration corridors, thereby posing a severe survival threat to the species. Consequently, there is an urgent necessity to reconstruct and optimize the habitat network for the North China leopard to restore and sustain its natural environment (Liang et al., 2022).

2. Material and Method

2.1 Material

2.1.1 Study area

The study area is Jinzhong City, located in Shanxi Province, China, encompassing a total area of 16,396.7 square kilometers (Figure 1). Jinzhong City is recognized as one of the regions with the highest known density of North China leopards, making it a critical site for studying the species' survival status. Furthermore, the area lies along a significant corridor connecting the Taihang and Taiyue Mountains, serving as a key source region for the northward migration of leopards within the Taihang Mountain range. This highlights its essential role in conservation efforts. Protecting this species not only safeguards the leopards themselves but also promotes the preservation of the entire forest ecosystem, making it a practical foundation for restoring the natural environment in northern China (CFCA, 2021).

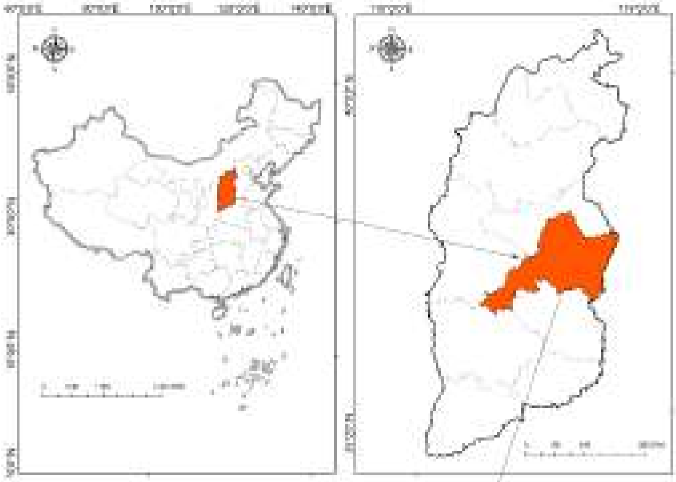

Figure 1. Location map of the study area

2.1.2 Data source and preprocessing

The data sources for this study mostly come from publicly available geographic information data, including China's 1-kilometer resolution monthly average precipitation and temperature dataset (Peng, 2019; Peng, 2020), SRTM 90-meter resolution digital elevation model (Jarvis, 2008), Peking University's GIMMS NDVI data (Muyi et al., 2023), and road and water system data provided by OpenStreetMap. The land use classification data is derived from China's Third National Land Survey (Figure 2), providing the study with higher accuracy due to its precise land use classification.

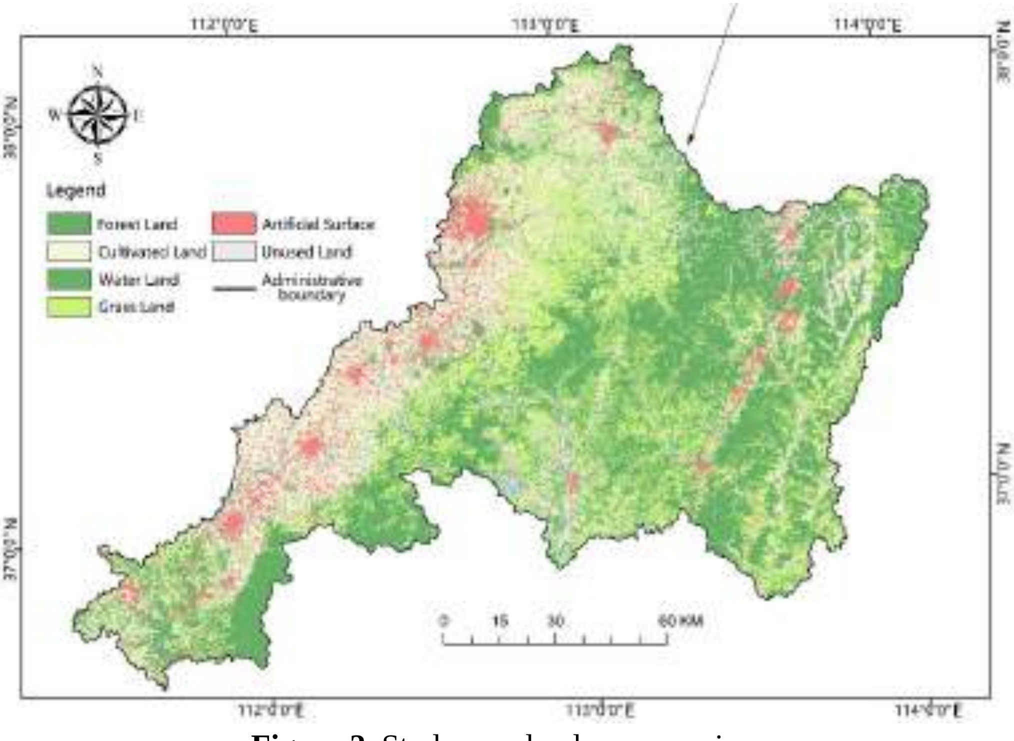

Figure 2. Study area land-use overview

2.2 Method

This study expands upon existing frameworks by integrating the habitat requirements and migration characteristics of the North China leopard (Gong, 2019). Habitat sources within the study area were identified through MSPA landscape element classification and habitat quality evaluations derived from the InVEST model. Building on this foundation, habitat corridors were delineated, and habitat nodes were determined using the MCR model. Ultimately, a habitat network for the North China leopard was constructed by combining the MSPA, InVEST, and MCR models.

2.2.1 Identify landscape types

The initial step involves identifying landscape types within the Jinzhong City region using Morphological Spatial Pattern Analysis (MSPA). Vector data from the Third National Land Survey (2021) was reclassified into six categories of raster data: forest land, cultivated land, water bodies, grass land, artificial surface, and unused land. The data was subsequently transformed into binary form, with the foreground denoting favourable habitats for the North China leopard, including water bodies, forestland, and grass land, and the background representing areas predominantly shaped by human activities, such as cultivated land, artificial surfaces, and unused land (Hu et al., 2022). Subsequently, the study area was analyzed using the eight-neighbor analysis method to identify seven landscape elements defined by MSPA. These elements were categorized into seven distinct types.

2.2.2 Identify habitat sources

The second step involves evaluating the habitat quality of the North China leopard using the habitat quality module of the InVEST model in combination with MSPA landscape types to comprehensively identify habitat sources for the leopard (Wang et al., 2020). By integrating MSPA with the InVEST model, this study combines spatial morphological attributes with functional attributes, enabling a more precise identification of habitat sources.

The InVEST model is an ecosystem service assessment tool with a built-in habitat quality module that quantitatively evaluates habitat quality based on land use types (Cao et al., 2019). In this study, cultivated land, artificial surface, and unused land were defined as sources of threat (Table 1). Using recommended values from the InVEST model, insights from relevant literature, and the specific habitat requirements of the North China leopard (Zhu et al., 2021; Wang et al., 2020; Zeng et al., 2022), We determined the impact ranges of threat sources, as well as the sensitivity and suitability parameters of habitat types (Table 2), which were subsequently used to calculate the habitat quality index for the North China leopard. The results were then overlaid with the core areas identified in the previous MSPA analysis. Areas larger than 10 square kilometers were selected and combined with the boundaries of existing national and provincial nature reserves to determine the key ecological sources (Wang et al., 2023).

Table 1. Assessment of habitat suitability and sensitivity

Land use type	Habitat	Threat		
	North China Leopard	Cultivated land	Artificial surface	Unused land
Forest land	1	0.5	1	0.8
Cultivated land	0	0	0.5	0.5
Water land	1	0.7	1	0.9
Grass land	0.8	0.3	1	0.8
Artificial surface	0	0	0	0
Unused land	0	0	0	0

Table 2. Overview of threat factors

Threat	Max_Dist	Weight	Decay
Cultivated land	1	0.7	Linear
Artificial surface	10	1	Exponential
Unused land	12	0.9	Exponential

2.2.3 Extract key ecological corridors

The third step involves developing a resistance surface based on the North China leopard's habitat requirements and migration characteristics. This surface is then utilized to identify key ecological corridors using the Minimum Cumulative Resistance (MCR) model and the gravity model.

Drawing on the habitat characteristics of the North China leopard and the impact of human activities, and referencing relevant studies, 11 evaluation factors were selected to construct the ecological resistance surface (Yang et al., 2022; Yu et al., 2021; Zeng et al., 2022; Zhang et al., 2022) (Figure 3). These factors include habitat environmental factors, such as elevation, slope, and precipitation, along with human activity factors, including proximity to settlements and roads. Using the Analytic Hierarchy Process (AHP) to determine the weights of each factor, the resistance surface was constructed through a weighted summation method. Resistance values for the influencing factors ranged from 0 to 100, where higher values represent greater resistance to the movement of the target species.

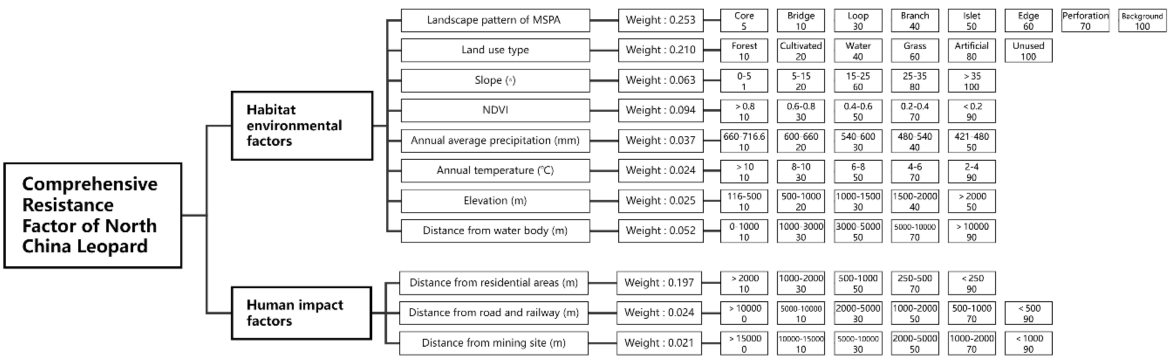

Figure 3. Grading assignment and weight of resistance factor based on the habitat and movement characteristics of the North China leopard

The previously identified ecological sources were converted into point data using ArcGIS software. Leveraging the comprehensive resistance surface, the Cost Distance tool was utilized to compute the minimum cumulative cost distance between source points, resulting in the creation of a cost-backlink raster (Hu et al., 2022). After eliminating redundant corridors, potential ecological corridors were identified.

The gravity model was applied to assess the interaction force between source and target points, with higher values indicating more significant corridors. This enabled the evaluation of the relative importance of ecological corridors. (Wang et al., 2023).

2.2.4 Identify ecological nodes

The fourth step involves identifying ecological nodes, which are categorized into strategic ecological nodes and artificial ecological nodes. Strategic ecological nodes refer to the intersections of multiple ecological corridors and ecological islets situated along critical corridors. According to landscape ecology theory, although islet patches have limited ecological capacity, some patches located on corridors can serve as vital stepping stones within the habitat network (Han et al., 2023). These islet patches are thus designated as strategic ecological nodes.

Islet patches identified through MSPA are extracted and overlaid with the habitat corridor identification results in ArcGIS. Islet patches located on critical corridors are selected and classified as strategic ecological nodes.

Artificial ecological nodes, on the other hand, represent intersections where the ecological network intersects with hard surfaces, such as roads and railways. These areas typically exhibit poor ecological functionality and require urgent ecological enhancement. Constructing three-dimensional ecological greenways at these breakpoints can facilitate species migration and material exchange, thereby improving connectivity within the habitat network.

3. Findings and Discussion

3.1 Findings and analysis

3.1.1 Landscape element identification

Using the MSPA tool in the Guidos Toolbox software, the 2021 land use data of the study area was analyzed. The analysis indicated that the core area represents the largest foreground element, covering 7,399.63 km². This accounts for 69.89% of the total foreground area and 45.13% of the overall study area (Figure 4) (Table 3).

Table 3. Results of MSPA classification statistics

Landscape Type	Total Area (km2)	Foreground Percentage	Study Area Percentage
Core	7399.63	69.89%	45.13%
Bridge	1037.44	9.80%	6.33%
Edge	883.53	8.34%	5.39%
Loop	398.202	3.76%	2.43%
Perforation	223.53	2.11%	1.36%
Branch	375.02	3.54%	2.29%
Islet	270.44	2.55%	1.65%
Total	10587.792	100%	64.57%

The largest patch within the core area is located in the central mountainous region of Heshun County, covering 273.46 km². Large core areas are predominantly distributed in the central and eastern Taihang Mountains within Jinzhong City, with a higher density of patches in the east compared to the west. In other regions, patches are relatively sparse and scattered. The high fragmentation observed in the core areas of the central and eastern regions significantly hinders overall connectivity.

The second largest foreground element is the bridge, accounting for 9.8% of the total foreground area. Enhancing these bridge elements could significantly improve the movement of the North China leopard between core areas. Edge and perforation elements, which are subject to edge effects, account for 8.34% and 2.11% of the foreground area, respectively, indicating the relative stability of the core areas.

Additionally, islets account for 2.55%, while loops constitute 3.76%, serving as diffusion media for species within the core areas. Branches make up 3.54%, facilitating connectivity between the foreground elements and the background.

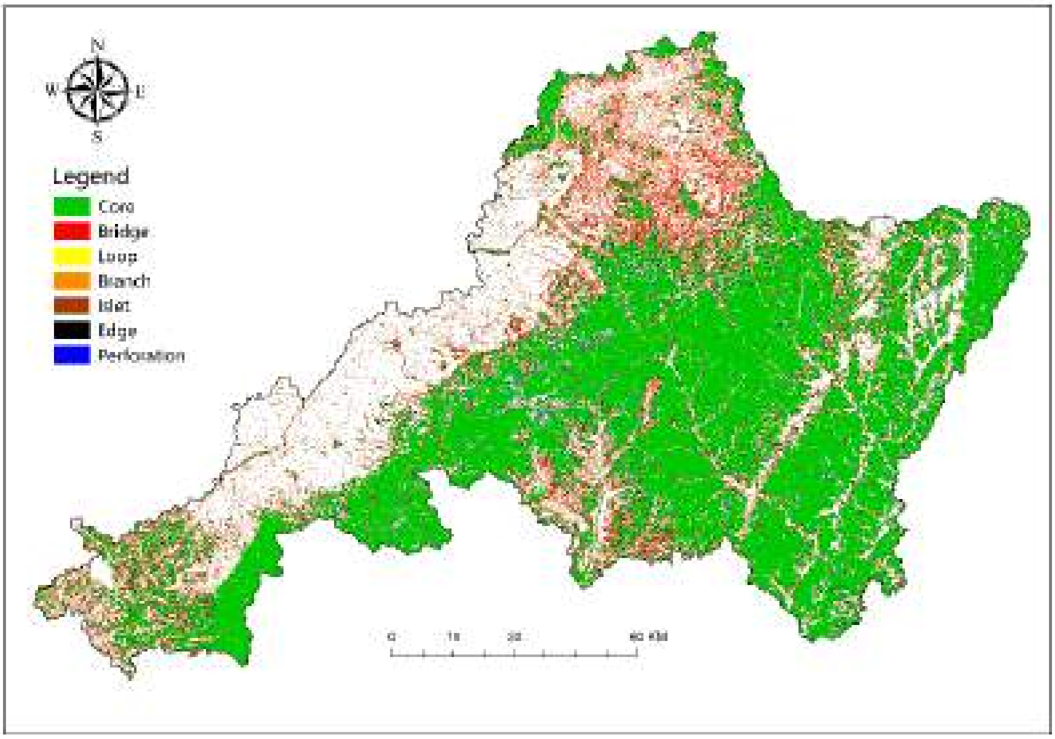

Figure 4. Landscape pattern of MSPA in Jinzhong

3.1.2 Identification and prioritization of habitat sources

The habitat quality index, ranging from 0 to 0.98 (Figure 5), indicates that large-scale, high-quality habitats are predominantly located in the central mountainous region.However, numerous scattered high-quality habitats are also distributed throughout the study area, including the eastern and southwestern parts of Jinzhong City. These high-quality habitats are generally fragmented and significantly impacted by roads, railways, urban areas, and administrative boundaries.

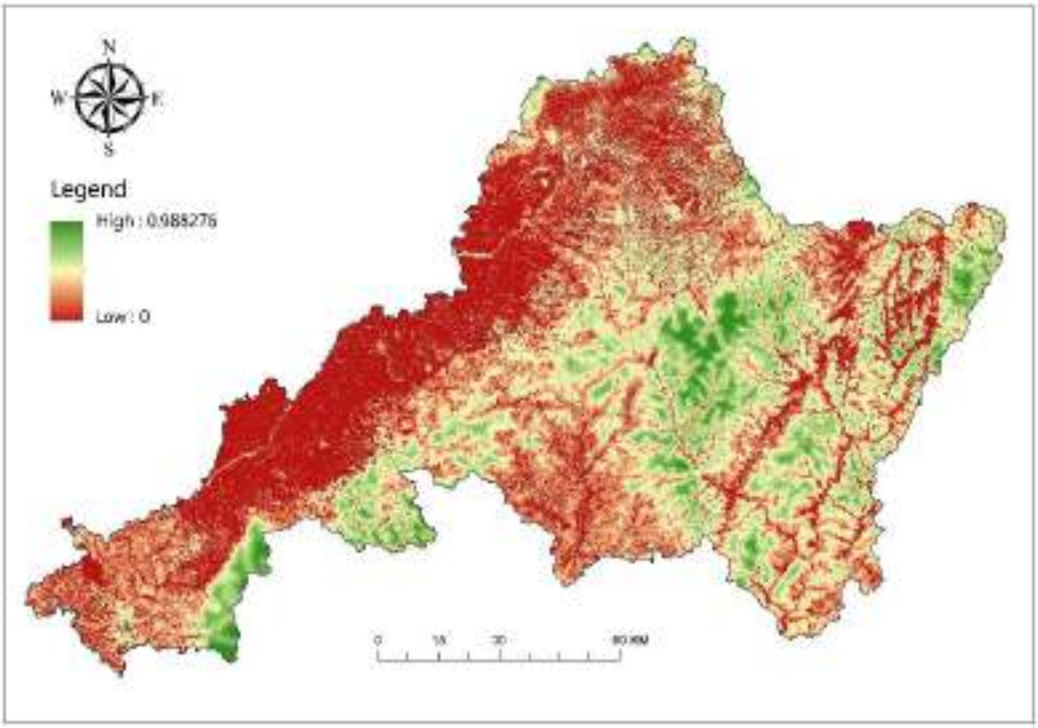

Figure 5. Habitat quality index results

Building on the results from the MSPA and InVEST models, 15 high-quality core habitat patches were identified as habitat sources, covering a total area of 1,701.23 km² (Figure 6). These core habitat sources are predominantly located in the central, eastern, and southern mountainous regions of Jinzhong City. In contrast, no core habitat sources were identified in the northern and western urban belt regions along the Fen River.

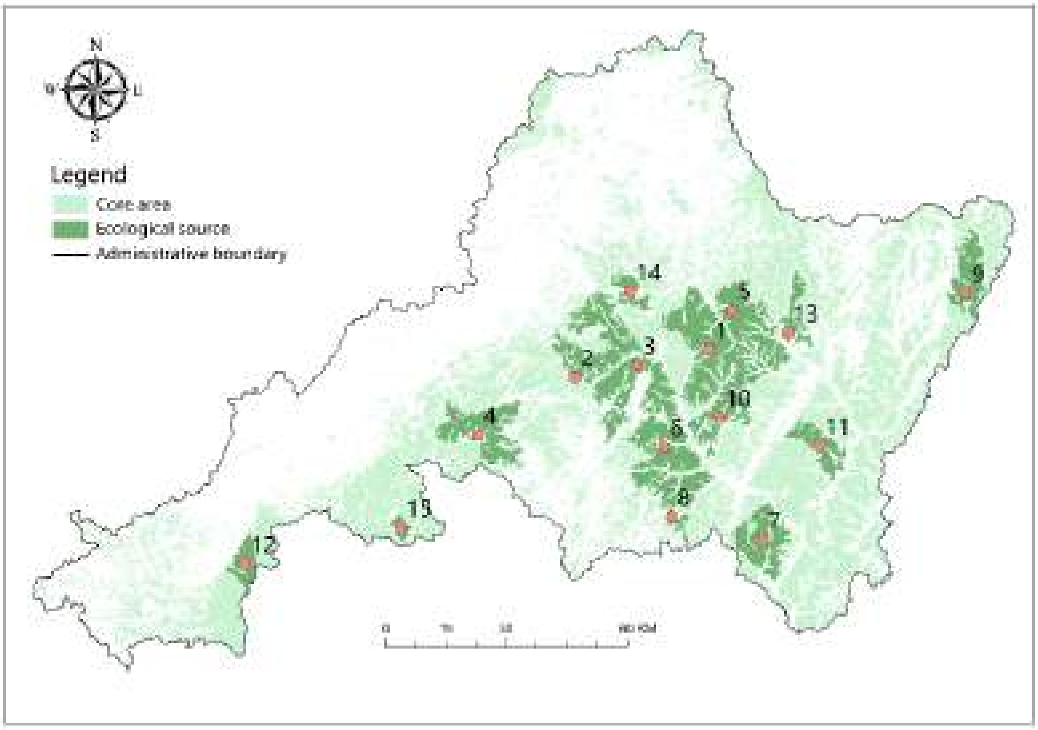

Figure 6. Ecological source land extraction process

3.1.3 Identification and prioritization of habitat corridors

Based on the generated comprehensive resistance surface, resistance values in Jinzhong City range from 8.2 to 97.4 (Figure 7). Resistance values are relatively low in the central-western and southern regions, whereas areas near construction land exhibit higher resistance values. These high-resistance areas include the urban belt along the Fen River valley in the west and the urban settlements along valleys and river corridors in the east. Particularly in the eastern region, urban settlements developing in a linear pattern along valleys and river corridors significantly fragment core habitat sources in mountainous areas, thereby compromising their integrity.

Using the comprehensive resistance surface, the minimum cumulative resistance values between high-quality core habitat patches were calculated in ArcGIS. After removing redundant ecological corridors, 105 potential ecological corridors were identified among the 15 habitat sources in the study area. The gravity model was used to calculate the interaction strength between habitat sources, applying a threshold of 6 and resulting in the identification of 20 significant corridors. These crucial ecological corridors are primarily concentrated in the central region, which benefits from a relatively favorable ecological environment and established nature reserves. However, ecological corridors connecting peripheral habitat sources are lacking, with notable deficiencies in the eastern and southern regions.

To address these gaps and enhance connectivity between the central mountainous region and high-quality core habitats in the southern and eastern regions, nine additional corridors were manually identified as priority corridors for optimization and upgrading. These corridors were selected based on terrain conditions, population distribution, and other relevant factors. Together, the 29 identified corridors are considered important ecological corridors requiring immediate protection.

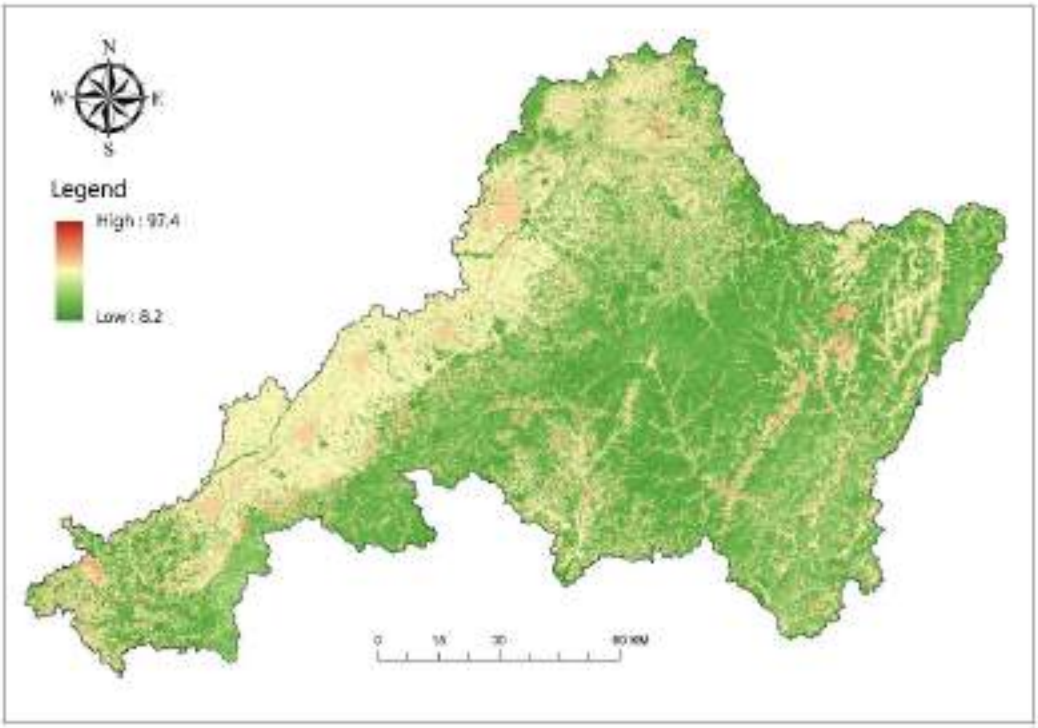

Figure 7. Comprehensive resistance surface derived from habitat and movement characteristics of the North China leopard

3.1.4 Identification of habitat nodes

Using the positive and negative terrain extracted from the comprehensive resistance surface, 24 strategic ecological nodes were identified at the intersections of ecological corridors and natural environmental elements (Figure 8). These strategic ecological nodes serve as fundamental control points within the ecological network.

In ArcGIS, the primary vector traffic network was overlaid onto the ecological corridor network. Combined with an analysis of the current conditions, 19 artificial ecological nodes were identified, including intersections with railways, national highways, and expressways.

In future ecological conservation and construction efforts, emphasis should be placed on the planning, construction, and maintenance of natural vegetation buffer zones along transportation routes. Furthermore, three-dimensional ecological greenways should be established at ecological breakpoints to provide migration corridors and pathways for material exchange, facilitating the movement of the North China leopard.

3.1.5 Construction and optimization of the North China Leopard habitat network

Based on the overlay of analysis results, an optimized habitat network pattern for the North China leopard in Jinzhong City was constructed. The network comprises 15 habitat sources, 29 ecological corridors, and 43 ecological nodes of various types (Figure 9). The spatial distribution follows a pattern of central concentration with peripheral dispersion, and the constructed ecological network exhibits a high degree of integrity.

The study findings indicate that integrating the MSPA, InVEST, and MCR models leverages the strengths of each method, proving both feasible and advantageous for the construction and optimization of habitat networks for focal species. This integrated approach offers an effective framework for enhancing urban ecological capacity and advancing biodiversity conservation efforts.

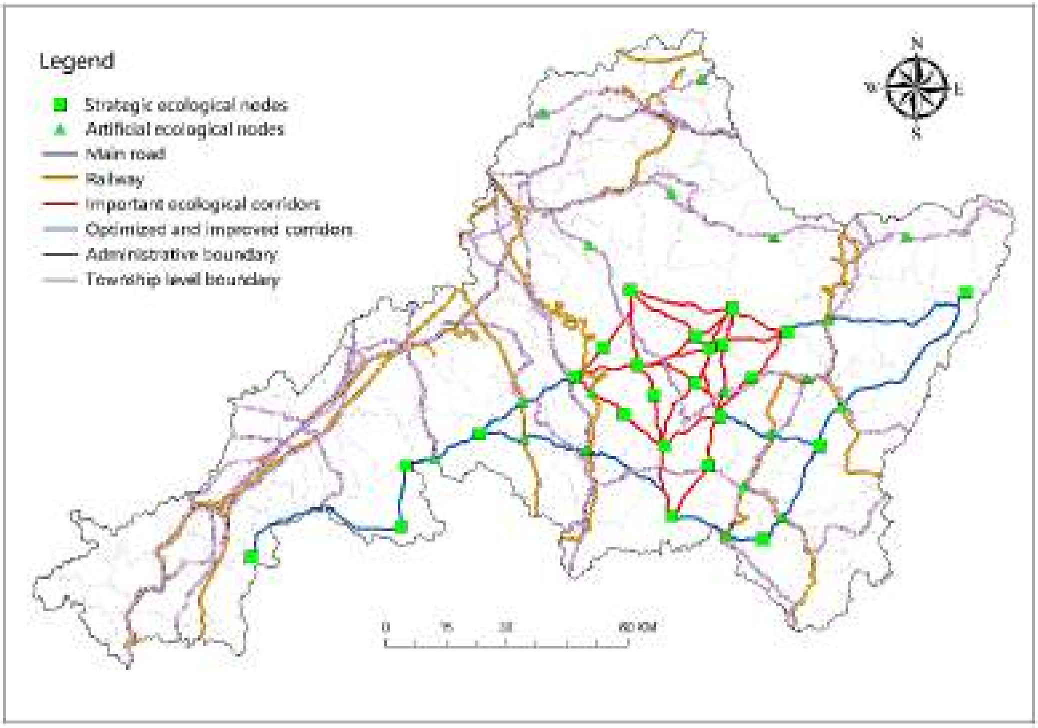

Figure 8. Spatial distribution of ecological corridors and nodes

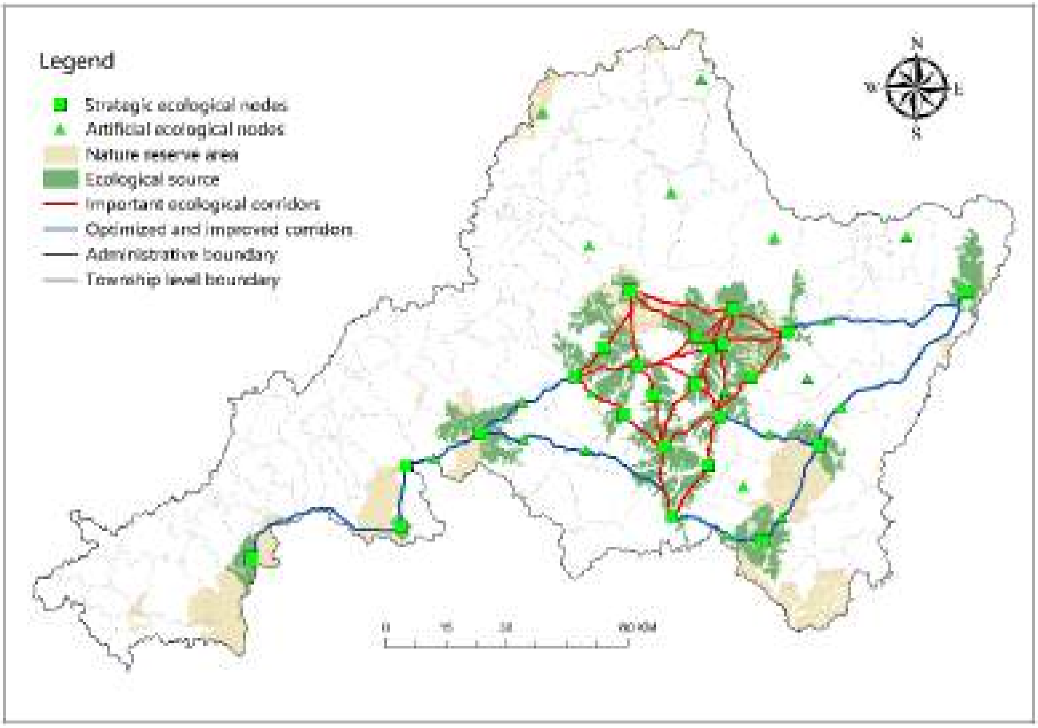

Figure 9. Comprehensive Habitat Network of North China leopard

3.2 Discussion

3.2.1 Strengthen connectivity between high-quality core habitat areas

The MSPA analysis shows that the core area, spanning 7,399.63 km², makes up 69.89% of the foreground elements and 45.13% of the study area. Most of these core areas are found in the central and eastern mountainous regions, with many large core habitat patches. This distribution highlights the strong ecological foundation of the mountainous areas in Jinzhong City. The second-largest foreground element, the bridge, accounts for 9.8% of the total foreground area, reflecting the high potential for North China leopard migration and mobility within the region.

However, the important corridors identified by the gravity model are predominantly concentrated among high-quality core habitat patches in the central mountainous area. Connectivity between the central mountainous area and external regions, particularly the eastern mountainous area, is significantly impeded by transportation infrastructure and settlements along valleys. This fragmentation disrupts the formation of a cohesive habitat network, preventing large core habitat patches in the central and eastern mountainous areas from functioning as a unified ecological unit, which undermines the establishment of a complete North China leopard habitat.

More critically, the eastern mountainous area serves as a key junction for the North China leopard's expansion eastward and northward into the broader central Taihang Mountain region. Limited dispersal opportunities and the gradual isolation of previously connected populations pose severe threats to population biodiversity.

To address these challenges, it is vital to prioritize the protection of existing high-quality habitats and ecological corridors within the central mountainous area while improving connectivity with external habitats (Fan, 2018). Strict protection of linear green spaces, such as forest belts and water systems along key ecological corridors, is essential to maintain their structural integrity. Furthermore, converting farmlands along the corridors into grasslands or forests would enhance habitat quality and connectivity, thereby strengthening linkages between high-quality core habitat areas.

3.2.2 Enhance regional protection cooperation and construct large-scale cross-regional ecological cores

Using the southwestern part of Jinzhong City as an example, the analysis reveals that this area, adjacent to mountainous regions, encompasses extensive high-quality core habitats. However, due to administrative boundaries, the current analysis methods cannot establish important ecological corridors connecting these habitats to the central high-quality core habitats within Jinzhong City's administrative limits. At a broader regional scale, potential routes for high-quality corridors may extend eastward into the neighboring city of Changzhi, and from there, either northward or further eastward. This situation creates potential discrepancies in jurisdictional responsibility for managing high-quality habitat sources and critical corridors.

Furthermore, the provincial-level Tieqiaoshan Nature Reserve in Jinzhong City, which is primarily dedicated to protecting the North China leopard, has boundaries that align with administrative divisions rather than ecological features. These boundaries fail to fully encompass the identified high-quality core habitats in the area. While defining reserve boundaries based on administrative lines facilitates management, this approach lacks scientific precision and limits the comprehensive protection of the habitat network.

To address these challenges, it is essential to coordinate relationships among various levels of protection entities, enhance cross-regional cooperation mechanisms, and develop large-scale cross-regional ecological cores based on a regionally optimized framework (Li et al., 2023). Such efforts will advance the holistic protection of the North China leopard's habitat and support the optimization of its habitat network.

4. Conclusion

This study proposes a method for constructing and optimizing the North China leopard habitat network in Jinzhong City using the integrated MSPA-InVEST-MCR model. The findings indicate the following:1) Core habitat sources are predominantly distributed in the central, eastern, and southern mountainous regions of Jinzhong City, while none are identified in the northern and western urban belt areas along the Fen River. The large core areas exhibit significant fragmentation, with internal patches failing to form tight connections and displaying noticeable characteristics of habitat fragmentation. 2)Important ecological corridors are concentrated in the central region, benefiting from a relatively favorable ecological environment and established nature reserves. However, there is a lack of corridors connecting to peripheral habitat sources, coupled with issues such as low connectivity and insufficient corridor coverage in specific areas. 3)The effective identification and protection of key habitat sources and corridors have improved the structure and connectivity of the ecological network. The constructed habitat network for the North China leopard comprises 15 habitat sources, 29 ecological corridors, and 43 ecological nodes of various types. The spatial distribution follows a pattern of central concentration with peripheral dispersion.

These research findings provide valuable decision-making references for the construction of the North China leopard habitat network in Jinzhong City, the planning and management of key ecological corridors, and regional biodiversity conservation efforts.

Although this study has optimized the selection of ecological sources based on the habitat characteristics and migration behaviors of the North China leopard, the absence of precise observational data on the leopard's specific locations may result in some degree of deviation in habitat source identification and network simulation. Future efforts should focus on integrating multiple data sources, such as biological observation data, to verify and refine the analysis results. This approach will contribute to the development of more precise and actionable strategies, thereby enhancing biodiversity conservation and supporting the habitat restoration in Jinzhong City.

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Conserving Migratory Bird Biodiversity: Habitat Network Optimization in Jiaozhou Bay

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Abstract

Qingdao Jiaozhou Bay is a vital node on the East Asia-Australia Migratory Flight Route (EAAF), which hosts a rich estuarine bay ecosystem. However, urbanization has fragmented crucial habitats for migratory birds. To address this issue, our study focused on seven endangered migratory birds as indicator species, to improve the ecological connectivity of the Jiaozhou Bay habitats. We used the MaxEnt model, incorporating bird distribution, habitat characteristics, and human disturbances, to identify suitable habitats. A resistance surface was created using data such as DEM, NDVl, and proximity to water, roads, and urban areas. The Least-Cost Path (LCP) model and circuit Theory were used to identify key nodes and construct a conservation network. The study revealed 88 core habitat hotspots in estuarine wetlands and marine parks, 317 ecological corridors covering 361.25 km, and 114 pinch points in ponds, tidal flats, and urban green spaces. Additionally, 257 barriers were identified on urban roads and industrial land, needing restoration. We propose optimizing the habitat network, offering practical guidance for conserving migratory bird biodiversity in Jiaozhou Bay.

Keywords: Migratory birds, biodiversity conservation, habitat network, protected area, Jiaozhou Bay

1. Introduction

Jiaozhou Bay, located along China's Yellow Sea within the East Asian–Australasian Flyway (EAAF), is one of the country's most crucial migratory bird routes (Xia et al., 2017). With its unique geographic position and abundant wetland biodiversity, this bay holds significant ecological importance as a vital stopover, wintering, and breeding ground for migratory waterbirds in the Asia-Pacific region. It supports a remarkable diversity of bird species, including gulls, plovers, herons, ducks, and other aquatic and wading birds, as well as raptors and wetland-dependent avian species. A considerable number of these species are classified as globally threatened waterbirds by the International Union for Conservation of Nature (IUCN) (Xing et al., 2024). Recognized internationally, Jiaozhou Bay's coastal wetlands are listed under the Ramsar Convention (UNESCO, 1971) and designated as an Important Bird Area by BirdLife International in *The Global 200: A Representation Approach to Conserving the Earth's Distinctive Ecoregions* (Olson & Dinerstein, 1998).

Despite its ecological significance, the coastal wetlands of Jiaozhou Bay faced substantial degradation before 2014 due to unsustainable human activities. These included shoreline erosion, pollution from water and soil contamination, and illegal poaching, which severely reduced the quality of habitats crucial for supporting migratory bird populations (Zhu et al., 2023). Such pressures not only threatened bird diversity but also weakened the ecological stability of the bay. Addressing these challenges requires the development and implementation of comprehensive coastal landscape planning strategies aimed at restoring degraded habitats, bolstering the resilience of migratory bird populations, and preserving the bay's internationally significant ecological functions.

In summary, as habitats in bay areas become increasingly fragmented and biodiversity continues to decline, species-specific conservation measures are essential to identify and protect the habitats of endangered species while enhancing habitat connectivity. This study focuses on Jiaozhou Bay National Marine Park and its surrounding areas, aiming to safeguard endangered migratory bird populations by establishing a habitat network that preserves the biodiversity and ecological resilience of the bay area. Specifically, the objectives of this research are: (1) to identify potential habitats for endangered migratory bird populations and determine the key environmental variables influencing their distribution, (2) to map connectivity corridors and construct habitat networks, and (3) to designate strategic areas for priority conservation or restoration and propose targeted conservation strategies aligned with the ecological needs of the species and the environmental context.

2. Material and Method

This study broadens the research scope beyond the confines of the Jiaozhou Bay National Marine Park, encompassing coastal regions reclaimed in the past 50 years. The total study area is 396.07 km², consisting of 185.24 km² of terrestrial area (46.77%) and 210.83 km² of marine area (53.23%).

Additionally, the study systematically compiled geospatial datasets of key protected migratory bird species and their surrounding environments within the Jiaozhou Bay area. All datasets were standardized to a spatial resolution of 30 meters, with a unified projection coordinate system of WGS_1984_UTM_Zone_50N, and subsequently clipped to match the study area's boundaries. Seven endangered migratory bird species were selected for analysis, based on their conservation status as listed in the National Key Protected Wild Animals (NKPWA), the IUCN Red List, and the number of recorded sightings within Jiaozhou Bay (Table 1).

Table 1. Information of endangered migratory birds selected for this study

Species	NKPWP	IUCN	Ecological Group	Distribution Records
Thalasseus bernsteini	I	CR	Waterfowls	16
Egretta eulophotes	I	VU	Waterfowls	5
Ichthyaetus relictus	I	VU	Waterfowls	4
Chroicocephalus saundersi	I	VU	Waterfowls	13
Aythya baeri	I	CR	Waterfowls	3
Tringa guttifer	I	EN	Waterfowls	4
Platalea minor	I	EN	Wading birds	3

First, we collected common observation points of endangered migratory birds and environmental data from the study area. We used the MaxEnt model to predict habitat distribution and manually screened core habitat patches for migratory birds by integrating existing satellite imagery. Second, we selected eight indicators from the perspectives of natural suitability and human interference, calculated the environmental resistance surface between habitats, and constructed ecological corridors using the least-cost model. Third, we conducted a spatial analysis of the network based on circuit theory, assessing the connectivity importance of core habitat patches and ecological corridors, and identified key ecological areas that require priority protection or restoration. Finally, we analyzed the relationship between the habitat network and migratory bird conservation on this basis, proposing planning and optimization strategies for the habitat network to achieve effective conservation and enhancement of migratory bird biodiversity in the bay area (Figure 1).

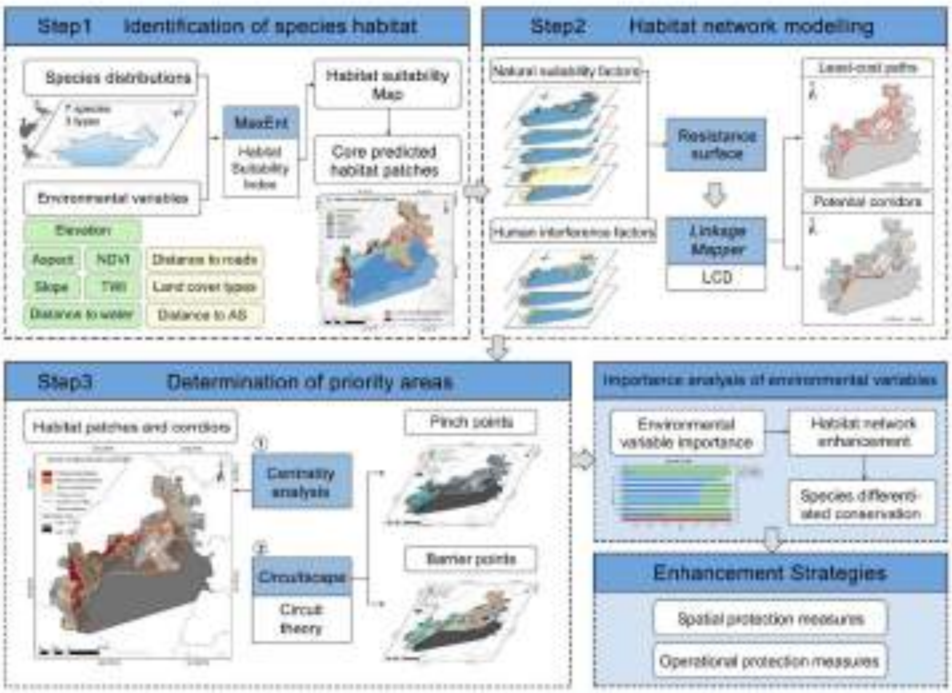

Figure 1. Methodological framework for identifying and optimizing habitat networks.

3. Findings and Discussion

3.1 Habitat patches and corridors

A total of 88 patches with an area larger than 5hm^2 from the most suitable habitat prediction area were identified as the core predicted habitat patches of migratory birds, which accounted for 10.82% of the land area of the study area, and their distribution was concentrated in the western and northern coasts of Jiaozhou Bay, and the land cover types were mainly wetland and grass vegetation.

We identified a total of 217 least-cost paths, with a combined length of 9,415.76 km and an average length of 17.24 km. These paths represent the linear routes between migratory bird habitats with the lowest connection cost. The longest path amounted to 94.21 km, while the shortest measures just 42 m, with 344 paths falling below the average length. Additionally, we identified a total of 7 high centrality-primary habitat patches, 44 medium centrality-secondary habitat patches, and 37 low centrality-tertiary habitat patches, with their area proportions shown in Figure 2a. The primary habitat patches are mainly distributed along the western side of the study area, including the wetlands by the Dagu River, aquaculture ponds, and undeveloped coastal wetlands. The number of corridors by importance level, from high to low, is 40, 62, and 115, respectively. The total length of primary important corridors accounts for the smallest proportion, at only 6.34%. The second most important corridors account for 33.60% of the total length, primarily running east-west and connecting high centrality habitat patches. Meanwhile, the tertiary important corridors constitute the majority, at 60.06% of the total length, with their numbers increasing from the side near the bay to the inland urban areas and generally oriented in a north-south direction. In addition, the habitat network can be divided into three clusters based on the distribution of migratory birds, as shown in Figures 2b, c, and d.

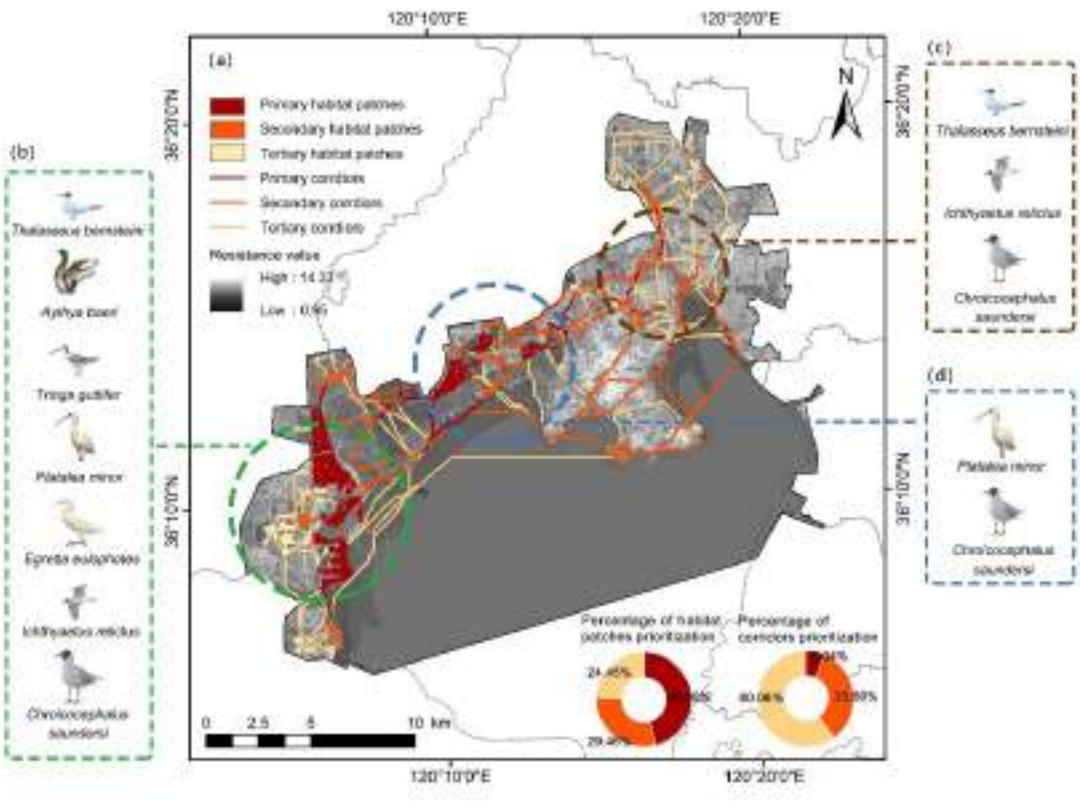

Figure 2. Identification results of habitat network.

3.2 Pinch points and barrier points

As shown in Figure 3, the habitat network contains 34 ecological pinch points with high cumulative current density values, spanning areas of 0.96 km². Analysis of land use data reveals that these pinch points are primarily composed of coastal intertidal mudflats (33.43%), followed by artificial surfaces (18.74%) and water systems (17.61%). In terms of spatial distribution, the pinch points in the western part of the study area are mainly distributed in ponds and mudflats, while the eastern pinch points are mainly distributed in urban construction land, and the increasing process of human activities in their vicinity suggests the risk of ecological degradation in the area. Consequently, there is an urgent need to enhance the safeguarding of these critical areas. Special attention should be paid to preventing undue disruptions caused by human actions.

As shown in Figure 4, a total of 31 ecological barriers were identified within the study area, covering a total area of 6.71 km². These barrier points are predominantly composed of artificial surfaces (68.78%), with the largest barrier point covering an area of 1.20 km² and the smallest at 5400 m². Spatially, barriers are concentrated in the western region of Jiaozhou Bay, particularly within Chengyang District, where residential and industrial land use dominates. In contrast, the eastern region, including Jiaozhou City and Huangdao District, features barriers primarily associated with roads and undeveloped urban construction sites, both of which represent critical elements of long-term urban infrastructure. Therefore, urban development plans should align with ecological protection needs by adopting bird-friendly strategies, such as increasing vegetation green belts and scattered ecological patches, and raising local community awareness about migratory bird conservation, to mitigate the negative impact of barriers on habitat connectivity.

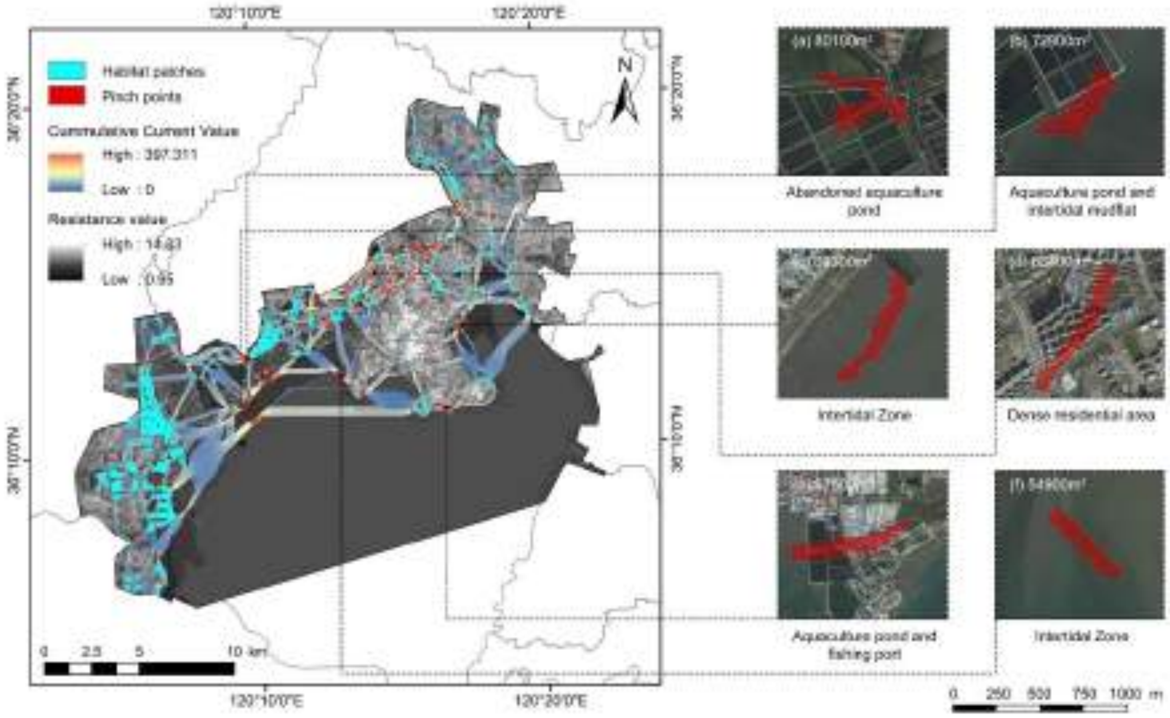

Figure 3. Identification results of habitat network.

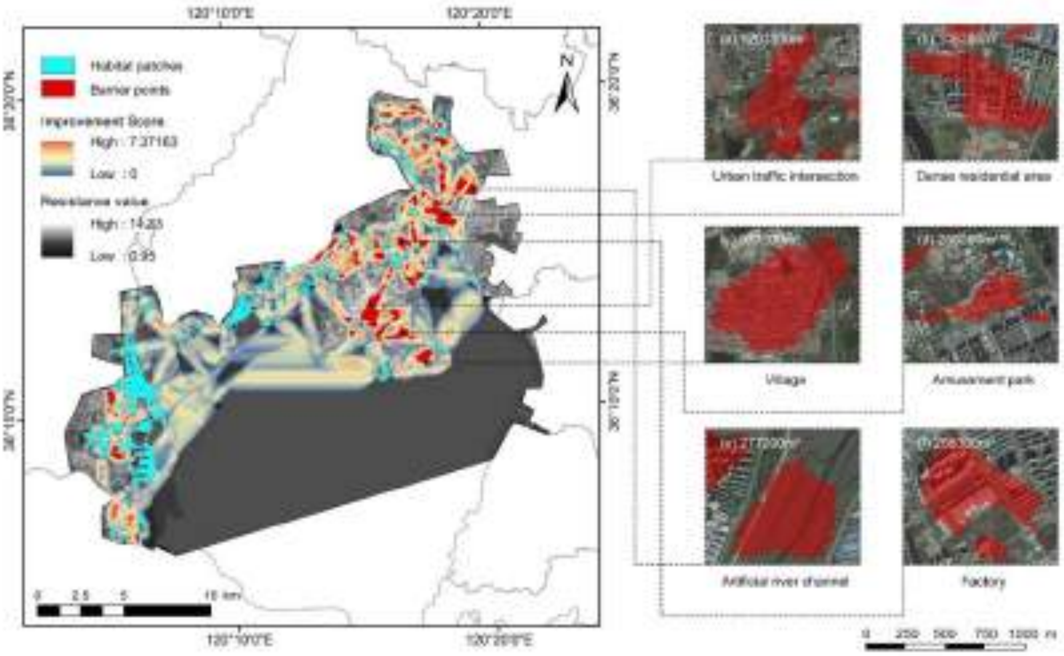

Figure 4. Identification results of habitat network.

3.3 The significance of habitat networks for migratory bird

Habitat networks play an important role in sustaining migratory bird populations in coastal cities, facilitating migratory exchanges, and helping species adapt to habitat changes caused by human interference and climate change (Donaldson et al., 2021). Our study showed that (1) habitat: the core predicted habitat patches of migratory birds, which accounted for 10.82% of the land area of the study area, were not included in the scope of the protected area; the estuarine wetlands, undisturbed grasslands, and pits around the Jiaozhou Bay became the main hotspots of migratory bird diversity, which accounted for 69.92% of the core predicted habitat patches, providing the natural environment with the highest habitat suitability. (2) Corridors: The length of primary and secondary corridors connecting important habitats is less than half of the total length of all corridors (39.94%), and these corridors with high ecological value should be prioritized. Most of the other corridors have low connectivity (60.06%), due to the distance between habitat patches and being blocked by artificial facilities, which makes it difficult for migratory birds to migrate between habitats, and the connectivity of these corridors should be enhanced by ecological stepping stones. (3) Stepping stones: previous studies have suggested that species richness and distribution are affected by corridor width and that the cost of corridor construction and planning options needs to be considered, especially in urbanized areas (Sun et al., 2023). We suggest a width of 200 m for the primary and secondary corridors, which can basically meet the migratory needs of meiofauna and migratory birds (Li et al., 2022). The buffer zone of the corridors encompasses 32 pinch points, which account for 93.60% of the total pinch points in the study area, and it is a convenient and effective way to carry out ecological conservation and restoration work on these pinch points and to use them as stepping stones. (4) Barriers: the corridor buffer zone covers 15 barriers, accounting for 26.36% of the total area of the barriers, which are mainly distributed in Chengyang sistrict in the western part of Jiaozhou Bay, and are dominated by artificial surfaces, shrubs, and grass vegetation, and ecological restoration and reduction of anthropogenic disturbances in these areas. Not only can this greatly enhance the connectivity and stability of the migratory bird habitat network, but it can also improve the quality of the human environment in the cities by the bay (Zhao et al., 2024).

The endangered migratory birds in this study are categorized into swimming birds and wading birds, which can be divided into three categories according to the species-genus: *Anseriformes*, *Ciconiiformes*, and *Charadriiformes*, and each of them has its own focus in the construction of the habitat network (Fig. 4). The *Aythya baeri* belongs to the *Ciconiiformes* and is good at diving to find underwater plants and small aquatic animals for food, usually inhabiting freshwater lakes and marshes. The inland lakes and wetlands on the west side of Jiaozhou Bay, with Ruyi Lake as the core, need to strengthen the construction of the habitat network for the *Aythya baeri*, to establish buffer isolation zones around the wetlands, and to reduce anthropogenic disturbances from the neighboring factories and residential areas. *Platalea minor* and *Egretta eulophotes* belong to the *Ciconiiformes* and usually inhabit estuaries, lakes, and wet coastal grasslands, relying on undisturbed natural environments for breeding and foraging. Its protection is mainly in the coastal wetland area on the west side of Ruyi Lake and Jiaozhou Bay, which is also the core group area in the western part of the habitat network. The *Thalasseus bernsteini*, *Tringa guttifer*, *Ichthyaetus relictus*, and *Chroicocephalus saundersi* belong to the *Charadriiformes*, and their habitats are usually closely related to the coastal environment, preferring to breed and nest on rocky coastlines and islands, and their protection is mainly on the coastline of Jiaozhou Bay, where corridors and stepping-stones can be used as the key areas for observation and protection of the *Charadriiformes*.

4. Conclusion

This study aims to protect the habitats of endangered migratory birds around Jiaozhou Bay by constructing a habitat network based on the MaxEnt model, the minimum cost model, and the Circuit theory and proposes optimization strategies for both spatial and operational protection. The results of the study showed that: (1) 88 suitable habitats for migratory birds (accounting for 10.82 % of the land area), their distribution was concentrated in the western and northern coasts of Jiaozhou Bay, the land cover type was dominated by wetlands and scrub grass vegetation, and the estuaries of the Dagu River and the Nungu River were important habitat gaps that required priority protection. (2) A total of 317 migratory bird habitat corridors were identified in the study area; 34 ecological pinch points are mainly located in wetlands, mudflats, and urban green spaces around the bay, which could potentially become stepping stones for the bird dispersal process; and 31 ecological barriers are mainly located in urban roads, industrial and construction sites, which need to be restored. (3) Only 38.32% of the land in the study area can be used to construct a representative habitat network for migratory birds, and the habitat types and distribution preferences of different families of migratory birds need to be taken into account in the process of network construction.

Our study highlights that critical habitats outside protected areas can be integrated into networks to enhance their ecological integrity and connectivity. Establishing ecological buffer zones in coastal wetlands and intertidal areas to reduce human interference is crucial for conserving migratory bird habitats in coastal bays. This approach offers significant potential to address gaps in the priority areas for waterbird conservation along China's coastline. Future research could extend the application of this framework to other migratory bird populations, urban environments, or scenario studies incorporating climate change and multiple temporal scales, thereby advancing the universality and sustainability of habitat networks for conservation. We propose a habitat network identification and optimization framework based on the ‘source-corridor-node-cluster’ concept, providing scalable and effective insights for the conservation of migratory bird diversity in coastal bays, both in China and globally.

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Assessment of Regional Ecosystem Health in Beijing under Multi-objective Scenarios

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Abstract

A healthy regional ecosystem can continuously provide ecosystem services, which is the foundation for achieving sustainable urban development. Therefore, how to plan and coordinate urban land use from a healthy perspective has become a key research topic in the field of landscape architecture and urban planning. Taking Beijing as an example, a regional ecosystem health assessment framework is constructed, including physical and functional health evaluations of the ecosystem. Based on land use types in 2010 and 2020, the PLUS model is used to predict four target scenarios of natural development, rapid development, ecological protection, and forest construction in 2030, and to explore new methods for healthier urban planning under these four scenarios. The results show that compared with the health status in 2020, the regional ecosystem health assessment results of Beijing's rapid development scenario show a negative value, while other scenarios show a good growth trend, with the forest construction scenario showing the most significant growth. Adhering to ecological priority, green development, and intensive development of construction land, as well as strengthening forest construction, can significantly improve the health status of regional ecosystems.

Keywords: Landscape architecture, regional ecosystem health, multi objective scenarios, predictive simulation, Beijing

1. Introduction

The rapid development of cities has led to continuous changes in the land use pattern. Meanwhile, environmental pollution has become increasingly severe, and the regional ecosystem has been greatly threatened. The regional ecosystem provides the material basis and ecological services for human survival. A healthy ecosystem is characterized by ecological diversity, stability, and recoverability (Liu et al., 2015). Maintaining the health of the ecosystem is the foundation for ensuring the sustainable development of the economy and society (Rapport et al., 2011). For the sustainable development of cities, people have begun to pay attention to the relationship between urban land use planning and ecosystem health, and explore scientific planning methods to improve the quality of the urban human settlement environment.

Land use planning has an impact on urban development, and urban development has a dominant influence on land use changes. Therefore, the simulation of land use changes is an important basis for exploring land use planning (Beroho et al., 2023). With the development of remote sensing and model theory, various land use prediction models have been continuously optimized. Widely used models mainly include the CA - Markov model (Fnais 2024), the PLUS model (Gao 2024). Through model operation and simulation, obtaining the spatio - temporal pattern changes and evolution process of land use can provide references for land use management strategies, which has strong practicality.

The spatio - temporal changes in urban land use types directly lead to changes in the structure and function of the ecosystem, and affect the growth status of regional vegetation, biological material cycling, and biodiversity (Xu et al., 2024). A healthy ecosystem can maintain the integrity of its structure and function under human activities interference (Rapport et al., 1999). Therefore, the health of the regional ecosystem can represent the ecological situation of land use. Currently, ecosystem health assessment methods can be divided into the indicator species method and the index system method. The "vigor - organization - resilience" evaluation system proposed by Costanza is a widely recognized ecosystem health assessment system in the academic community (Costanza et al., 2012), which focuses on evaluating the physical health of the regional ecosystem. The equivalent value of ecosystem services is widely used in the assessment of natural capital (Wu et al., 2024; Zhang et al., 2020). For example, Xie Gaodi (2015) improved it on this basis and released the equivalent table of ecosystem service value per unit area in China. Therefore, this paper combines ecosystem services with the traditional "vigor - organization - resilience" ecosystem health evaluation system to lay a solid theoretical foundation for subsequent planning.

At the present stage, the research on land use planning and regional ecosystem health is relatively comprehensive, but there are still some limitations: 1) Most of the land use planning research based on scenario simulation purely analyzes the changes in land use types and their mechanisms. A small number of literatures explore better solutions for urban development planning from perspectives such as landscape pattern (Qi et al., 2018; Jiang et al., 2023) and ecosystem services (Feng et al., 2023; Wu et al., 2015). However, the above - mentioned index system perspectives are relatively single, unable to comprehensively consider the spatio - temporal differentiation law of the ecosystem and relevant regional resource and environmental issues, making the final planning decision somewhat one - sided; 2) The regional ecosystem health assessment system integrates theories of ecology, landscape architecture, human geography to analyze ecological and social problems in the process of urbanization (Peng et al., 2015; Khoroshev et al., 2024). It focuses more on the analysis of past or current urban development, and has a relatively complete evaluation system (Peng et al., 2017; Xiao et al., 2023). However, in the existing ecosystem health assessment, there is a lack of comparative research on the assessment of future urban land use planning, so further exploration is needed.

2. Material and Method

2.1 Research area and data sources

Beijing is located at 39°40′ - 40°20′N and 116°00′ - 117°00′E. It has a warm – temperate semi - humid continental monsoon climate, with a total area of about 16,410.54 km². The terrain is high in the northwest and low in the southeast. The west, north, and northeast are surrounded by mountains, and the southeast is a plain. The main land use types are construction land, forest land, and cultivated land. A large amount of construction land is concentrated in the plain area and shows a radiation trend. Forest land is mainly distributed in the mountains in the west and north, and cultivated land is mainly distributed in the suburban areas outside the construction land.

The 30m×30m Landsat TM remote - sensing images of Beijing in 2010 and 2020 from the Geospatial Data Cloud are interpreted into six land use types, namely forest land, grassland, cultivated land, construction land, water area, and unused land, through ENVI5.3. ArcGIS10.2 is used to visualize the digital elevation and slope of Beijing with a resolution of 30m. The PLUS model is used to simulate the land use distribution of Beijing in 2030 based on the above data, and Fragstas4.2 is used to analyze the landscape pattern index of the study area.

2.2 Research Methods

2.2.1 Land use simulation: PLUS model

The Patch - generating Land Use Simulation (PLUS model), which is raster - based, has the advantages of better exploring and analyzing the change mechanisms of various land use patches, revealing the laws of land use structure changes and their driving factors, and effectively improving the simulation accuracy (Liang et al., 2021). It has certain advantages in expressing the spatio - temporal changes of land use and can better simulate the spatio - temporal pattern of regional land use.

The PLUS model is utilized to obtain the transfer probabilities of various land use types based on the land use types in 2010 and 2020. On this basis, the land use transfer probabilities of each scenario are adjusted according to the urban development goals. The relevant natural and social elements are configured according to the attributes of each type of land use, and the limiting conditions and influencing factors are determined.

2.2.2 Regional ecosystem health assessment framework

The basis and core of regional ecosystem health assessment is to construct a reasonable indicator system (Ashraf et al., 2023). Traditional regional ecosystem health assessments usually adopt the "vigor - organization - resilience" system to measure the physical health level of unit ecosystems, focusing on the integrity and sustainability of the ecosystem itself. However, simply analyzing the structure of the ecosystem is incomplete. Marcello pointed out that the comprehensiveness and integrity of the ecosystem require considering the role of the ecosystem for humans (Marcello et al., 2022). As an important evaluation system for characterizing the health of the human - nature coupled ecosystem, ecosystem services are an important bridge connecting the impact of land use on human activities and ecosystem health.

Therefore, the regional ecosystem health (H) evaluation indicator system constructed in this paper consists of two parts: ecosystem physical health (PH) and ecosystem functional health (FH). The calculation formula is:

$$H = \sqrt{PH \times FH}$$

Among them, PH covers three evaluation contents of "vigor (V) - organization (O) - resilience (R)", The calculation methods for each indicator are shown in Table 1.The calculation formula is:

$$PH = \sqrt[3]{V \times O \times R}$$

Table 1. The Vigor (V) and Resilience(R) of Ecosystems of Different Land Use Types

Land use	Forest	Grassland	Farmland	Construction land	Water area	Unused-land
vigor (V) NPP(gC/m2·a)	642.9	382.0	426.5	374.1	236.8	80.9
resilience (R)	0.85	0.73	0.47	0.80	0.27	1.00

The organization selected six research indicators, Shannon Diversity Index (SHDI), the Area-Weighted Mean Patch Fractal Dimension (AWMPFD), the Landscape Fragmentation Index (FN1), the Landscape Contagion Index (CONT), the Forest Fragmentation Index (FN2), and the Patch Cohesion Index (COHESION), for the research. The calculation formulas are as follows:

O=0.35×LH+0.35×LC+0.3×CC

=0.25×SHDI+0.1×AWMPFD+0.25×FN1+ 0.1×CONT+0.2×FN2+0.1×COHESION

Ecosystem Resilience (R) refers to the ability of a regional ecosystem to restore its original structure and functions after being subjected to external disturbances (Feng et al., 2015). The resilience of an ecosystem is closely related to land use types.

$$R = \sum_{i=1}^{n} A_i \times RC_i$$

R represents the resilience of the regional ecosystem; Ai is the area of land use type i; RCi is the ecosystem recovery coefficient of land use type i; and n is the number of land use types.

FH is composed of the value of ecosystem services. The entire assessment system, while maintaining the stability and sustainability of its own structure, functions, and ecological processes, also ensures the sustainability of ecosystem services.

For the evaluation of the ecosystem service value in Beijing, the ecosystem service value evaluation model published by Costanza (2012) and the equivalent value table of ecosystem service value per unit area in China improved by Xie Gaodi (2015) were referred to, in order to calculate the values of four types of services provided by different land use types.

3. Findings and Discussion

3.1 Analysis of land use characteristics

Analysis of Land Use Area: During the land use changes from 2010 to 2020 (Figure 1), the areas of ecological land (woodland, grassland, and water areas) all showed an upward trend. Among them, the increase in woodland was the most significant, with a growth of 10.36% from 2010 to 2020, and the main changes occurred in the western and northern parts of Beijing. Next came the grassland, which increased by 3.28% compared to 2010. Other ecological land, including grassland and water areas, increased by 3.28% and 0.17% respectively. In contrast, the transfer probabilities of cultivated land, construction land, and other land showed a downward trend. The decline in cultivated land was the largest, dropping by 9.42%, and construction land decreased slightly by about 0.56%. The analysis results of the changes in land use types are in line with policies such as the million-mu afforestation, returning farmland to forest, and intensive urban development in Beijing from 2012 to 2020. Against this backdrop, Beijing has formed a forest city ecological pattern with large areas of forests as the base and large ecological corridors as the framework.

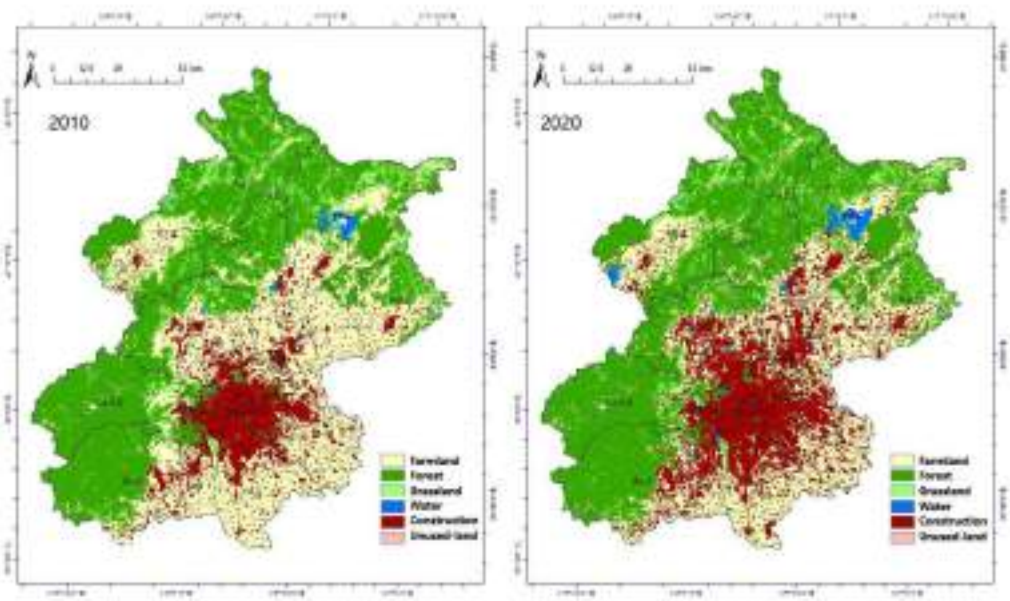

Figure 1. Land use types in 2010 and 2020

Analysis of Land Use Conversion: Beijing's planning and development adhere to the principle of ecological priority and green development in ecological civilization construction. Combining with the current construction conditions, four scenarios, namely natural development, rapid development, multi - objective protection, and forest construction, are selected to simulate the land use changes in Beijing in 2030 (Figure 2). Scenario 1 is Natural Development (ND), that is, according to the historical trajectory and current trend of urban development, the simulation is carried out based on the land use transfer probabilities in Beijing from 2010 to 2020; Scenario 2 is Rapid Development (RD), which only emphasizes the development of construction land with high social and economic value, expands the area of the urban built – up area. Under the condition that the water area remains unchanged, the transfer probabilities of forest land, grassland, and cultivated land to construction land increase by 30%, and the transfer probability of other land to construction land increases by 50%; Scenario 3 is Ecological Protection (EP), aiming to strengthen the protection of ecological land such as forest land, grassland, and water area. At the same time, considering the economic development needs of Beijing, the transfer probabilities of construction land and cultivated land remain unchanged, and only the transfer probabilities of other land to forest land and grassland increase by 10% and 5% respectively (Table 4); Scenario 4 is Forest Construction (FC). This scenario refers to the forest - construction strategies in "Beijing Forest City Construction and Development Plan (2018 - 2035)" and "Overall Plan for the New - round One - Million - Mu Afforestation and Greening Action Plan in Beijing in 2018", giving priority to expanding the area of forest land, reducing the expansion speed of construction land, and increasing the transfer probability of the other five types of land to forest land by 15%.

Overall, except for the rapid - development scenario, forest land is the main land use type in other scenarios, all exceeding 55%. This is an advantageous condition for Beijing's forest - city construction; the areas of construction land all show a downward trend, indicating that urban construction is more inclined to intensive.

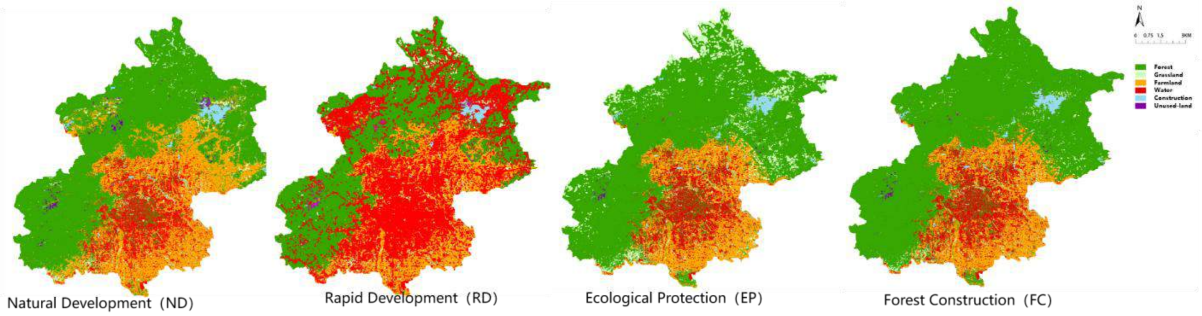

Figure 2. Land use under four scenarios of simulation in 2030

3.2 Regional ecosystem health assessment

Taking the land use data in 2020 as a reference, the regional ecosystem health assessment and analysis were carried out to explore the urban land use planning methods that are healthier than the current situation. Judging from the values of H, PH, and FH under each scenario (Figure 3), except that a negative value appeared in Scenario 2, the other scenarios all showed a good growth trend. Both Scenario 3 and Scenario 4 had relatively obvious growth, and the increase in Scenario 4 was the largest, indicating that ecological land such as grassland, water areas, especially woodland in land use types has an important impact on the regional ecosystem health. Among the four scenarios, except that the V indicator in Scenario 2 showed a relatively high negative value, the V, O, and R in the other scenarios all showed an improvement trend, indicating that the negative value of the ecosystem physical health in Scenario 2 was mainly affected by V.

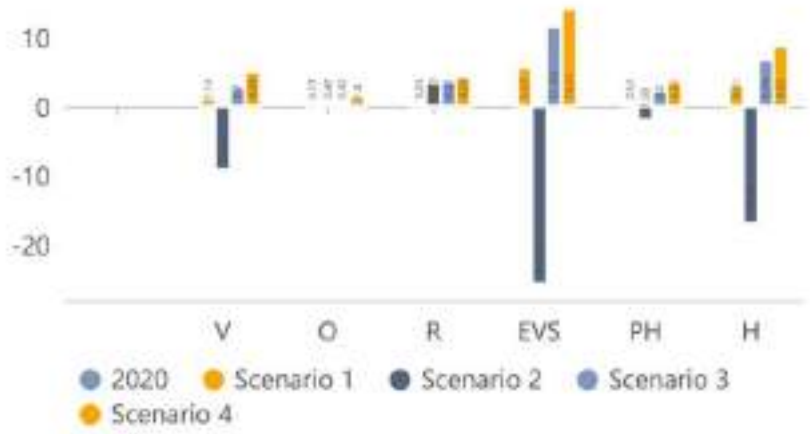

Figure 3. The increase in the results of the four - scenario ecosystem health assessment in 2030 compared with 2020.

4. Conclusion

Land use planning is the carrier for studying urban development. The urban development goals have a relatively direct impact on the planning results and are also the most direct manifestation of the mutual influence between humans and ecosystems. Combining the theoretical knowledge of multiple disciplines such as ecology and landscape architecture, a regional ecosystem health assessment system composed of Physical Health of Ecosystems (PH) and Functional Health of Ecosystems (FH) has been reconstructed and incorporated into land use planning research to expand relevant research directions such as regional ecosystem health and land use planning.

Based on the PLUS model, this paper divides the land use into four scenarios, namely natural development, rapid development, ecological protection, and forest construction, according to urban development goals for predictive analysis. Compared with the data in 2020, the regional ecosystem health data under the four scenarios showed negative growth only under the rapid development scenario, while the other three scenarios all had good growth. In particular, the increase in regional ecosystem health under the forest construction and development scenario was 8.63%. From the land use and health data, it can be seen that excessive occupation of other land by construction land will have an adverse impact on regional ecosystem health, while ecological land such as grassland, water areas, especially woodland, has an important positive impact on regional ecosystem health, which is closely related to the relatively high Net Primary Productivity (NPP), resilience, and ecosystem value of woodland. Therefore, Beijing needs to adhere to the principle of ecological priority, intensively develop construction land, and increase the construction of forest land, so as to improve regional ecosystem health to a greater extent.

At present, the regional ecosystem health assessment lacks applied research on urban land use planning, but it has been widely applied to land use changes within the existing urban area, forming a relatively mature system. Therefore, the research method that combines land use simulation with the establishment of a regional ecosystem assessment system has certain applicability to urban land use planning and can make planning decisions more objectively. If the research method is applied to different cities, from the perspective of land use simulation, it is necessary to clarify the development scenarios defined by future urban development goals and the transfer probabilities of various types of land; from the perspective of regional ecosystem health, since there is no absolute measurement standard for health, the weights of the indicators in the assessment system can be set according to the specific research area.

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A Case Study of Cultural Heritage Protection from the Perspective of Landscape Architecture

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Abstract

Cultural heritage is the wealth left by history to humanity. It is a cultural relic with historical, artistic, and scientific value, and it is a traditional culture closely related to people's lives and inherited from generation to generation. China has many cultural heritage sites of diverse types that need urgent Protection and utilization. Current research on heritage conservation mainly focuses on architecture and urban Planning, lacking theoretical perspectives from landscape architecture. This paper examines how designers from different cultural backgrounds interpret and evaluate cultural heritage, exploring its cultural and social values while applying landscape approaches for conservation. By analyzing global case studies, this study introduces new directions for heritage preservation, emphasizing landscape architecture's role in cultural sustainability and international heritage protection.

Keywords: Cultural heritage, landscape architecture, heritage protection, heritage value

1. Introduction

Cultural heritage, including natural heritage, architectural heritage, agricultural heritage, and any historical heritage related to human civilization, often records the honor, disgrace, rise, and fall of a region or a period of history (Li, 2012) and has important value in the history of human development. Therefore, designers explore the cultural and social values of different types of heritage through the process of interpretation and evaluation of heritage and protect and continue the heritage through landscaping. This paper analyzes how designers from different regions and cultural backgrounds in the world will face the problems and cultural background of the site when facing different types of cultural heritage and how to integrate the landscaping techniques into their works to provide a new perspective for future cultural heritage protection - the perspective of landscape architecture.

2. Overview of World Cultural Heritage Protection and Case Selection

2.1 Overview of Cultural Heritage Protection

Cultural heritage is a natural landscape and human historical site with scientific, aesthetic, and cultural values recognized by UNESCO (Zhang, 2011). The concept of cultural heritage has expanded from focusing on historical relics, historical buildings, human cultural sites, and other material cultural heritage to covering intangible cultural heritage. From the beginning of the Protection of historical cities and historical sites to the development of the historical environment, the international community has covered more and more extensive content. People's vision has also developed from the initial focus on the importance and uniqueness of heritage components to the focus on the natural environment, social customs, and traditional culture. Therefore, the Protection of cultural heritage has changed from focusing on the heritage itself to focusing on the development of the surrounding environment, from focusing on individuals to focusing on groups, from paying close attention to the material level to paying equal attention to both material and non-material, from the Protection of a single element to the Protection and development of a composite overall system, from passive Protection to active use, the issue of heritage protection has become more and more comprehensive, and the protection concept has become more and more scientific and inclusive. However, the current research practice on the Protection and continuation of cultural heritage mainly focuses on the perspective of architecture and urban Planning. It lacks relevant theories and research from the perspective of landscape architecture.

2.2 Case selection

Facing more and more comprehensive heritage protection issues, designers began to try to integrate the perspective of landscape architecture to protect and continue cultural heritage. More and more heritage protection projects have begun to emerge and reflect on this new perspective. These projects can be summarized in four aspects: materialization of human civilization imprints, landscaping of historical industrial features, Protection of cultural relics and natural features, and integration of heritage features and public life. Therefore, we choose the Xihoudu Relics Torch Park in Shanxi Province, the Blood Run Relics in Iowa, the United States, the Owens Lake Earth Art in California, the Olana State Historical Site in the United States, the vegetable and fruit garden irrigation system in Caldes de Montevideo, Spain, and the Algaida salt marsh path in Cadiz Bay, the United States, which focuses on the materialization and reproduction of human civilization, Shanxi Datong Ancient Great Wall Cultural Site, mainly focusing on the Protection of cultural relics and natural features, and the Lorsch Monastery in Lorsch, Hesse, Germany (Cloister Lorsch), Spanish Iberian Peninsula Cross Cape Mediterranean Club, Te Whau Pathway in Auckland, New Zealand, which focuses on the integration of heritage style and public life, Mount Royal Heritage Site in Montreal, Canada, and Ringdijk Park in Amsterdam, the Netherlands. This paper discusses the Protection and utilization of cultural heritage in the world from the perspective of landscape architecture.

3. Case analysis of cultural heritage protection

3.1 Materialized reproduction cases of human civilization imprints

3.1.1 Xihoudu Relics Holy Fire Park - a narrative cultural landscape that reproduces the process of human "fire" civilization.

3.1.1.1 Project overview

Xihoudu Site is located in Fenglingdu Town, Ruicheng County, Shanxi Province, at the junction of Shanxi, Shaanxi and Henan provinces. It is a world-famous site and one of the most important archaeological sites for prehistoric human activities. The second National Youth Games will be held in Shanxi in 2019. The existing flame square at the Xihoudu site needs to be reconstructed to hold the flame collection ceremony of the second Youth Games.

3.1.1.2 Protection and utilization methods of cultural heritage

The plan preserves the existing facilities, such as the fire-taking platform and ignition platform on the flame square, and uses the creation technique of earth art to transform the flame. The square and its surrounding environment are integrated into a holy, flexible, and philosophical place. With the theme of "the discovery of fire," "the etiquette of fire," and "the tame of fire," the philosophy of "the unity of man and nature" in ancient civilization is reinterpreted, thus forming three narrative and coherent cultural experience landscapes.

The first scene takes "discovery" as the theme, implying the relationship between the discovery of fire and the birth of human civilization. The sound device takes Xun as the prototype, which represents the cave life after the discovery of fire. In addition, the device connects the inside and outside of the cave through sound, connecting heaven and earth and becoming a place and container for people to talk. The second venue, themed "etiquette," built a stepped viewing platform around the ignition platform by taking advantage of the large sandstone blocks demolished during the reconstruction of the original square and combining them with the surrounding terrain. Here, people can enjoy the surrounding scenery and appreciate the beauty of the ancient "Yue Du looks at each other" ("Yue" refers to Huashan Mountain, "Du" refers to the Yellow River). The third field takes "tame" as the theme. It transforms the original construction waste dump into the form of a "gully," forming a labyrinth-like path, symbolizing the arduous process of human discovery and use of fire (Xihoudu Relics Holy Fire Park, 2020).

3.1.2 Overall Planning of the Blood Run site landscape in Iowa - reproduction of Indian settlement culture

3.1.2.1 Project overview

The Blood Run Site, located in Lyon County, Iowa, USA, is currently the largest and most complex Indian site in the Americas. It includes many earthmounds and other Indian settlement characteristics.

3.1.2.2 Protection and utilization methods of cultural heritage

The design team applied the method of building a cultural landscape to carry out the overall Planning of Blood Run so that a series of cultural nodes in the site would have a "dialogue" on the spatial sequence. During the planning process, various stakeholders, including local aborigines, farmers, landowners, outsiders, economic experts, historians, and naturalists, were gathered to listen to their demands and voices, and through comprehensive quantitative and qualitative research, the "will" of the landscape itself was deeply understood. The resulting cultural landscape master plan provides a thorough and detailed framework for the creation of interstate parks that respect, protect, and emphasize the unique heritage of the region, enhance the cultural, historical, and natural resource values of Indian sites, and promote people's understanding, utilization and appreciation of heritage through popular science education and supporting leisure facilities, aiming to provide a foothold for the future development of Blood Run sites. It seeks to find a foothold for the future development of the blood transportation site and make it an inspiring spiritual harbor and home for life (ASLA, 2018).

3.1.3 Land Art of Owens Lake - Translation and Landscape Reproduction of Indigenous Culture

3.1.3.1 Project overview

Owens Lake is located in Owens Valley on the east side of the Sierra Nevada in Inyo County, CA, USA. Due to the population expansion in this area, water resources are continuously lacking. As the lake dried up in 1926, it became the largest single source of dust pollution in the United States.

3.1.3.2 Protection and utilization methods of cultural heritage

The landscape designer has designed a land artwork named "Whitecaps" using local native materials, which was inspired by the Owens Valley on the east side of the site. It shows the scene of the 110 square mile (about 285 km^2) lake surface blown by the strong wind from the valley. In addition, the form of "white spray" encloses different spaces, providing shelter and habitat for migratory birds, mammals, and invertebrates. At the same time, the design also takes into account the integration of Indigenous culture in the site, such as the commentary platform and information pavilion designed with the inspiration of Indigenous symbols and rock paintings found in local archaeology, the pavement designed with local woven patterns as the prototype, and the pavilion and square designed with local endangered animals as the prototype (ASLA, 2017).

3.2 Landscape reproduction of historical industrial characteristics

3.2.1 Planning and design of Orana strategic landscape - exploring the aesthetic and ecological potential of the manor farm

3.2.1.1 Project overview

Olana State Historic Site is located on 101 hm2 of land in Hudson Valley, New York, USA. Frederic Church used to live, work, and paint here. He is also a famous painter of the Hudson River Painting School. Against this background, the strategic landscape planning and design of Olana put forward rectification suggestions for the entire site, mainly the Olana Center, the farm, and the residential environment, aiming to transform the historical sites of Olana into a complete comprehensive tourist area.

3.2.1.2 Protection and utilization methods of cultural heritage

The design team uses historical data, field research, and workshop opinions. It combines the consulting team's views on the Orana site and a series of geographical and spatial analyses of its surrounding environment, drawing maps and charts so as to identify landscape elements such as land use properties, hydrology, soil, and slope. Based on this, the team developed a restoration plan for the farm complex to restore the historical landscape of the site in the second half of the 19th century (Figure 3). It is planned to move the existing tourist center to the Orana Center so that tourists can establish a basic understanding of the site before entering the historical core area and encourage people to integrate into the site faster. Restore the historical appearance of the residential environment and reproduce the world described by the Church. The farm is the core of the manor. It has the style of Ferme Orn é e Garden in Europe in the 18th century and is an important part of the Church's paintings. In the Planning and design of the farm, the historical scene and agricultural function of the farm will be restored, and the local tax will be created by providing popular science education for tourists. At the same time, the aesthetic value of the local agricultural landscape will be highlighted. On the basis of protecting the existing historical sites, Olana's strategic landscape planning and design explores the artistic value of productive landscape and integrates various activities, thus activating the connection between landscape and the broader ecosystem and reflecting the historical, cultural, and ecological values of the sites (ASLA, 2017).

3.2.2 Revitalization of vegetable and orchard irrigation system in Caldes de Montevideo - restoration of agricultural facilities and activation of town

3.2.2.1 Project overview

The project is located at the outer edge of the "Hortes de Baix" in Caldesdemonbuye, Spain, and has a history of irrigated agriculture. However, with the development of the city, the proportion of water pollution, farmland degradation, and agricultural population has decreased year by year, making the formerly rich land gradually decline. Fortunately, this issue has received public attention. As the carrier of public property and intangible heritage, water needs to be reintegrated into people's lives.

3.2.2.2 Protection and utilization methods of cultural heritage

The Municipal Public Space Committee launched the water body restoration project, hoping to clean irrigation water sources, drain wastewater, and other ways to build a historic water system and reintegrate it into the city. Through community-based participatory investigation, the team proposed an innovative plan to establish a "floating garden" to address water pollution. By planting aquatic plants in the water system, the team absorbs pollutants in the water body through their filtration and adsorption. In the whole process, the design team cooperated with the agricultural organization, found loopholes in the management of private hot spring water, and decided to introduce the surplus water into the irrigation water system, as well as the excessive water use in the hot spring bath (Revival of irrigation system in Kardesdemonte vegetable orchard, 2017).

3.2.3 Algaida salt marsh path - reappearing the features of historical salt production

3.2.3.1 Project overview

The site is located in the Cadiz Bay Natural Park in Spain, which is a salt marsh. It has become a part of the Bah í a de Cadiz's Network of Free Spaces. It provides leisure places for residents in the surrounding expanding cities. The site was once a salt field used for salt production, but now it is abandoned.

3.2.3.2 Protection and utilization methods of cultural heritage

Through investigation, biologists found that the whole site has three prominent environmental units, which are connected by means of an embankment top road. Therefore, the designer selects locally recycled sand and stone as construction materials, sets up landscape footpaths in the original accessible places, and builds railway sleeper bridges above the salt marsh, improving the road system in the site and ensuring the water flow of the salt marsh. In order to protect historical traces, the designer designed devices for people to stay and think on the site by using a large number of waste metals and wood. These devices are half buried in the soil, just like the traces left by the sea when the tide ebbs (ACTA, 2010).

3.3 Protection of cultural relics and natural features

3.3.1 Datong Ancient Great Wall Cultural Relics Corridor - Site Revitalization Plan for Overall Landscape Protection

3.3.1.1 Project overview

The ancient Great Wall of Datong was mainly built in the Ming Dynasty. After many vicissitudes, it is still partially preserved in Datong, Shanxi Province, but is facing weathering invasion Threats such as erosion, water and soil loss, and artificial damage. Based on this, the design team proposed a revival plan based on linear cultural heritage protection.

3.3.1.2 Protection and utilization methods of cultural heritage

Use the research framework of heritage corridor for reference, conduct comparative research on different technical methods, and the team finally determines "heritage Prime identification - resource evaluation and analysis - spatial pattern construction ". The cultural heritage shall be protected and repaired in the way of minimum intervention and overall Protection, and the virtual reality technology shall be combined to provide a variety of cultural display and experience services for heritage in different construction periods and different conservation statuses. In addition, the plan not only protects historical sites but also guides rural residents to plant cash crops, develop sightseeing agriculture and rural tourism, and promote the flexible development of local industries. This has achieved a balance between Protection and development, culture and tourism, industry and ecology, and driving the development and Revitalization of the region (Feng & Chen, 2019).

3.3.2 Lorsch Monastery - leave the spiritual memory of the place with "carving."

3.3.2.1 Project overview

Cloister Lorsch, located in Lorsch, Hesse, Germany, was recognized as a world cultural heritage by the United Nations in 1991. It is one of the most representative relics of Germany's "pre-Roman" architectural art and represents the achievements of engineering construction between the 8th and 18th centuries. However, there are few scriptures stored in it earlier, and the empty shells left behind are like distant cultural memories. The history of the monastery can be traced back to 767 AD when the monks lived in a monastery near the Weschnitz River and later moved to a small hill surrounded by walls. Today, the "Torhalle Gate" and church buildings on the hill are the only relics of the entire monastery (Zhuston & Tang, 2015).

3.3.2.2 Protection and utilization methods of cultural heritage

This project is based on the only two remains of the monastery site. The design team adjusted the location of the entrance and parking lot of the original monastery, Replan the tour route according to chronological order so that people could trace back the history on the basis of the overall perception of cultural heritage, and establish the line of sight connection between the riverside and the former sites of the two temples on the hill. The entrance is in the form of stone and grassland. The historical sites covered by grassland are like "Braille," waiting for the world to touch and understand. Based on the design language of terrain and earth art, the central axis of the monastery and the base site of the disappeared structures are reshaped, and the outline of the Church, the entrance courtyard surrounded by walls, and the meeting hall with an ambulatory are sketched using slightly prominent terrain. The design remolds the relics through the shaping of historical reliefs to preserve the integrity of historical strata. The design also continues to enhance the perception of the site's history through clever space design. Through the winding path, the historical river is depicted as a garden space that can be visited, showing the past of the site without painting and expressing the humanistic spirit of the site. With reference to the records of medicinal herbs in monasteries in the early Middle Ages in the Lorsch Pharmacopeia, plant vegetation, and the site create a historical interpretation space with artistic appreciation.

3.3.3 Landscape restoration of Mediterranean Club at Cross Cape - restoring the natural beauty of the site

3.3.3.1 Project overview

The project is located at the eastern end of the Iberian Peninsula in Spain. It was built in 1961 and used as a holiday resort. With the awakening of people's democratic consciousness and the enhancement of ecological protection consciousness, the Cross Cape area was planned as a natural park. Because of its outstanding geological environment and plant community value, the site has been designated as the highest-level protected area, the Mediterranean Club has been permanently closed, and the restoration project has officially started.

3.3.3.2 Protection and utilization methods of cultural heritage

The key to the design project is to give people new recognition of the site by creating a public landscape while carrying out ecological restoration knowledge. Therefore, the project focuses on the identifiability and exhibition of the site and the adaptability of the final transformation results to the original landscape, revealing and highlighting the "real" landscape of the site to enjoy its unique beauty. By combining some repair interventions with various valuable detailed plans, the project concept is more consistent with the engineering plan than the master plan. The designer believes that human beings only exist for a short time in nature, so he has introduced as much natural force as possible in the design process, which is equivalent to human actions, turning a mediocre natural restoration project into a unique landscape project (Aldwal et al., 2013).

3.4 Integration of heritage style and public life

3.4.1 Tewa Greenway - greenway facilities integrating natural features

3.4.1.1 Project overview

Te Whau Pathway, located in Auckland, New Zealand, is a 12 km urban slow green road infrastructure. This historical route along the Te Whau River was once regarded as an important Indigenous Maori (M ā Ori) water transportation route. The new compound greenway, with its symbolic and artistic form and structure, shows the long history of Auckland City.

3.4.1.2 Protection and utilization methods of cultural heritage

The greenway takes the river course as the element, connecting the community with all parts of the river, making it a safe, comfortable, and natural slow route. The plan reflects the local characteristics through three elements: "fish scale," "river," and "water surface." The simple and winding shape of the greenway imitates the water waves of the river channel, reflecting the beautiful curve of the river channel and the sparkling water surface. It is perfectly integrated into the natural environment and looks simple and beautiful. In addition, the greenway provides a place to experience nature and history, as well as meet the functions of daily cycling and walking. People here enjoy the sunrise and sunset, the intersection of the Tasman Sea and the Pacific Ocean, and Waitemat ā) And Manukau, which depicts a long scroll of ecology, nature, history, and culture (Thomas, 2020).

3.4.2 Royal Hill Park in Montreal - a journey of site discovery and exploration with minimal intervention

3.4.2.1 Project overview

Montreal, Quebec, Canada, is a city with a long history, unique natural scenery, and vibrant neighborhoods. In 2017, to celebrate the 375th anniversary of the city, Montreal completed a series of urban renewal projects, including the renovation of the Mount Royal Heritage Site.

3.4.2.2 Protection and utilization methods of cultural heritage

The project shall take into account the factors such as the heritage itself and the complex stakeholders of the site. The site park shall enhance the space's connectivity and exploration, and the establishment of narrative lines will provide tourists with a new spatial experience to re-examine and understand this natural and historical heritage. The design team uses the "Conventional place markers" to replace conventional guided tours, commemorative signs, and other facilities. "Conical markers" of different sizes are scattered on the site, which is closely integrated with the site environment, like the rocks of mountains. Each "conical marker" takes the inscription as a clue, suggesting the natural scenic spots or historical sites on this site (Civiliti, 2019).

3.4.3 Ringdijk Park - polder landscape integrated into urban life

3.4.3.1 Project overview

Ringdijk Park is located at the edge of Amsterdam, the Netherlands. It is a community park for citizens. Historically, the Ringvaart area has a pronounced polder texture, and the dam height is high. However, with the construction of the city, the traditional polder land structure has become vague and tends to disappear.

3.4.3.2 Protection and utilization methods of cultural heritage

The project starts with the production landscape texture of field polder irrigation. It reproduces the ancient history of the region through the protective renewal of the regional landscape of the Old production civilization. There is an open field extending between the greenway and the water surface. The extended area ends at a raised cornfield. Flowers and trees are planted in the field. Vegetation with different seasonal characteristics is planted to enrich the landscape of the site during the four seasons. There is a greenway along the canal under the cornfield, with slightly raised terrain on both sides, and white wax trees are planted as street trees. The greenway is equipped with a rest area for children's activities and provides an excellent viewing space for the polder area.

4. Conclusion

Through the analysis of the above four types of cultural heritage protection cases, it can be seen that in the perspective of landscape architecture, these cases often adopt such methods as earth art, narrative tour routes, regional landscape style protection, ecological restoration, low impact development, and place spirit building. They are not limited to the Protection and utilization of a single heritage site but focus on the heritage and its surrounding environment, as well as the natural ecological network where the heritage is located. At the same time, the flexibility and flexibility of landscape construction is used to integrate more thinking into the social and cultural system where the heritage is located. Therefore, looking at the Protection and Revitalization of cultural heritage from the perspective of landscape architecture will enable us to pay more attention to the natural beauty, spirituality, differences, and rich diversity in different cultural systems, giving more cultural diversity value to the heritage (Armstrong & Han, 2017). This paper hopes to provide a new perspective on cultural heritage protection through the landscape transformation of heritage in order to deeply understand and understand the landscape genes carried in the protection practices and policies of different heritage and can defend, inherit, and disseminate their landscape genes in practice, making contributions to international cultural heritage protection.

Note

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Multi-scale Landscape Character Assessment in the Pearl River Delta, China

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Abstract

Managing landscape characterization is an effective way of reacting to the decline of natural environments and the gradual fragmentation of landscapes. It has become a core tool for sustainable development, nature conservation, and land management in several countries and regions. China's Pearl River Delta is one of the fastest-urbanizing regions in the world. The research adopted a combined framework of parametric and holistic approaches to assess landscape character across scales in the Pearl River Delta region. A parametric approach was used at the regional scale to overlay factors such as elevation, land cover, and urban/rural distribution to generate 17 landscape character types. At the city scale, a holistic approach generates landscape types by integrating factors such as land use, building layout, and agricultural patterns. The detailed landscape classification at the city scale was re-combined for each of the 9 cities. For example, Guangzhou includes 45 landscape character types. The cross-scale correspondence of landscapes was demonstrated using the downtown of Zhongshan as an example. The above cross-scale perspective is used to describe the overall landscape structure of the PRD, to understand the regional landscape in urbanization, and to provide a nested spatial framework for applications such as regional spatial governance.

Keywords: Landscape character assessment; holistic method; parametric method; landscape baseline; Pearl River Delta

1. Introduction

Multiple threats, such as climate change, agricultural intensification, urbanization, population growth, and changes in people's lifestyles, are losing their uniqueness in contemporary landscapes (Agnoletti, 2007; Chuman & Romportl, 2010; Li & Zhang, 2017). There is a growing demand for planning strategies that combine the conservation of landscape diversity and the sustainable use of landscape resources (Kim & Pauleit, 2007; Simensen et al., 2018). Managing landscape characterization is an effective way of reacting to the decline of natural environments and the gradual fragmentation of landscapes (Simensen et al., 2018; Zhao et al., 2023). The most important aspects are surveying landscape characteristics, mapping landscape types, and developing initiatives to protect and restore their value (Van Eetvelde & Antrop, 2009; Chuman & Romportl, 2010; Agnoletti, 2014).

“Landscape character” combines natural, cultural and social attributes that cross administrative boundaries (Wascher, 2005). Since the formal introduction of the European Landscape Convention in 2000, the character-based approach has been recognized as an expression of the holistic nature of landscape (Jessel, 2006; Van Eetvelde & Antrop, 2009; Fairclough, 2018). Landscape Character is “a distinct, recognizable and consistent pattern of elements in the landscape that makes one landscape different from another, rather than better or worse" (Swanwick, 2002). The Landscape Character Assessment was first developed in the UK and has been widely used in many European countries. It has become a core tool for sustainable development, nature conservation, and land management in several countries and regions (Van Eetvelde & Antrop, 2009; Mücher et al., 2010; Griffiths, 2018). The LCA emphasizes the difference and diversity of landscape character and divides the landscape into different types and areas, thus forming a spatial framework for planning and development (Butler, 2016; Fairclough, 2018).

Numerous studies indicate that landscapes are scaled not only in space but also in time, making a multi-scale approach essential (Hay et al., 2001). All elements within the spatial structure of the landscape are interconnected, often forming a nested "pyramid" pattern across different scales and levels (Gómez-Zotano et al., 2018). This pyramid structure allows for the identification and description of various landscape types and areas at different spatial scales. As a result, it creates opportunities for integrating land use and landscape management decisions across multiple levels (Bastian et al., 2015). This provides opportunities for integration with land use and landscape management decisions at different scales (Bastian et al., 2015).

Landscape classification is the first step in identifying and integrating landscape character, providing a spatial framework for communication in landscape management and research (Brabyn, 2009; Cullotta & Barbera, 2010). Scholars such as Van Eetvelde and Antrop have summarized the current landscape classification approaches into the holistic and parametric methods and established a framework for combining them (Van Eetvelde & Antrop, 2009). The holistic method relies on the human "Gestalt" ability to perceive and interpret complex patterns, utilizing satellite imagery to recognize and classify landscapes (Antrop & Van Eetvelde, 2017). However, it is not easy to standardize the classification criteria (Chuman & Romportl, 2010). So, the holistic method is more applicable to urban and local scales. In contrast, the parametric method uses an overlay in Geographic Information Systems (GIS) based on a multi-thematic base map (Van Eetvelde & Antrop, 2009). This process is standardized and repeatable, but the patches generated tend to be overly fragmented and collaged (Chuman & Romportl, 2010; Simensen et al., 2018). Thus, the parametric method is better suited for regional and larger scales. Previous studies have selected different landscape categorization methods depending on the characterization scale (Van Eetvelde & Antrop, 2009; Mücher et al., 2010; Primdahl & Kristensen, 2016; Yang et al., 2020). However, research on the structural links in assessing landscape character at multiple scales and across scales still needs further development.

The Pearl River Delta (PRD) in China is one of the fastest-urbanising regions in the world. This region features a unique and diverse combination of urban, rural, and natural landscapes. The study established a combined framework of parametric and holistic methods to identify landscape character in the PRD at both regional and urban scales (Fig. 1). The study aims to provide a comprehensive overview of the complex landscape patterns in the PRD and establish a systematic baseline of landscape information to guide and manage rapid urbanisation and landscape change.

2. Material and Method

2.1 Study area: defining the research scope and recognizing preliminary characteristics

The PRD is one of the most important economic centres in China. It is located in the south-central part of Guangdong Province in China and comprises 9 cities with a total land area of 55368.7 km^2 (Fig. 1). Despite occupying less than one-third of the land in Guangdong Province, the PRD gathers more than one-half of the population and accounts for approximately

80% of its economic aggregate. The delta is an alluvial plain formed by the convergence of three rivers and is abundant in resources, including mountains, water, fertile fields, and coastal areas. However, rapid urbanization and industrialization have significantly transformed the landscape of the PRD.

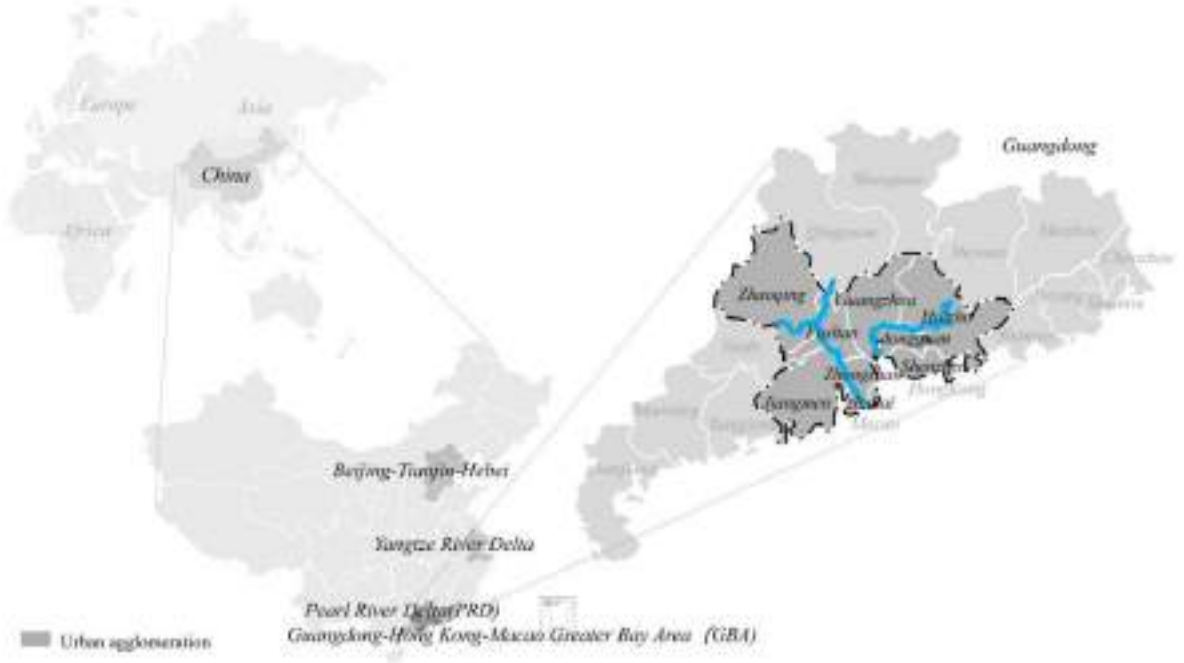

Figure 1. Location of the Pearl River Delta, south-central Guangdong province, China

2.2 Selection of variables and establishing the database

The classification of landscape character at the regional scale primarily relies on natural geographic factors such as topography, vegetation, and land cover. To refine this classification at the urban scale, we must incorporate human impact factors, such as land use and agricultural patterns. We gather essential data on natural geography, social structures, history, and culture to create a comprehensive database of landscape information using ArcGIS 10.3 software. This database includes 12 vector data types, which are utilized for landscape classification, boundary modification, and landscape evaluation. Specifically, 5 data types are used to classify landscape types: landform, elevation, land use, water classification, and buildings.

2.3 Identification of landscape character types by the parametric method at the regional scale

At the regional scale, landscape types are first classified into 3 regions: natural, urban and rural regions. The natural landscape is fully covered, with landforms classified into 6 types based on elevation, slope, and undulation, and water systems classified into 3 types. The urban landscape first identifies spatial boundaries based on the density of built-up land and then is classified into 3 types based on the development intensity. The rural landscape is initially identified by spatial boundaries based on the density of farmland and then is classified into 8 types based on the farmland types and density. Finally, the classification maps for the natural, rural, and urban landscapes are overlaid using the parametric method, providing a comprehensive view of how human behaviour has modified the natural environment.

Table 1. Definition of landscape types and attributes at the regional scale

Landscape dimension	Landscape Types	Attribute Definition	Code
Natural Landscape	High mountain	Altitude >300m	HM
	High hillside	100m<altitude <300m, undulation>30m	HH
	Hill	40m<altitude <100m, undulation>30m	H
	Valley	Narrow sunken landforms, altitude < 50m, width of opening <1500m	V
	Low hillside	10m<altitude <40m, undulation<30m, slope<15°	LH
	Plain	Areas with flat ground and less undulation	P
	Island	Land area surrounded by water on all sides	I
	Main River	Rivers with a watershed area >1000 km2	MR
	Reservoir	Reservoirs in the list of medium and large reservoirs in Guangdong province	R
Rural Landscape	Dryland rural area	Dryland density ≥ 30% and patch size > 50km2	DR
	Paddy rural area	Paddy density ≥ 30% and patch size > 50km2	PR
	Mixed rural area	Arable land types are more mixed, with <30% of any one type	MR
Urban Landscape	High-density urban area	Construction land density contour ≥15%, building plot ratio >2.2	HU
	Urban area	Construction land density contour ≥15%, 0.7 < building plot ratio≤2.2	U
	Urban sprawl area	Construction land density contour ≥15%, building plot ratio≤0.7	US

2.4 Identification of landscape character types by the holistic method at the city scale

A classification framework based on human construction is first constructed at the city scale. Then, a holistic method that involves manual visual analysis of satellite images is utilized to classify detailed landscape types for each city. The rural landscapes are subdivided into types based on factors such as topography, the different combinations of villages and farmland and the proportions of different arable land types. The urban landscape is subdivided into types based on factors including land use, building heights and layout patterns. This approach shows the subtle differences in how human behaviour influences landscape forms in both urban and rural environments.

Table 2. A framework for classifying landscapes at the urban scale

Landscape area	**Classification dimension**		**concrete types**							
			1	**2**	**3**	**4**	**5**	**6**	**7**	**…**
Rural Landscape Types (Definition: i+ii+iii)	i	terrain and spatial location	plain (P)	low hillside (LH)	hill (H)	coastal (C)	urban (U)	…	…	…
	ii	Spatial relationship between village settlement and farmland	linear (l)	scattered (s)	reticular (r)	congregate (c)	…	…	…	…
	iii	rural land type	paddy rural land (PR)	dry rural land (DR)	village settlement(VS)	mixed rural land (MR)	…	…	…	…
Urban Landscape Types (Definition: iv+v+vi+vii)	iv	spatial location	downtown (D)	edge of downtown (ED)	…	…	…	…	…	…
	v	building height	low-rise (lr)	mid-rise (mr)	high-rise (hr)	…	…	…	…	…
	vi	patterns of layout	regular (r)	farious (f)	disordered (d)	modern (m)	older (o)	…	…	…
	vii	site function	resident (R)	commercial (C)	industrial (I)	public institution (PI)	park&waterfront park (P&WP)	traffic (T)	mixed (M)	…

3. Results

3.1 Regional scale: landscape character assessment outline map of the Pearl River Delta

The regional-scale Landscape Character Outline Map is divided into 17 landscape character types and 1,440 landscape character areas, with an average patch size of approximately 32 km^2 (Fig. 2). This map presents a diverse interwoven landscape encompassing natural, rural, and urban elements. The top 5 landscape types covering the largest areas are highland hillside landscape (21.08%), plains urban sprawl landscape (12.89%), high mountain landscape (11.08%), lowland hillside landscape (9.85%), and hilly landscape (8.70%). The sum of the above areas accounts for 63.60% of the PRD.

3.2 Landscape character assessment detailed map of the Pearl River Delta

The landscape character assessment detailed map of the Pearl River Delta was combined with the detailed classification maps for 9 cities. For example, the detailed landscape characterization map of Guangzhou is divided into 45 landscape types and 4,090 landscape character areas with an average patch size of 2.12 km^2 (Fig. 3). The area proportion of natural landscapes is 39.34%, including 7 types, of which the top three types are highland hillside landscapes (16.58%), high mountain landscapes (8.66%), and lowland hillside landscapes (7.14%). The area proportion of rural landscapes is 40.44%, including 11 types, of which the top three types are lowland rural mixed landscapes (19.91%), reticulated paddy rural landscapes (7.25%), and linear paddy rural landscapes (3.43%). The area proportion of urban landscapes is 20.23%, including 27 types, of which the top three types are industrial mixed landscape (3.23%), disordered industrial landscape (3.00%), and high-rise modern residential landscape (1.62%).

Regarding the overall landscape pattern, the northern part of Guangzhou is dominated by mountain landscapes and low mountain mixed rural landscapes. The central area of Guangzhou forms a high-intensity urban core along the Pearl River, featuring a diverse array of landscape types. The suburbs of the city present a mixed urban and rural landscape, with villages in the city and many mixed industrial areas. In the southern region, a dense network of rivers flows into the sea, creating a reticular and linear layout of paddy fields that shows the coastal water village landscape style.

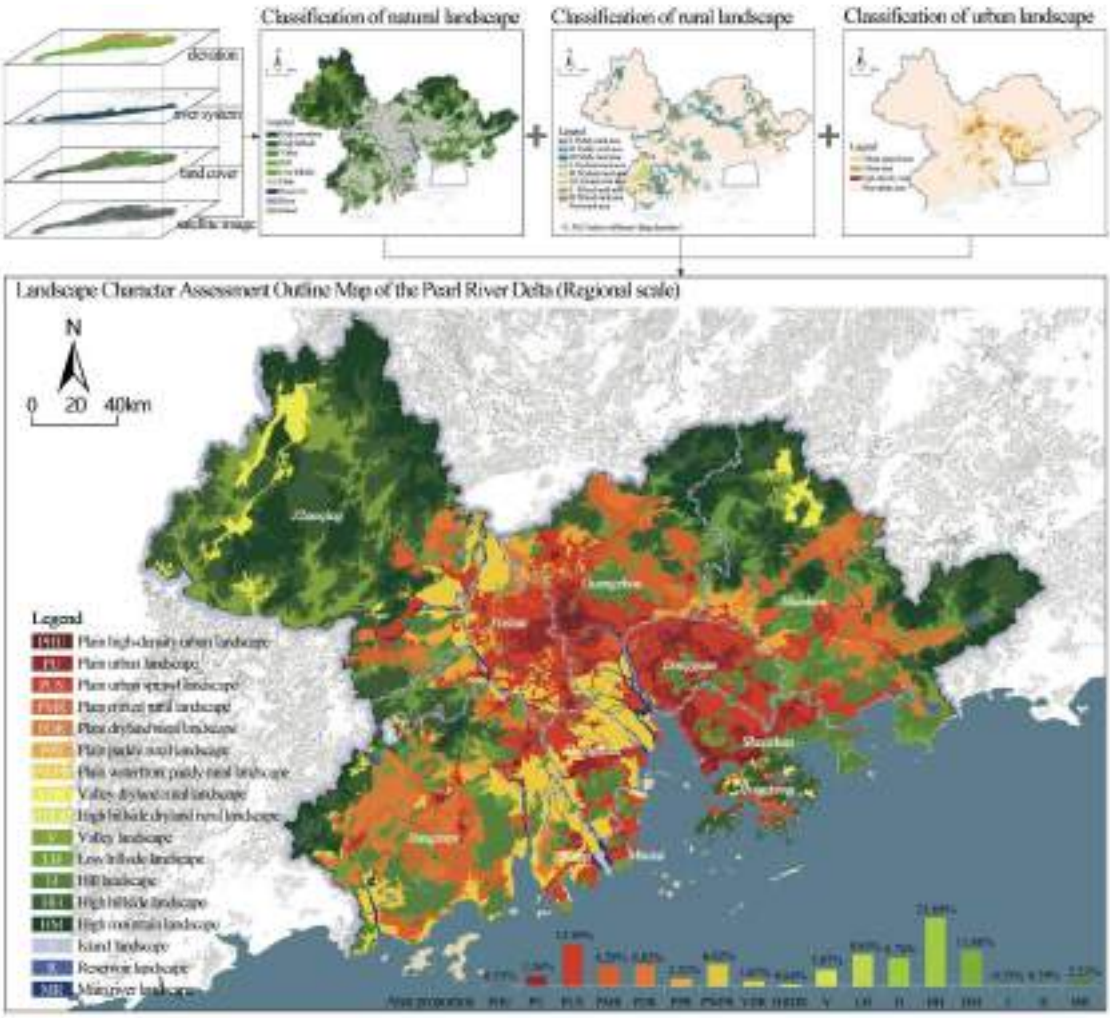

Figure 2. Landscape character assessment outline map of the Pearl River Delta (regional scale)

3.3 Landscape classification across scales - an example of downtown of Zhongshan

Taking the downtown of Zhongshan as an example, the cross-scale correspondence of the landscape can be demonstrated (Fig. 4). In the outline map at the regional scale, the downtown area is divided into 3 urban landscape types with different intensities. In the detailed map at the city scale, factors such as functional use and built form allow us to subdivide the downtown area into 35 landscape types.

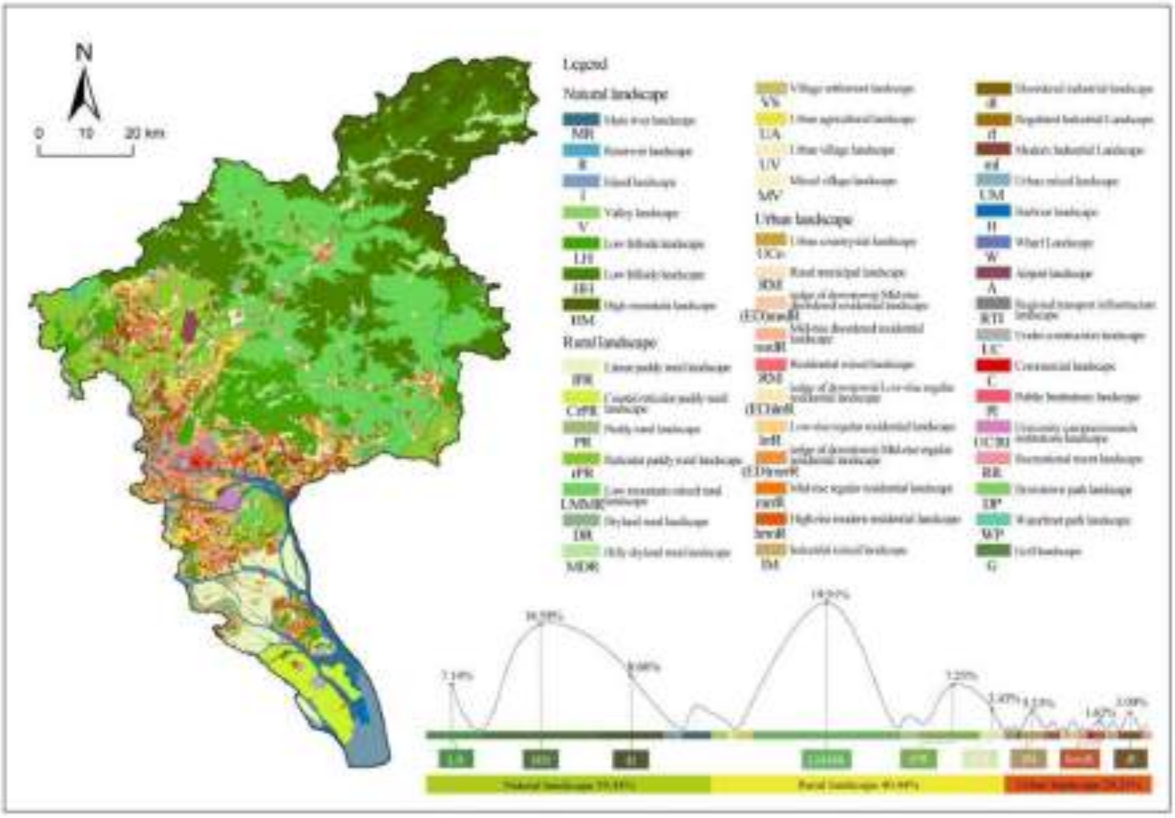

Figure 3. Landscape character assessment detailed map of Guangzhou (city scale)

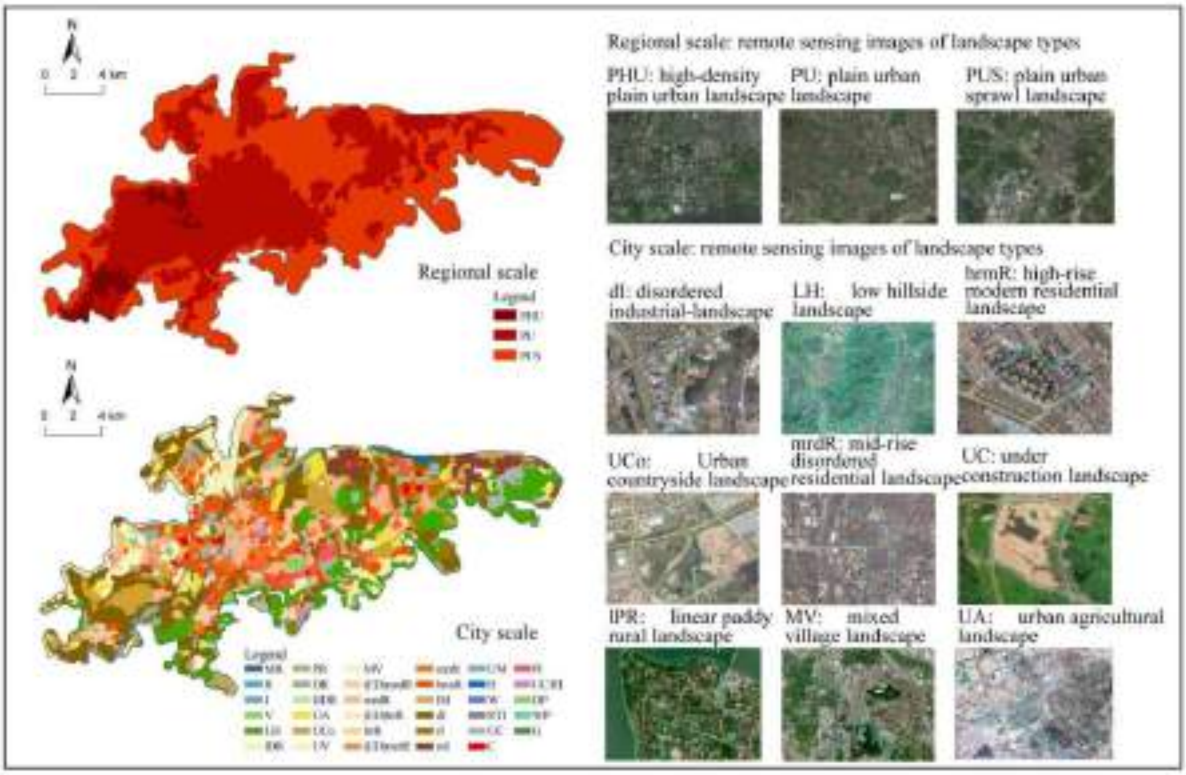

Figure 4. Correspondence of landscape types across scales (downtown Zhongshan)

4. Discussion

4.1 The pyramid nested landscape structure in the Pearl River Delta and the applicability of holistic and parametric methods at different scales

The study of the landscape character assessment (LCA) in the PRD used a parametric method at the regional scale and a holistic method at the urban scale, which were combined and resulted in a cross-scale nested landscape classification structure. This structure results in a GIS database that can be expanded at multiple levels.

From the perspective of cross-scale spatial analysis, the estuarine deltaic plains formed by the three rivers provide a foundational substrate for the overall landscape (Fig. 6). Elements such as topography and geomorphology influence the regional landscape's overall pattern. Additionally, humans have modified the natural environment in various ways, developing urban and rural landscape types. From macro to micro scales, the independence and stability of the landscape categorization decreases and the degree of public participation increases. This nested structure of 'pyramids' provides an integrated spatial framework across scales.

The research also validates the different applications of the holistic and parametric approaches. Parametric methods are usually based on the superimposed analysis of multiple geographic class data and are, therefore, more applicable at regional and superregional scales. In contrast, holistic methods rely on subjective human judgment to identify and delineate landscapes, making them more applicable at urban and local scales.

4.2 The potential application of the landscape character assessment of the PRD as a spatial framework

The landscape character assessment in the PRD provides a clear and recognizable spatial framework. The landscape baseline provides a better spatial basis for regional spatial development, protection and management. It can assist decision-makers in actions such as maintaining or improving the various landscape characters within the area to achieve the desired spatial conditions. For example, the mixed urban-rural landscapes are the key to spatial governance in the PRD. The assessment results in the PRD can create a desirable landscape pattern by focusing on managing and transforming mixed urban-rural landscapes.

5. Conclusion

Landscape character assessment across scales in the PRD helps to recognize the overall landscape structure of the PRD systematically. The results provide an integrated spatial framework linking natural ecosystems and social and human systems, supporting regional spatial governance. Additionally, it verifies the characteristics of landscape classification across scales. The assessment often relies on indirect perceptions through various parameters at larger scales, while smaller scales depend more on direct human perceptions (Van Eetvelde & Antrop, 2009). In the future, machine learning techniques such as image segmentation, algorithmic clustering and random forests can be combined to extract and classify landscape characters, improving the efficiency and accuracy of landscape character assessments.

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Discovering public-perceived cultural ecosystem services for Maritime Cultural Landscape management

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Abstract

The maritime cultural landscape results from the interaction between human activities and the coastal environment, and it is gaining attention for heritage tourism. This landscape provides various cultural ecosystem services (CES), such as recreational, aesthetic value, and a sense of place, which contribute to human well-being. However, there is limited understanding of CES in maritime cultural landscapes, particularly regarding socio-ecological relationships and stakeholder values. This study assessed public perceptions of CES in Quanzhou's maritime cultural landscape using social media photos and deep learning-based visual content analysis. Spatial pattern analysis of geo-tagged images from the Little Red Book revealed that tourists focus more on natural views and recreational facilities, while locals' perceptions are more dispersed. Landscape features contribute differently to CES categories, with historical villages contributing most to cultural heritage value. This research emphasizes the importance of CES assessment in maritime cultural landscape management, supporting urban well-being and sustainable cultural heritage preservation, and offering insights for marine heritage tourism management.

Keywords: Maritime cultural landscape, cultural ecosystem services, social media data, deep learning

1. Introduction

The coastal cultural landscape is shaped by the interaction between human processes and the environment over time, attracting increasing attention for tourism (Huang et al., 2024). However, coasts and coastal heritage face challenges such as changing shorelines, the collapse of traditional fisheries, and tourism pressures (Dou et al., 2021). Effective solutions require listening to diverse voices to balance resource conservation and community sustainability (Veidemane et al., 2024).

Cultural Ecosystem Services (CES) refer to non-material benefits derived from ecosystems, including spiritual enrichment, cognitive development, and aesthetic experiences. CES can reflect dynamic ecosystem changes and promote sustainable human-environment interactions (Clemente et al., 2019). Despite the recognized value of CES in coastal landscape management (Barr, 2013), research mainly focuses on terrestrial ecosystems (Dou et al., 2017), with limited attention to coastal CES (Martin et al., 2016), particularly in developing countries like China.

In China, the coastal cultural landscape, particularly Quanzhou along the Maritime Silk Road, has gained attention after its inclusion in the World Heritage List. The Maritime Silk Road facilitated cultural exchanges and shaped a diverse coastal landscape, encompassing tangible aspects like settlements and ports, and intangible elements like maritime trade and Mazu worship (Niu et al., 2023). However, socio-ecological changes and complex interactions challenge the sustainable development of these landscapes (Bürgi et al., 2017). Furthermore, differing perceptions between tourists and residents pose conflicts that hinder effective management (Mihalic, 2018).

Existing studies often focus on heritage characteristics, such as spatial patterns and conservation, while neglecting the complex human-nature interactions and the varied values of stakeholders (Weinstein, 2018). Understanding these interactions from a public perspective is crucial for sustainable landscape management. Previous research emphasized integrating stakeholder management across spatial and temporal scales, with a focus on cultural values and conflicts (De Juan et al., 2017). Social networks and deep learning models, like convolutional neural networks, offer new tools for large-scale perception studies (Liu et al., 2015; Cardoso et al., 2022).

This study uses geo-tagged photos from the Little Red Book and deep learning techniques to analyze CES perceptions in the Quanzhou Maritime Silk Road Cultural Landscape. Our objectives include creating a dataset of public perceptions, analyzing spatial distributions of CES among residents and tourists, and exploring how their perceptions relate to landscape features. The findings aim to inform public policies, address tourism conflicts, and enhance sustainable coastal landscape management.

2. Material and Method

This study focuses on Quanzhou, Fujian, a UNESCO World Heritage city along the Maritime Silk Road, which faces challenges in preserving its cultural landscape due to urbanization and infrastructure development. The city's recent listing as a World Heritage site has brought a surge in visitors, providing valuable data for sustainable tourism development. Data was collected from the Little Red Book app (2018-2023) using keywords such as "must-visit Quanzhou," resulting in 7,412 notes from 4,160 users and 44,537 images to assess Cultural Ecosystem Services (CES).

CES were classified into ten categories, based on maritime cultural landscapes. The ResNet50 deep learning model was used for image content analysis, achieving an accuracy of 84% and an F1 score of 0.81. Users were categorized as locals or tourists, creating three datasets for analysis. The spatial distribution of CES perceptions across Quanzhou was visualized using ArcGIS 10.5. The Random Forest algorithm assessed the contributions of different landscape features (POIs) to each CES category, revealing the importance of various features in shaping public perceptions.

3. Findings and Discussion

This study analyzed the distribution of 7,408 CES points perceived by 4,156 users. Cultural heritage (60%) emerged as the most prominent CES category, followed by entertainment (50%) and aesthetic appreciation (29%). The highest number of users shared cultural heritage (66%), with entertainment and sense of place following. Cultural heritage remains the most significant CES type, with the largest number of points and users, while research and educational values received the least attention.

Spatially, CES points were concentrated in the southeast, particularly in Licheng district, home to Quanzhou's ancient city. Other coastal areas like Jinjiang, Shishi, and Hui'an also featured significant hotspots. High-density areas aligned with the urban core, with cultural heritage and recreation being widespread, especially in areas with numerous World Heritage Sites. Aesthetic and landscape appreciation were more prominent in eastern coastal regions and natural landmarks like Qingyuan Mountain. Hotspots for social connection and religious value were found in districts with key tourist attractions and temples.

Local users' hotspots were concentrated in Licheng and Fengze districts, with a decrease in perception intensity toward the northwest. Tourist hotspots also focused on Licheng and Fengze, with strong cultural heritage and recreation values along the coast.

Figure 1. Spatial statistical analysis: all data group

Figure 2. Spatial statistical analysis: local people

Figure 3. Spatial statistical analysis: tourists

POIs contributed differently to CES categories, with artificial features like historic villages and recreation places playing a larger role than natural ones. Historic villages were crucial for cultural heritage, research, education, and social relations. Recreation places and cultural parks significantly impacted aesthetic and landscape appreciation. Natural POIs, like beaches and parks, were more important for residents, whereas tourists valued historic villages, cultural parks, and built environments for their recreation and aesthetic value.

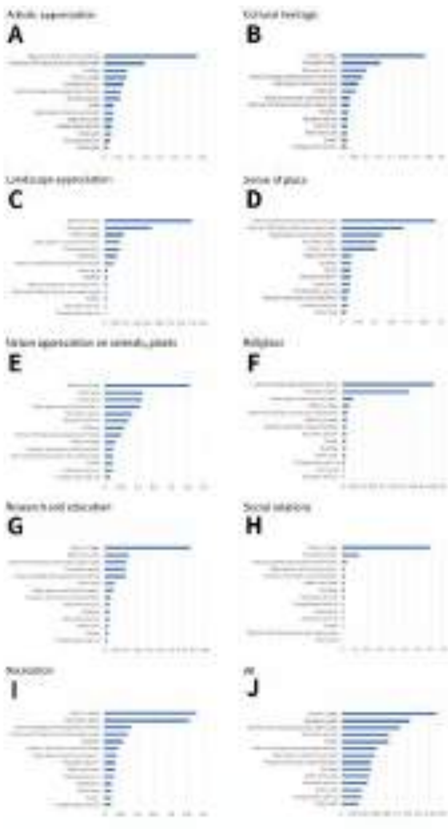

Figure 4. Random forest analysis: all data group

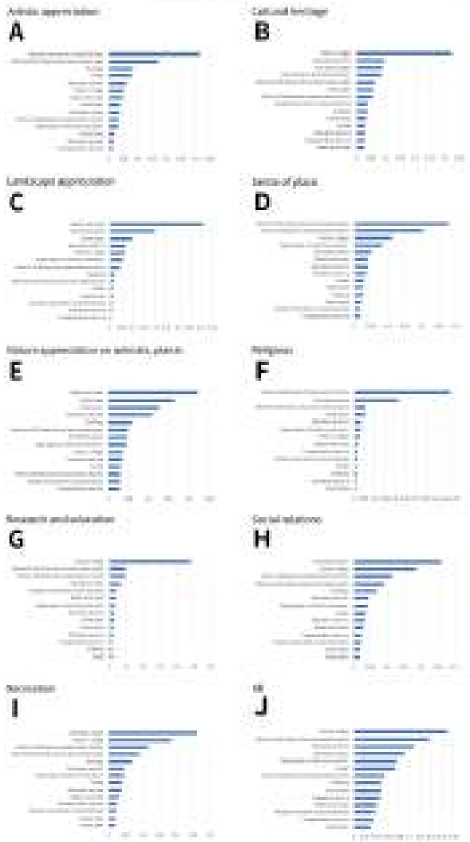

Figure 5. Random forest analysis: local people

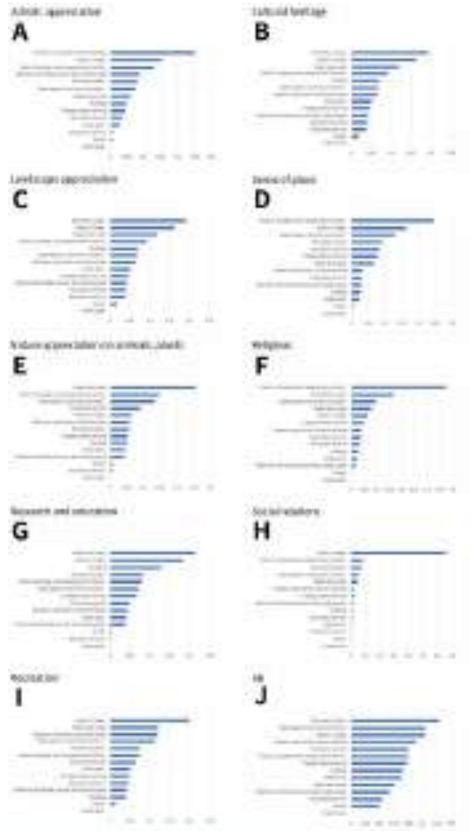

Figure 6. Random forest analysis: tourists

In summary, POIs varied in their contributions to CES, with historic villages, recreation places, and cultural parks standing out, while natural features played a smaller role, especially for tourists.

4. Conclusion

This study used deep learning models to analyze social media data, assessing public perception of CES in Quanzhou. The results reveal both shared and distinct preferences for CES and landscape features between locals and tourists, highlighting the need for tailored planning strategies based on spatial analysis. Furthermore, the use of deep learning and social media data enables large-scale CES assessment in coastal heritage cities. These findings contribute to balancing the conservation and development of Maritime Silk Road cultural landscapes and offer insights into the human interaction with coastal cultural environments.

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Sydney's Urban Sprawl, a Koala Belt and the Blue Green Grid : A Governance Issue

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Abstract

Sydney's unique city morphology is that it is circumnavigated by its two largest rivers - the Hawkesbury-Nepean River (Deerubbin) and the Georges River (Toggerai), this also acts as Sydney's Koala Belt, however, urban sprawl is threatening to break through this belt in south west Sydney around Appin.

The south western edge of Sydney - Greater Macarthur Growth Area, is home to perhaps NSW's only thriving colony of Koalas, yet it is also the largest residential area to be opened up on Sydney's peri-urban edge in recent memory. As part of this process innovative governance measures have been engaged that have not been seen in Sydney before. We flag the implications they have for Greater Sydney, and continuing Koala cohabitation in this landscape.

New governance instruments developed by the NSW Planning Department such as the Cumberland Plain Conservation Plan (CPCP) a regional landscape scale undertaking to ready the land for residential zoning, and the Technical Assurance Panel that speeds up the process and minimizes Council involvement, are contrasted with the influence of the Office of the Chief Scientist's and Engineers and the Campbelltown Council's Koala Plans of Management (KPoM) on their impact on Koala corridor recommendations. The final result is a landscape masterplan that we can assess objectively for its ability to ensure Koala habitat and connectivity will continue or not.

Keywords: Sydney, urban sprawl, koala, blue-green grid, governance

1. Introduction

Koalas populations are crashing in NSW & Queensland. In 2022 their federal status worsened from Vulnerable to Endangered, only 10 years earlier they were first listed as Vulnerable. Extinction in the wild by 2050 was first flagged as possible in early 2019 during the NSW Parliament Upper House Koala Inquiry. Soon after the unprecedented bushfires of 2019/2020 saw koala populations devastated, and Chlamydia has continued to impact Koala numbers. However, the inquiry found the greatest threat to Koalas survival in the wild was habitat loss and fragmentation.

Within this bleak horizon the genetically unique Greater Macarthur Koala population of south west Sydney that is still chlamydia-free and expanding in number and reach is a bright spot. They now number possibly between 500 to 1,000 koalas, perhaps the only recovering Koala colony in NSW (McAlpine, 2015). It was also a population that escaped the devastation of the Australian 2019/20 bushfires. This remarkable population was considered locally extinct until 1986, their numbers had been growing steadily from what was likely a remnant population of about 20 that had escaped the 1920s Koala culls by seeking refuge within the gorges of the Holsworthy Army Base (Close, 2019).

Spatially, this population at Macarthur occupies a keystone position on Sydney's 'Koala Belt' as its two longest rivers - the Hawkesbury-Nepean River (Deerubbin) and the Georges River (Toggerai) that define it, almost touch at Macarthur. This riparian ring road acts as a "Biodiversity Super Highway" connecting small Koala populations along Sydney's periphery. Such as the now extinct populations of the Pittwater and Central Coast at Broken Bay in the north all the way round to populations south of Botany Bay, along the way there are persistent colonies at Arcadia, Kurrajong and the Blue Mountains. The Macarthur colony is now radiating out along this belt, though mostly to the east. Since CoVID Koalas have been spotted in Heathcote National Park and even further east in the Royal National Park. This Koala Belt not only connects up disparate Koala colonies it allows paths for them to escape bushfires and paths again to re-colonize habitat thus stopping their fragmentation and maintaining their genetic diversity.

Figure 1. Sydney's Koala Belt : Georges river (yellow) connects to the Nepean river (Blue) through Macarthur's koala corridors (purple) (Deane, 2025)

However, Koala protections in the last ten years have become both spatially blind and de-prioritised in the face of major property developer interests. The changing nature of these habitat protections are well illustrated at Macarthur.

2. Methodology

I am writing this from an advocacy point of view. I co-founded Save Sydney's Koalas and are the urban sustainability campaigner at the Total Environment Centre. Since 2018 I have been closely involved with the Macarthur landscape and the development and implementation of regulations and policies mentioned in this paper. To document this process we are going to first outline the landscape, then the historical regulatory environment of Macarthur, before spelling out the basic landscape requirements needed for Koalas in a greenfield site. After that we record the changes in that regulatory environment since 2018, and identify two different trajectories, one a scientific one pushing Koala conservation, the other prioritizing housing development and thus trying to minimize Koala protections. The economic incentives influencing the governance process are identified, and finally the credibility of the Koala vision for Macarthur area is assessed.

The focus here is on the NSW State Department of Planning (Department). All three levels of government in Australia's federal system carry some responsibility for protecting Koalas. However, the state government has the most direct influence through its planning and environmental departments, a combined department for the majority of this narrative. Local Councils are often tasked with implementing planning controls and have the most direct engagement. Above them both is the federal government which has a final oversight role, but little direct engagement.

Many of these state regulatory reports and controls appear to sit within a grey area of regulation and implementation, some are obviously required as part of a regulatory process such as the Campbelltown Koala Plan of Management, required under a State Environmental Planning Policy (No.44) though now its implementation seemingly sidelined. Others such as the Conserving Koalas Report seem to have no legal framework from which to operate yet appear to be guiding state policy and have been used for certification approval, while the Chief Scientist Reports seem to derive their power from the Ministers that called for them. The Cumberland Plain Conservation Plan is a bilateral agreement at both state and federal levels.

3. Historical Regulatory Protection Incentivizes Developers

Historically the south west periphery of Sydney has stopped at Campbelltown, protected primarily by distance from the pressures of urban development, it is over 50 kms away from Sydney's centre, perhaps the furthest peri-urban edge of Sydney. With new zoning principles established after world war two, Campbelltown was gazetted as rural under the County of Cumberland Planning Scheme. The Sydney Regional Outline Plan of 1968 identified Campbelltown, Camden and Appin as development sub-regions, and in 1973, a detailed Structure Plan released by the NSW State Planning Authority established parameters for the development of Campbelltown as a satellite city to "balance growth needs with the conservation of the special assets of history and landscape." (Campbelltown-McArthur Advertiser, 2015). It achieved these objectives through land-use zoning and minimum lot sizes in the Scenic Hills of Macarthur. Residential development was prohibited in the Scenic Hills and a 100-hectare minimum lot size was introduced to encourage rural land use only. "allowing urban-style development to expand over the carefully protected Scenic Hills … will have the potential to have a catastrophic impact on the scenic values and unique character of the Campbelltown LGA."

Large state infrastructure projects in the area have also hindered residential use. Sydney's water supply via the state heritage listed Upper Canal System runs through Macarthur as does the high-pressure Gas pipeline from Moomba in South Australia. Long wall mining and fracking have an extensive underground footprint beneath Macarthur too.

While conservation zoning was primarily driven by aesthetic rather than environmental considerations - Scenic Protection Zoning, the effect was the same - protection of large areas of rural and bushland in the Scenic Hills. As large areas were protected, and development was limited wildlife connections across the landscape were diffused, contiguous and intact. An unintended effect of using large lot conservation measures however was that it kept the original land grants of the first colonists of the 1810s intact too. The irony here was that these unusually large lots on the edge of Sydney in the 2010s made them very attractive to large property developers such as Walker and Lendlease whose business models specialized in the large windfall gains that followed their ability to gain new residential spot rezonings, and as it large lots took a similar effort to upzone as smaller ones, they maximized their 'effort to reward' ratio. It is for this reason that Macarthur has become the target for one of largest new housing growth declarations in recent history despite it being a bad planning idea.

4. Macarthur Rezoning Bad Planning

From a planning perspective Macarthur does not suit large residential rezoning, it has little infrastructure - no rail, one local road in, no water or sewerage and will rely on taxpayers to provide this later at a cost that will come in at billions of dollars. The area's inherent issues of distance, bushfire and air pollution remain. However, it is Macarthur's development of wider threats such as Sydney's water supply and colonial landscapes that it overlaps with our Koala concerns.

There is also the opportunity cost and competitive threat involved as just north of Campbelltown closer to Sydney, there are rail stations with infrastructure, surrounded by low density existing residential zoning, identified and waiting to be upzoned for increased density at little taxpayer cost, but the competitive threat this would pose to the major developers of the nearby greenfield sites in Macarthur and the diffused upzoning benefit to many small landholders appears to have weakened political pressure to prioritize development here. So despite Sydney having one of the largest urban footprints for a city of a comparable population, major developers continue to relentlessly drive Sydney's greenfield urban sprawl outwards.

The size of property development to the state economy sees major developers influence remain powerful and their reliance on state government to spot rezone their land banks to release massive windfall gains means they are an industry incentivised to get as close to the Department of Planning as possible. Their drive is to keep housing prices high to maximize profit by increasing demand and restricting supply and keep development costs low by removing transaction costs. The pressure to remove Koala protections is that it is seen solely as a development cost.

5. Regulatory control flows in Macarthur that impact Koalas.

In Macarthur we have two drivers working on Koala protections. One driven by science through agencies that sit outside the Department of Planning (Department) demanding a web of wide Koala corridors. The second is driven by developers via the Department of Planning seeking to minimize those protections to the extent it takes away area from potential housing development. Below is an image that describes those two processes through the planning instruments created. The top is the green independent assessments flow trying to assert Koala protections, the bottom is the red Department of Planning flow trying to maximize developable housing area.

Figure 2. Macarthur's regulatory evolution : Koala recommendations of the Science driven reports versus Planning department ones (Deane, 2025)

In Macarthur, in 2016 the Campbelltown Council drew up The Campbelltown Koala Plan of Management (CKPoM) with guidance from Koala specialists Biolink (Dr. Steve Phillips). The CKPoM had one major landscape recommendation for Koala protections in greenfield sites - a web of Koala corridors, and for these to be effective they had three basic requirements: to be numerous and contiguous, wide enough to act as a habitat as well as a corridor, and three that their integrity as a habitat corridor be respected. In Macarthur like much of NSW these Koala corridors were found to occur along existing watershed's creek and river lines. These are a good baseline for corridors as watershed water lines are naturally contiguous and in NSW their immediate vegetated riparian setbacks were already protected under the NSW Water Management Act. In Macarthur the CKPoM identified three east-west corridors along the creeks (Menangle, Woodhouse and Mallaty) and two north-south ones along the Nepean and Georges Rivers, with a required width of 425m.

However, the Department of Planning had to gazette the CKPoM for it to become law, it did not do so until August 2020, in the meantime it began the process of opening up Macarthur for housing through its 2018 Greater Macarthur 2040 Interim Plan (2040 Plan). This plan originally promised Koala protections, such as "sufficient corridors to support koala communities, with a minimum preferred width of 425 metres for primary corridors" - the Nepean and Georges River (2040 Plan, 2018 p.33). Whether there ever was a genuine intent to do so is muddied by the fact that the Department was writing another document at the same time aimed specifically at removing koala protection in the area - the Conserving Koalas in the Wollondilly and Campbelltown Local Government Area 2019 Report (Conserving Koalas Report 2019) it rejected not only the need for East-West Koala corridors but aimed to actively fence Koalas out of the Macarthur growth area (west of Appin road). It proposed one east-west corridor in Appin not in the CKPoM, nor on any major developers land - the Ousedale Creek Koala Corridor. The report also rejected the need for any minimum corridor width like the 425m identified in the 2040 Plan and CKPoM.

The Conserving Koalas Report's two attached referees; Koala experts Dr. Crowther and Dr. Phillips rejected its strategy as a long term solution to Koala survival, but despite this the report and its questionable legal standing it was used by the Department to approve Biodiversity Certification (land clearing) for one of the first developments in the new Macarthur Growth Area (Lendlease's Gilead). This development was to cut an east-west corridor identified in the CKPoM - the Menangle Creek Koala corridor. This was later re-established to some degree through community and legal action taken by Save Sydney's Koalas (SSK).

While the Department's Conserving Koala Report attempted to sideline wide corridor requirements, it was resurrected via community advocacy and representative intervention. The Total Environment Centre (TEC) invited the Environment Minister Matt Kean out to Gilead in 2019 where he and many other local representatives were able to see a wild koala in Macarthur beside Appin road opposite Beulah. Minister Kean consequently called for an independent assessment of the landscape requirements for koalas through the Office of the Chief Scientists and Engineers (OCSE); this state agency operates outside the Department of Planning's direct control.

The OCSE would go on to write three reports with recommendations that applied not only to Gilead but the Greater Macarthur Growth Plan and the Cumberland Plain Conservation Plan. However, by the third report the Planning Department was once again changing the terms of reference - Advice 2021, to minimize the need for numerous or wide corridors.

The first Chief Scientist's Advice on the protection of the Campbelltown Koala population 2020 (Advice 2020) reiterated the Koala requirements set out in the CKPoM, and went further, including the need for more east-west corridors south of Campbelltown, it too recommended 425m wide corridors that should be "widened through revegetation (average size 390 to 425 m), include a buffer on either side of the corridor habitat that is at least 30 m" (Advice 2020 p.XIV).

The Chief Scientist's Advice 2020 report, while aimed at the Gilead development, was directed to inform the wider Macarthur landscape through the development of the Cumberland Plain

Conservation Plan (CPCP) that was also being drafted up by the Department of Planning. The CPCP, a regional scale Biodiversity Certification, aimed at simultaneously removing state and importantly federal conservation regulatory hurdles so the land could be rezoned residential. In 2020, TEC directed the Cumberland Plain Conservation Plan - Community Reference Group and uploaded its report in 2020.

OSCE's re-assertion of the need for wide corridors would impact on Lendlease's developable area, and thus saw Lendlease focus on absolute minimum requirements and go on to exploit the corridor calculation methodology, evident in the Department of Planning's request for clarifications on Lendlease's behalf. The OSCE's Response to questions about advice provided in the Koala Independent Expert Panel Report Advice on the protection of the Campbelltown Koala population 2021 (Response 2021), "rather than drawing 90 degree cross sections that demonstrate a minimum corridor width of 250 m … instead lines appear to have been drawn at random angles to meet the minimum width requirement of 250 m" (Response 2021 p.10).

Though the CKPoM was gazetted in 2020, it was effectively sidelined as a policy or regulatory tool by the Department, who cemented in the Conserving Koalas report's policy of not prioritizing Koala corridors in the 2022 NSW Koala Strategy's. This strategy mentioned 'translocation' 18 times but 'corridors' not once. Translocation is an 'operational management' tool used to fix a failure to design a contiguous landscape for Koalas, it relies on personnel physically moving (translocating) Koalas trapped by landscape dead ends and bottlenecks.

The Department pressure to reduce Koala corridor numbers, weaken minimum width requirements and obfuscate a calculation methodology continued beyond Gilead, as the implications of OCSE corridor requirements intruding into developable areas already penciled in by the major developers/landholders (particularly Walker) became apparent. Developer corridor widths were based on existing bushland setbacks rather than a minimum width that would thus also require restoration. The Department tried to resolve this in the developers favour by changing the OCSE's Terms of Reference to explicitly not undo Walker-Department agreed corridor widths thus their- Advice regarding the protection of koala populations associated with the Cumberland Plain Conservation Plan 2021 (Advice 2021), was faced with this conundrum, they nevertheless reiterated their corridor requirements - "average minimum width of 390 - 425 m, include a buffer on either side (30 m)" (Advice 2021 p.21) as stated originally in Advice 2020. And the importance of numerous corridors.

The Department left the translation of the OCSE's Advice 2021 and its effect on corridors in the CPCP to itself and a consultancy firm Biosis in 2021 - Cumberland Plain Conservation Plan Functional Koala Corridors (Biosis 2021). Private consultancies are problematic as they are reliant on the major developers for business. Biosis's report more closely reflected the Department's Conserving Koalas report than the OSCE's advice; it effectively just measured the width of the existing bushland and noted its average measurements. Only one east-west corridor at Ousedale Creek was studied and there was no minimum Koala corridor width nor did the average width along the Nepean River width meet the minimum of 390m.

But more than that the Department weaponised the OCSE investigation into 'functional' Koala corridor widths against Koalas by rather than arguing that widths that were too narrow needed to be restored to a functional width should instead be removed altogether as Koala corridors ! An argument so perverse it has only been used once, to remove the Mallaty Creek corridor identified by the OCSE but not part of the Conserving Koalas report from the CPCP. Note Corridor D - Mallaty Creek is coloured brown in the image below it will be fenced off to exclude Koalas.

Figure 3. This is a close up of the Macarthur area as shown in purple in Figure 1, it shows the East–West corridors as identified by OCSE connecting the Georges River to Nepean River. They are Corridors - A: Menangle Creek to Noorumba; B: Woodhouse Creek to Beulah; C: Nepean Creek to Beulah; D: Mallaty Creek to Georges River; E: Ousedale Creek to Appin North; F: Elladale Creek and Simpson Creek to the colliery. (CPCP 2022 p.29)

In 2022 the listing of Koalas deteriorated after the 2019/20 bushfires from Vulnerable to Endangered both at the NSW state level and Federally. Unfortunately a degraded listing does not trigger any extra protections. The Department, when asked by SSK and TEC what extra protections would follow in light of the new listing, said none, and the CPCP was soon signed off at the state level by the new State Environment Minister James Griffin and new Federal Environment Minister Tanya Plibersek in the same year. In 2023 the new Labor Planning Minister Paul Scully endorsed Walker's planning proposal for Macarthur that had been shepherded through planning regulations by the previous Liberal Planning Minister Anthony Roberts - the largest expanse of urban sprawl in Sydney’s living memory.

However a cloud hangs over this process on why the Department was insistent on sidelining an effective web of Koala corridors in the only place in NSW where koalas appear to be thriving, for outcomes that only appear to greatly benefit large developers, Walker in particular.

There is also a pattern of senior departmental staff eventually working for the same large developers who were the direct beneficiaries of their decisions, this too undermines the credibility of those decisions. This happened at Gilead with Lendlease, but the most obvious example was at Macarthur when in 2023 the NSW Department of Planning Secretary Michael Cassel (the Department's most senior role) went to work for Walker Corporation after he was involved in fast-tracking the rezoning of land for Walker's Appin developments, through a novel and confidential Technical Assurance Panel (TAP) process where regulation obstacles were identified and settled, governed by a metric that prioritized speed. The new Planning Minister Paul Scully ordered a review of Cassel's involvement via the new Planning Secretary Fishburn who found no wrongdoing.

6. Findings and Discussion

The requirements for Koala corridors are explained in some detail and specifically applied to Macarthur are well documented in three Chief Scientists reports and the Campbelltown Council's Koala Plan of Management. The use of these as a basis to generate a contiguous landscape that modern conservation demands, was investigated for application more widely via TEC's Blue-Green Grid report that expanded on similar but disparate Department programs. But the regulatory tussle at Macarthur over Koala corridor implementation through a governance system captured by the major developers (Hellman et al 2000) means public interest and good public policy are not prioritized. Thus systemic regulatory changes that minimize developer and maximize public influence are required. The assertion of public interest within governance is difficult if that culture is lost, the democratic process provides the potential for renewal at the representative level, but at the bureaucratic level a culture of 'independence and service' is perhaps harder to recreate.

How these governance issues are addressed within the bureaucratic system, I leave to another paper but removing the massive financial incentive of spot rezoning via taxing 'Windfall Gains', ensuring the process is transparent via continued public notifications, blocking departmental staff from working for ex-developer clients, and ensuring the public can police this process via third party legal appeal rights would be necessary tools. The lack of public interest assertion in Macarthur now expresses itself in master plans that are to be built in fire prone zones, hard up against Sydney's water supply canals, over the top of Australia's first frontier massacre cultural landscape at Appin and of course via deliberately aiming to cut an identified koala corridor at Mallaty Creek.

7. Conclusion

The physical landscape issues the Macarthur Koalas faced were ones of contiguity, where the dimensions, numbers and character of the required web of Koala corridors was well documented. However, the major developers' economic incentive to rezone every inch of land was to minimize or remove those requirements. The Developers interests were made legally possible through state capture of the state level bureaucracy (and some direct political representatives) who were able to parry the continual assertion of koala needs from forces outside the Department by bringing approval mechanisms back under their control.

It is a Code Red trajectory for our wild animals, but the Macarthur Koala narrative tells us that beyond just understanding ecological landscape issues it is the invisible economic drivers working through and influencing governance processes that are pushing our wild animals into an existential crisis. Thus understanding the regulatory landscape is just as important as the landscape problems we seek to address.

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Ecological Effects of Invasive Species on Migratory Bird Communities

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Abstract

Biological invasions strongly alter the biotic and abiotic characteristics of ecosystems, thereby affecting native vegetation, insects, mammals, birds, and many other taxa, and are currently one of the most significant causes of biodiversity loss. The Spartina alterniflora is the most widely impacted invasive alien species in coastal zones globally, significantly altering coastal wetland ecosystems and profoundly affecting other taxa. Migratory birds, at a higher trophic level in the ecosystem, are sensitive to habitat changes caused by the invasion of the Spartina alterniflora. The degradation of migratory bird habitats and ecological impacts due to the invasion of the Spartina alterniflora have attracted long-term and widespread attention worldwide. The coastal wetlands in the eastern part of China are located along the migratory route of migratory birds from East Asia to Australasia and are an important stopover site for many rare migratory birds. The Spartina alterniflora has invaded and developed in several coastal wetlands, forming dominant communities and significantly altering the distribution pattern of vegetation and migratory birds in the region. It has been shown that the Spartina alterniflora can disrupt the homeostasis of migratory birds in terms of habitat, food resources, and other aspects. However, as the history of the invasion grows, the habitat of Spartina alterniflora also provides blank ecological niches for some migratory birds, which enriches the diversity of local species to a certain extent. Therefore, this study scientifically classifies migratory bird taxa according to their ecological habits and habitat strategies, predicts the distribution and development trends of invasive and native species through ecological niche modeling, and explores the distribution and changes in the habitat of different groups of migratory birds in the process of invasion and development. At the same time, this study investigates the correlation between communities in different invasion periods, systematically identifies the positive and negative effects of the Spartina alterniflora on migratory bird communities, and then provides theoretical support and practical reference for the scientific management of the Spartina alterniflora in different regions.

Keywords: Biodiversity conservation, Migratory bird, *Spartina alterniflora*

1. Introduction

Global biodiversity is experiencing an unprecedented decline, with approximately 14% of migratory birds facing the severe threat of dwindling populations or outright extinction. Extending over 24,000 km^2, China's coastal line boasts numerous intertidal wetlands that serve as critical habitats for migratory birds within the East Asia-Australia migration zone. The expansive coastal mudflats offer exceptional stopover sites for nearly 100 species and over ten million migratory waterbirds, facilitating fat reserve replenishment essential for their continued migration. Waterbirds breeding in the Russian Far East, and northern China migrate along the coastline to overwinter in the Yangtze River’ s middle and lower reaches and southern China, with journeys extending to Southeast Asia, Australia, and New Zealand. The *Spartina alterniflora* significantly alters the landscape pattern of migratory bird habitats, consequently compressing the habitat space of these communities. This encroachment leads to a pronounced decline in large populations of waterbirds, severely affecting their wintering and breeding activities. The *Spartina alterniflora* also substantially affects the dietary composition of avian species. Research has demonstrated that the invasion of Spartina alterniflora modifies the distribution, abundance, and diversity of avian food resources, potentially influencing feeding preferences throughout the food chain (He et al., 2023). Quantifying the relative contributions of multidimensional driving factors to the habitat patterns of migratory birds and elucidating their coupling mechanisms are critical for identifying conservation measures to mitigate the decline in migratory bird biodiversity. Numerous studies have analyzed the impacts of large-scale environmental variables, such as habitat quality (Wang et al., 2022), food resources (Rangel et al., 2024), water level fluctuations (Xia et al., 2017), climatic conditions (Osborn, 2024), vegetation types (Hieb E et al., 2023), and human activity intensity (Campioni et al., 2024), on the distribution of migratory bird habitats. However, research by Sirén et al. has demonstrated that species distribution patterns are shaped by the combined effects of direct and indirect abiotic and biotic factors (Sirén et al., 2022). Consequently, studies relying solely on large-scale environmental variables often overlook environmental heterogeneity and the complex roles of interspecies relationships, potentially leading to biased conclusions and reduced effectiveness in biodiversity conservation efforts (Gao X et al., 2023). Based on these insights, this study takes Dongying City as its focal area, examining the distribution patterns of suitable habitats for various species and the evolution of habitat quality. From a multidimensional perspective, it aims to uncover the issues and underlying causes of the habitat pattern contraction of migratory birds in Dongying City. The research aims to clarify the explanatory power and driving mechanism of environmental factors on migratory bird communities, identify ecological niche environments suitable for migratory bird habitats, and provide reference for the protection and management of endangered and rare migratory birds in Dongying City, as well as the restoration and improvement of regional biodiversity levels.

Encompassing nearly 96% of the Yellow River Delta, Dongying City boasts a diverse array of wetland ecosystems, with an average regional vegetation cover of 55.1% and home to 1,627 recorded wild species. The annual migratory bird populations here fulfill the Convention on Wetlands’ Criteria 5 and 6, designating it as a Wetland of International Importance. However, the misalignment between Dongying City's unique watershed environment and its urban development strategy has led to numerous challenges, including ongoing biodiversity decline, a dispersed urban spatial layout, and low land-use efficiency (Liang & Zhang, 2011).

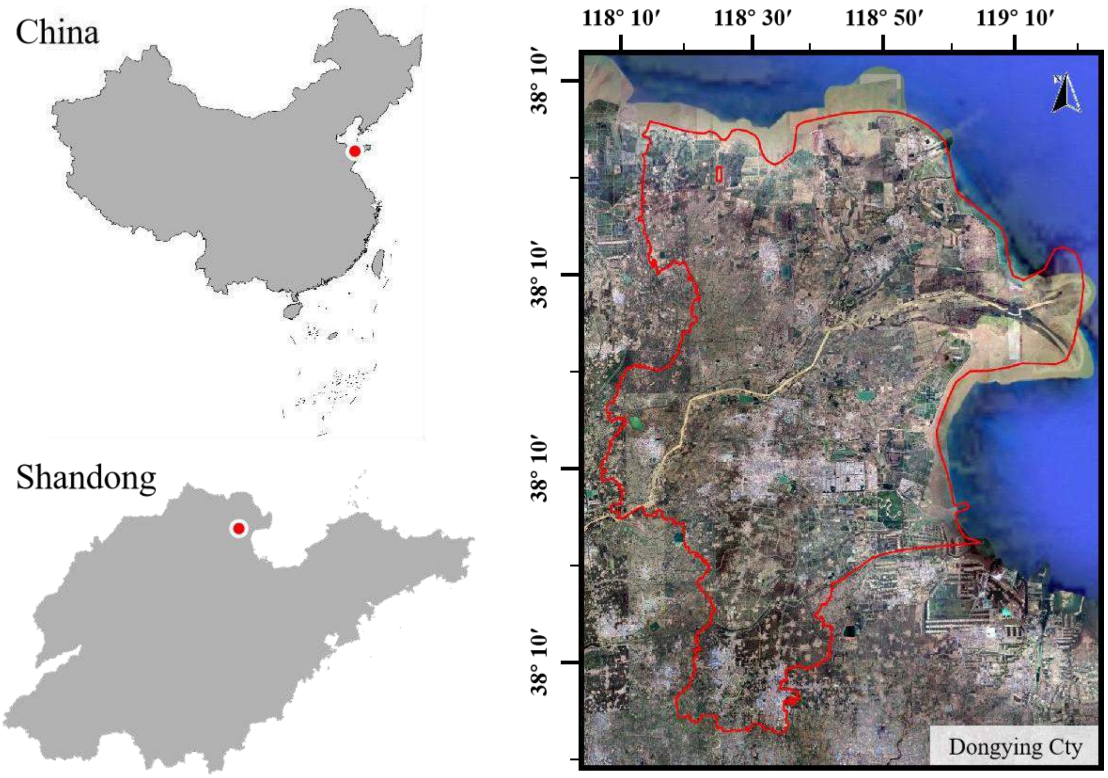

Figure 1. Research location

2. Material and Method

The study utilized four types of data: land use, species distribution, natural environment, and socio-economic data. To ensure the scientific rigor and consistency of the research results, we used the administrative boundaries of Dongying City as the spatial constraint for our analysis. All data were projected using the WGS_1984_UTM_Zone_50N coordinate system, with a uniform resolution of 30 m×30 m and with the row and column numbers of the raster data aligned.

Table 1. Data profile and sources

Data types	Specific data	Data format	Spatial/temporal resolution	Sources of the data
Land Use	China Land Use/Cover Change (CNLUCC)	Raster	30m	Resource and Environmental Science Data Platform
Species data	Bird distribution point data	CSV	-	China Birdwatching Records Center; eBird; Global Biodiversity Information Facility
	Spatial distribution dataset of Euphorbiaceae	Raster	30m	National Earth System Science Data Center
Natural environment data	DEM	Raster	30m	Geospatial Data Cloud
	Climate and environmental data	Raster	30arc-seconds	WorldClim
	NDVI	Raster	30m	Resource and Environmental Science Data Platform
	Spatial Distribution Data	Raster	1km	Resource and Environmental Science

	of Soil Types			Data Platform
	Natural Feature Boundary Data	Shapefile	–	National Catalogue Service For Geographic Information
	China Soil Dataset	Raster	1km	National Cryosphere Desert Data Center
	Traffic Network Classification Data	Shapefile	–	OpenStreetMap
Socio-economic data	Traffic Network Classification Data	Shapefile	–	Resource and Environmental Science Data Platform
	GDP	Raster	1km	Resource and Environmental Science Data Platform
	POP	Raster	1km	Resource and Environmental Science Data Platform

This study is primarily divided into three parts: (1) Clarifying the spatial competition between migratory bird communities and *Spartina alterniflora*; (2) Elucidating the explanatory power and driving mechanisms of *Spartina alterniflora* concerning the distribution of migratory bird habitats; and (3) Proposing optimization strategies based on the findings of the study. The research framework integrates specific research content and methodologies.

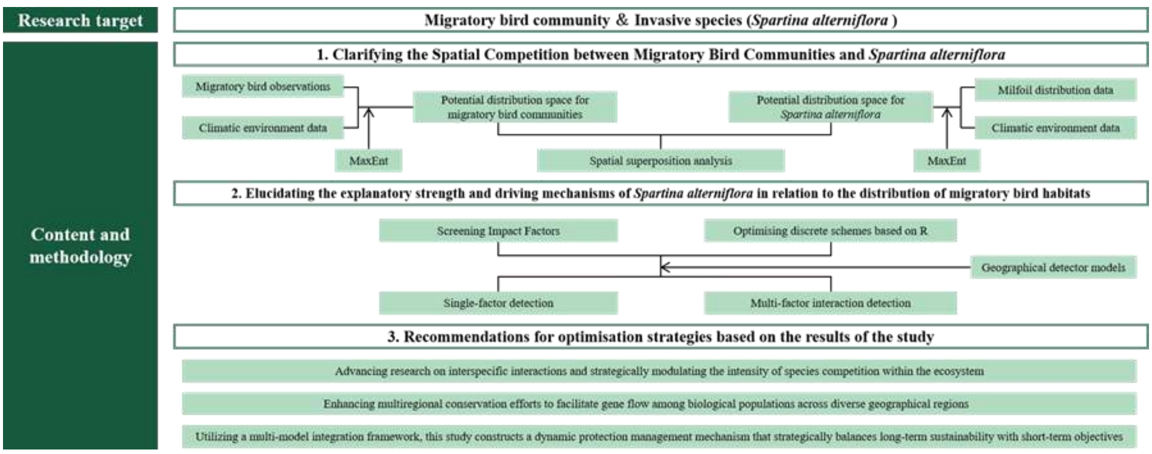

Figure 2. Research framework

3. Findings and Discussion

The results of the study showed that the potential habitats of migratory birds were generally centred on the high value of the northern coastal breeding area and the ecotourism area at the mouth of the Yellow River, showing a gradient trend from the centre to the periphery, and from the coast to the inland, with a gradual decrease. The habitat of *Spartina alterniflora* exhibits significant overlap, occupying 20.74% of the ecological niches of migratory bird populations. This substantial overlap poses a severe threat to the survival of various avian groups, including the piping plovers, and compromises the ecological integrity of the estuarine wetlands. In the designated study region, the Spartina alterniflora exhibited a continual acceleration in its expansion rate, averaging an increase of 1368.93% per decade, widely occupied the estuaries of the Yellow River and Guangli-Zhimai River, as well as the adjacent offshore mudflats and previously undeveloped lands.

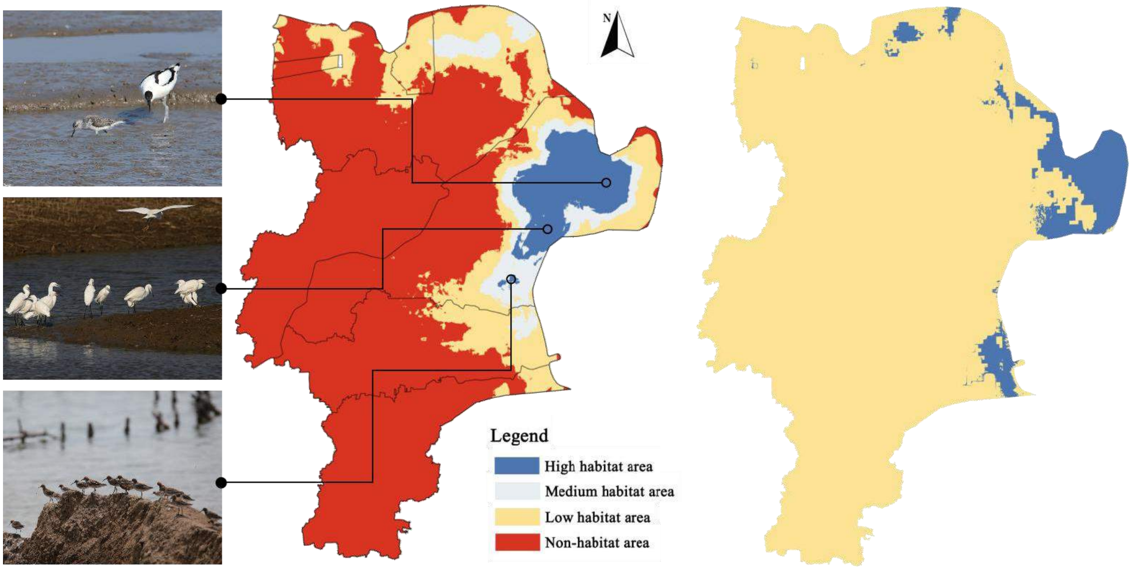

Figure 3. Potential habitat simulation results (The left panel represents the simulation results for migratory bird communities, while the right panel depicts the simulation results for Spartina alterniflora.)

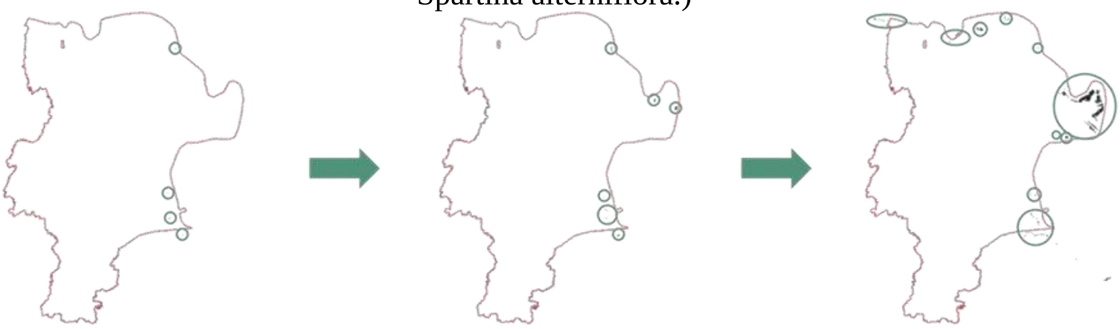

Figure 4. Expansion of Spartina alterniflora Communities (from left to right: 2000, 2010, 2020)

The study systematically selected eight indicators as explanatory variables to analyze the factors influencing the distribution of migratory birds. These indicators were carefully chosen to represent four critical aspects: species competition, climatic environment, habitat environment, and human activities. This comprehensive approach ensures a multidimensional understanding of the ecological and anthropogenic factors driving habitat distribution patterns within the study area. The majority of explanatory variables in this study demonstrated elevated q-values upon segmentation into eight categories via interquartile breaks or natural breaks classification techniques.

Table 2. Overview of driving factors

Variable types	**Factor types Datatypes**	**Factor**	**names**
Explained variable	Distribution patterns of migratory birds	Distribution patterns of Migratory bird community	Continuous
Explanatory variables	Species competition (X1)	Distribution patterns of *Spartina alterniflora*	Continuous
	Climatic environment (X2)	Bio15 (X21)	Continuous
		Bio4 (X22)	Continuous

Habitat environment (X3)	Habitat quality (X31)	Continuous
	LULC (X32)	Dispersive
Human activities (X4)	GDP (X41)	Continuous
	POP (X42)	Continuous
	Distance to railway (X43)	Continuous

The results indicate that species competition, represented by the distribution patterns of Spartina alterniflora, is the primary factor influencing the distribution of migratory birds in the study area, with a explanatory power (q-value) of 0.617. Human activities ranked as the second most influential factor, with a mean q-value of 0.532, followed by habitat environment (mean q-value = 0.469). In contrast, the influence of the climatic environment was relatively minor, with a mean q-value of 0.193. The study results demonstrated that pairwise interactions among explanatory variables significantly increased their q-value explanatory power for the spatial differentiation of dependent variables, with primary forms of enhancement identified as synergistic and nonlinear effects. This indicates that the spatial distribution patterns of migratory birds are shaped by the combined influence of multiple factors, rather than being determined by any single variable. Overall, factor combinations associated with X1 demonstrated the higher explanatory power, followed closely by those involving X4. These findings suggest that human activities may intensify interspecies competition in the study area or disrupt the region's biological patterns.

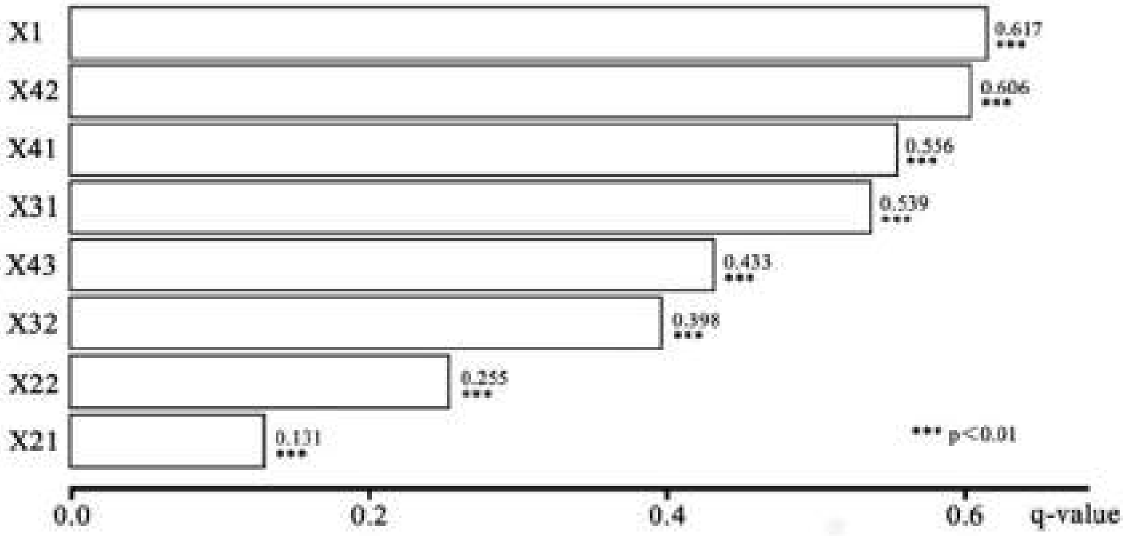

Figure 5. Detection results for single factors

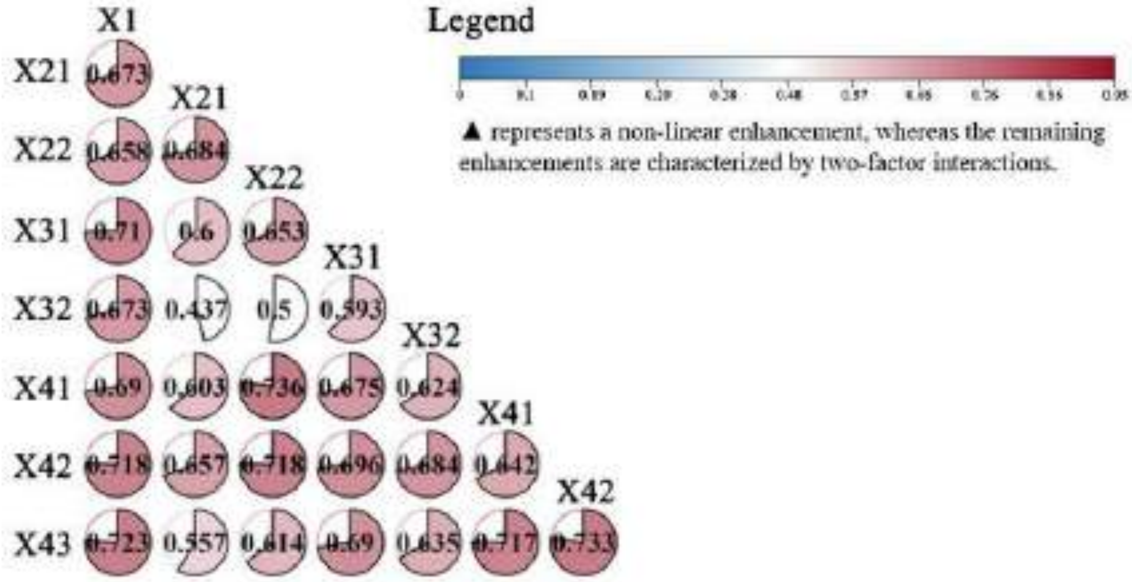

Figure 6. Interaction detection results for each type of factor

With the introduction of the Yellow River High-Quality Development Strategy, Dongying City has made significant progress in biodiversity conservation. Against this backdrop, the core challenge for current conservation efforts lies in effectively balancing interspecies relationships and natural processes while minimizing potential human disturbances. Based on the current status of migratory bird populations and their habitats in Dongying City, this study proposes the following strategic recommendations, informed by the analysis presented earlier:

(1) Advancing research on interspecific interactions and strategically modulating the intensity of species competition within the ecosystem.

This study emphasizes the importance of advancing research on interspecific interactions and adopting targeted strategies to regulate species competition intensity within ecosystems. Policymakers are encouraged to implement a diverse range of bird-watching facilities to enhance the spatial and temporal coverage of tracking observations, providing a more comprehensive understanding of migratory bird behavior. Additionally, it is crucial to rationally plan the distribution density of ecological niches based on the survival habits of different migratory bird species, effectively reducing interspecific competition. Furthermore, the adoption of seasonal crop rotation in productive spaces is recommended to foster coexistence between human activities and natural ecosystems, creating a harmonious and sustainable conservation framework.

Figure 7. Strategy Diagram (for Strategy 1)

(2) Enhancing multiregional conservation efforts to facilitate gene flow among biological populations across diverse geographical regions.

The study highlights the need to strengthen multiregional conservation efforts to ensure gene flow among biological populations across varied geographical areas. It is recommended to advance riverine waterfront restoration initiatives that promote ecological connectivity and synergistic coexistence between upstream and downstream regions. Facilitating natural rewilding in areas fragmented by administrative boundaries is also vital, as it helps regulate the intensity of human activities and restores ecological balance. In addition, enhancing public ecological awareness through science education initiatives is crucial, fostering a collective understanding and support for biodiversity conservation efforts across multiple regions.

Figure 8. Strategy Diagram (for Strategy 2)

(3) Utilizing a multi-model integration framework, this study constructs a dynamic protection management mechanism that strategically balances long-term sustainability with short-term objectives.

This study recommends that policymakers adopt the proposed multi-model integration framework to ensure effective long-term planning and periodic evaluation of migratory birds and their habitats. By leveraging this framework, conservation strategies can be dynamically adjusted based on the achievement of short-term objectives, enabling a responsive approach to emerging challenges. Such a mechanism is particularly crucial for mitigating the adverse effects of extreme climate events and minimizing the impacts of sudden environmental changes on the survival and habitat stability of migratory birds. The integration of long-term sustainability goals with adaptive short-term strategies ensures that conservation efforts remain robust, flexible, and effective in the face of ecological uncertainties.

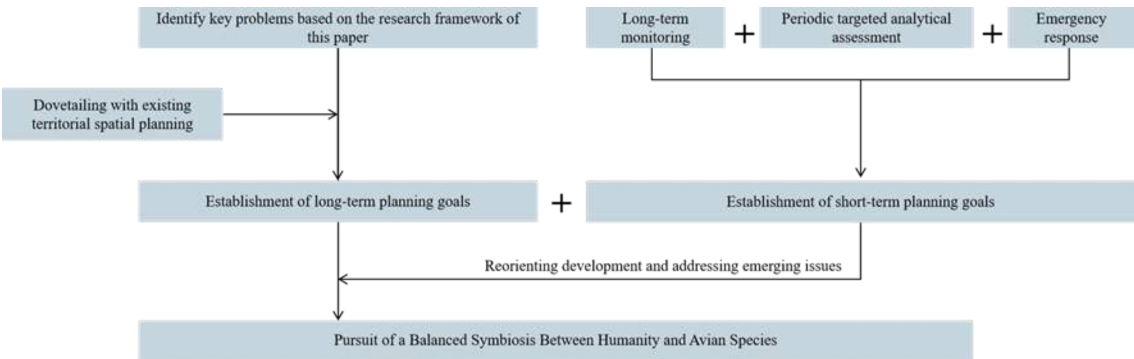

Figure 9. Strategy Diagram (for Strategy 3)

This study focuses on migratory birds as the research subject and employs them as key indicators of biodiversity to define the criteria for habitat patch identification. This research approach exhibits applicability across coastal towns. However, the migratory behavior of birds is a pan-regional phenomenon that encompasses multiple regions or even countries. Consequently, future studies should broaden their scope to encompass the provincial level or the Yellow-Bohai Sea region, examining the strategic decisions of migratory birds across various stopover sites, and the seasonal effects of their migratory activities on species diversity from a macroecological perspective.

4. Conclusion

In this manuscript, the endangered and rare migratory birds in Dongying City were chosen as the focal points of investigation. Employing the integrated research framework of MaxEnt, InVEST, and optimal parameters-based geographical detector models, the study explored the ecological niche competition between migratory bird communities and invasive species within Dongying City. This approach elucidated the explanatory power and underlying mechanisms governing the distribution of migratory bird habitats, influenced by a diverse array of environmental factors. Moreover, this approach effectively minimized systematic errors by leveraging the synergistic features of multiple models and meticulously accounting for the subsurface land-use realities. The study delineated strategic measures for the conservation of migratory bird communities and their habitats in Dongying City.

The principal findings of the research are summarized as follows: The species interactions, particularly competitive relationships, play a pivotal role in shaping the ecological niche of species. Additionally, the insufficient focus on species interactions and the magnitude of environmental responses has been pinpointed as the chief factor contributing to the disconnect between theoretical research and conservation practices, as well as hindering the attainment of both conservation efficiency and equity.

Prior Publication Statement

The original study has been accepted by ***Acta Ecologica Sinica*** **(ISSN 1000-0933)** and is scheduled for publication in the journal. This manuscript presents partial findings from the original study, along with an extension of its design applications. This submission unequivocally does not represent duplicate publication.

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Sustainable Drainage Systems in Urban and Rural Landscape Design

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Abstract

As precipitation patterns evolve, the accessibility of water to communities is increasingly compromised each year, yet the water that does reach communities is not being preserved! Urban infrastructure systems, which were built on the principles of collecting surface runoff and directing it into storm drains, are rapidly losing their effectiveness due to the increase in impermeable surfaces and urbanization. Climate change and the resulting floods and avalanches are forcing humans to return to nature's cycle.

The present study comparatively described "Sustainable Drainage System Design and Practices" experienced in design, construction and consultancy in different geographies and climatic conditions. While elucidating the similarities and differences among the details, the drawings and pictures of essential elements were included.

The systems that regulate surface runoff and flooding by emulating natural drainage patterns while improving water quality, environmental aesthetics, and biodiversity are collectively termed "Sustainable Stormwater Management". The implementations of these systems are concepts intrinsically linked to urban planning and landscape design. Consequently, Landscape Architects should favor sustainable, ecologically based drainage systems over conventional ones that have diminished in functionality in future landscape designs. Change is feasible only when a requisite majority of society embraces, and mobilizes. This is the sole method to guarantee sustainability.

Keywords: Urban landscape, rural landscape, landscape design, drainage systems, permeable landscape, stormwater management, sustainability

1. Introduction

In recent years, the significance and administration of rainfall have been increasingly acknowledged as vital in the management of natural resources for the development of urban-rural communities. It follows that, Water Sensitive Urban Design (WSUD) in Australia, Sustainable Urban Drainage Systems (SUDS) in the UK, and Low Impact Development (LID) in North America have concurrently arisen in several countries as more sustainable paradigms for stormwater management (Tim D. Fletcher, 2015).

The first instances of rainwater management and drainage systems originate from antiquity. The urban design of the Babylonian and Mesopotamian Empires in Iraq (around 4000-2500 BC) and the Minoans and Harappans in Crete and the Indus Valley around 3000 BC, respectively, demonstrates the existence of the earliest sophisticated sewage and drainage systems. (G. De Feo, G. P. Antoniou, F. Fardin, F. El-Gohary. The Global Historical Evolution of Sewers, June 2014) The materials, details, and solutions of these ancient towns and ruins may differ based on historical evolution, geographical factors, and cultural values. Nevertheless, the paramount shared characteristics are the natural surface flow regime that emulates nature, together with the management and diversion of water and the mitigation of erosion. The same common features constitute the basic design principles of today's "Sustainable Stormwater Management" and "Sustainable Drainage System" concepts.

The objectives of this paper are as follows;

- To increase the awareness of Landscape Architects by drawing attention to stormwater management and drainage concepts closely related to urban planning and landscape design.
- To remind the role of landscape architects in the design of drainage systems and the integration of these systems with infrastructure - superstructure and other disciplines.
- To motivate and inspire Landscape Architects by creating an awareness with my experience and projects of urban and rural sustainable landscape drainage systems designed and implemented for extreme geographical conditions

2. Material and Method

This study's drainage system experiences, which vary significantly based on geographical conditions, climatic characteristics, and project types, formed the primary material and methodology. Furthermore, the study's findings were corroborated by the subsequent literature study. Fletcher, Shuster, Ashley and Butler, 2014, *Urban Water Journal, DOI: 10.1080/1573062X.2014.916314; SUDS, LID, BMPs, WSUD and more – The Evolution and Application of Terminology Surrounding Urban Drainage;* Payne, Hatt, Deletic, Dobbie, McCarthy and Chandrasena, 2015, *Cooperative Research Centre for Water Sensitive Cities, Adoption Guidelines for Stormwater Biofiltration Systems;* Feo, Antoniou, Fardin, El-Gohary, Zheng, Reklaityte, Butler, Yannopoulos and Angelakis, 2014, *Sustainability 2014, 6, 3936-3974; DOI:10.3390/su6063936, The Historical Development of Sewers Worldwide;* Ramos, Pérez-Sánchez, Franco and López-Jiménez,2017, *Fluids 2017, 2, 61; DOI:10.3390/fluids2040061, Urban Floods Adaptation and Sustainable Drainage Measures; Filimonov,* Kamnev, Shein and Vaganova, 2022, *Land 2022, 11, 1102, DOI:10.3390/land11071102, Modeling the Temperature Field in Frozen Soil under Buildings in the City of Salekhard Taking into Account Temperature Monitoring;* Tregubov, Uyagansky, 2024, *Urban Science 8(3):23 DOI:10.3390/urbansci8030094, Substantiation of the Monitoring Network of Talik Zones in Urbanized Permafrost Areas Based on GPR Profiling Data(Anadyr, Chukotka)*

Examples were provided detailing drainage systems from urban design and landscape projects implemented across diverse geographical and climatic conditions, spanning from the Arctic Region (Chukotka and Yamal Autonomous Okrug) to the equatorial line (Middle and South Africa).

3. Findings and Discussion

Upon examining the system specifications of project examples created and executed across various geographies and extreme climate zones, the following conclusions have formed;

- ❖ Although the principles of sustainability and the natural water cycle are foundational in both severe environments, the components, detail designs and solutions of the drainage and infrastructure system differ significantly.
- ❖ A transition is occurring from conventional stormwater management to sustainable stormwater management.

Upon analyzing the common characteristics of sustainable drainage systems developed for urban and rural environments, it became evident that their fundamental and immutable premise is "Supporting the Natural Water Cycle." Their distinct characteristics were shaped by geographical and climatic needs.

The Arctic Climate Zone is illustrated through numerous site, urban design and landscape projects in the cities of Anadyr and Salekhard, worked within Yamata Investment between 2002 and 2007.

Case studies of the Tropical and Subtropical Climate Zone were assessed through site and landscape projects managed and supervised in the cities of Kampala and Maputo from 2018 to 2024.

Figure 1-2. Photographs and graphics utilized to represent the geographical location and severe climatic attributes of the sampled projects (Erdem, 2003 & 2024)

Common Features of the Projects;

- Appreciating, considering and sustaining vernacular, indigenous and local knowledge. *The recognition and valuation of traditional, local knowledge observed in various cultures throughout antiquity underpin the advancement of natural and sustainable systems.*
- Directing the water to the "Natural Flow Route" with simple details suitable for climatic conditions.
- Prevention and management of erosion.

Differences in Projects;

The Arctic Climate Zone	***Tropical and Subtropical Climate Zone***
• *Controlled runoff with impermeable paving materials and open drainage channels.* • *Reducing the runoff velocity of drainage and consequently limiting erosion and reducing "Permafrost" degradation.*	• *Reducing runoff with permeable surfaces and blue-green drainage systems.* • *High-speed drainage solutions proportional to the high rainfall rate in tropical rainfall*

a. Arctic Climate Zone Projects

This section provided details on the drainage systems in the arctic climate zone, illustrated by projects executed in Anadyr *(Chukotka Autonomous Okrug)* and Salekhard *(Yamal Autonomous Okrug)* in Siberia, where we worked within Yamata Investment from 2002 to 2007.

Figure 3. Geographical locations of the cities of Salekhard and Anadyr (Erdem, 2024)

Anadyr Annual Climate Data;

Average	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High	-18°C	-17°C	-14°C	-8°C	3°C	12°C	16°C	14°C	7°C	-2°C	-10°C	-16°C
Temp.	-22°C	-21°C	-18°C	-12°C	-0°C	8°C	12°C	11°C	5°C	-4°C	-13°C	-19°C
Low	-25°C	-24°C	-22°C	-14°C	-3°C	5°C	10°C	8°C	2°C	-7°C	-16°C	-22°C

Days of	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rain	0.1d	0.0d	0.0d	0.2d	2.2d	5.7d	8.2d	8.2d	6.1d	2.3d	0.7d	0.2d
Mixed	0.2d	0.1d	0.2d	0.4d	0.7d	0.1d	0.0d	0.1d	0.3d	1.1d	0.5d	0.5d
Snow	4.1d	4.4d	3.2d	2.4d	1.1d	0.0d	0.0d	0.0d	0.2d	2.3d	3.6d	4.1d
Any	4.4d	4.6d	3.4d	3.0d	4.0d	5.8d	8.2d	8.3d	6.7d	5.7d	5.4d	4.6d

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall	0.7mm	0.3mm	0.3mm	1.5mm	10.4mm	31.4mm	47.2mm	49.5mm	37.7mm	17.3mm	7.6mm	2.1mm

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Snowfall	186.5mm	213.1mm	150.9mm	113.6mm	52.3mm	3.1mm	0.0mm	2.3mm	25.7mm	141.6mm	215.2mm	212.5mm

Figure 4-5-6. https://weatherspark.com/y/144950/Average-Weather-in-Anadyr-Russia-Year-Round

(Annual data for the cities of Anadyr and Salekhard have similar values. Data from Anadyr, where snowfall is more extreme, was included for reference)

Annual weather reports containing temperature, freeze/thaw and rainfall data, which form the basis for the design and planning of the project areas and drainage systems, can be observed in Figures 4-5-6.

Following an extended, frigid winter characterized by a blanket of snow, the yearly climatic cycle culminates in a brief, relatively mild spring/summer season during which the snow and surface ice soften and melt, resulting in flooding. Thus, the drainage system is designed and computed based on hydrological data from late April and May, when the melting snow and surface ice contribute to flood conditions.

Figure 7. Annual cycle of the journey of the drainage waters that end up in Anadyr Bay, which turns into floods and inundations when the white cover melts (Yamata, 2002-2007)

Arctic permafrost zone construction techniques; in cities located in these regions, buildings and infrastructure systems are built according to the principle of preserving the frozen natural ground / permafrost zone. The buildings are located on piles extending to the depth of the permafrost zone, which is appropriate according to the ground survey reports. This method eliminates thermal contact between the structure and the frozen soil.

Figure 8-9. Buildings built on piles to protect the permafrost zone (Yamata, 2002-2007)

Nonetheless, even when the structures are situated on piles, the piles between the building and the permafrost substrate provide a thermal bridge effect due to the temperature fluctuations caused by air conditioning and similar anthropogenic activities. To assess the fluctuation of this thermal influence, a specific type of thermo stabilizer, either horizontal or vertical, utilized in permafrost areas, is positioned adjacent to the piles. These thermo stabilizers function by cooling the ground and preserving the natural ice temperature, reacting in response to potential temperature fluctuations. They undergo annual inspections, and any defects are meticulously monitored. Currently, thermal stabilizers are monitored digitally. (M. Yu. Filimonov, Y. K. Kamnev, A. N. Shein, N. A. Vaganova, Modeling the Temperature Field in Frozen Soil under Buildings in the City of Salekhard Taking into Account Temperature Monitoring, 2022)

Arctic permafrost zone infrastructure-drainage techniques; roads, structural landscaping, infrastructure and drainage systems, as well as buildings, are designed on the basis of permafrost zone protection. Accordingly, the system is interconnected with impermeable structural landscaping and open drainage channels. Snow and precipitation runoff from impermeable surfaces is directed to rivers and oceans. This also ensured the sustainability of the natural water cycle.

Typical sections and construction details of Arctic Climate Zone;
Prior to proceeding the specifics of the drainage system used in Arctic region cities, it is beneficial to recall the diagram of the natural water cycle to comprehend the fundamental principles of the associated system.

Figure 10. "Natural Watershed Diagram" (*Diagram Credit: Wolf River Conservancy*)

Figure 11. Schematic drawing of the length profile of the road and drainage ditches on a bird's-eye view of the city of Salekhard (Yamata, 2002-2007).

This graphic illustrates, at a master size, the planning of a drainage network utilizing impermeable road surfaces by emulating a natural waterbed.

The cross-sections of impermeable road surfaces and drainage ditches are constructed with two distinct types of cross-sections for urban and rural areas.

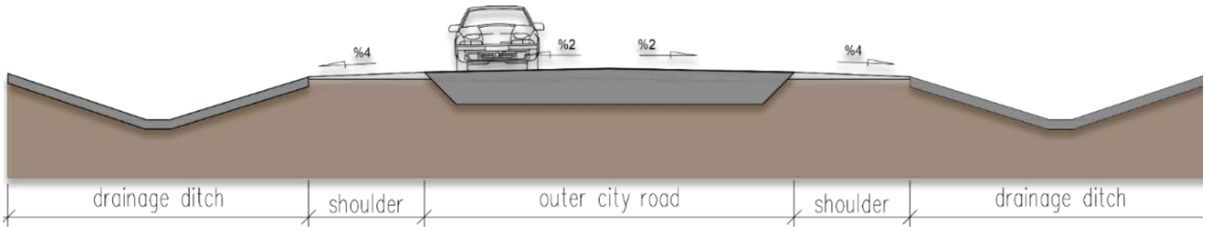

Figure 12. Cross section of a suburban type road (Yamata, 2002-2007).

Figure 13-14. Open roadside drainage ditches in the suburbs (Yamata, 2002-2007).

By the end of April, the surface runoff generated from the melting and thawing of snow and ice is directed over the impermeable reinforced concrete pavements beneath the pile-constructed structures, extending to the driveway with a gradient of 1-2%. Drainage water on the road surface is sent to rivers or seas via impermeable surfaces with an ideal longitudinal gradient of 2-8%.

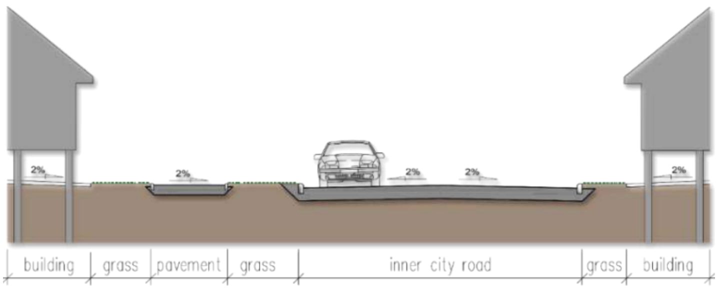

Figure 15: Type cross-section of urban road and structural landscape areas (Yamata, 2002-2007).

Figure 16. Conveyance of melting runoff snowmelt across the longitudinal gradient of the urban roadway (Yamata, 2002-2007).

b. Tropical and Subtropical Climate Zone Projects

This section covered project samples and drainage information for tropical and subtropical climate zones in Kampala, Uganda, and Maputo, Mozambique, where I served as project manager, controller, and consultant from 2018 to 2024.

Figure 17. Geographical locations of Kampala and Maputo (Erdem,2024)

Kampala Annual Climate Data: *Kampala, the capital of Uganda situated on the equatorial line in Central Africa, experiences a tropical rainy climate. Although the city has two dry and two wet seasons annually, it lacks distinct dry season months, with heightened precipitation occurring from August to December and February to June.*

Average	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High	27°C	28°C	27°C	26°C	25°C	25°C	25°C	25°C	26°C	26°C	26°C	26°C
Temp.	22°C	23°C	23°C	22°C	22°C	21°C	21°C	21°C	21°C	21°C	22°C	22°C
Low	18°C	18°C	18°C	18°C	18°C	18°C	17°C	17°C	17°C	17°C	18°C	18°C

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall	67.6mm	79.2mm	167.1mm	230.8mm	157.5mm	58.9mm	49.7mm	86.2mm	112.8mm	154.8mm	155.4mm	103.4mm

Days of	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rain	11.3d	11.6d	20.2d	25.2d	22.0d	12.2d	12.0d	17.6d	20.5d	23.9d	20.8d	14.2d

Figure 18. https://weatherspark.com/y/97219/Average-Weather-in-Kampala-Uganda-Year-Round

Maputo Annual Climate Data: *The climate of Maputo, the capital of Mozambique in southern Africa, is subtropical, characterized by a hot and rainy season from December to March and a cool and dry season from June to August.*

Average	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High	29°C	29°C	28°C	27°C	25°C	24°C	23°C	24°C	25°C	26°C	27°C	28°C
Temp	26°C	26°C	25°C	24°C	22°C	20°C	20°C	20°C	22°C	22°C	23°C	25°C
Low	23°C	23°C	22°C	21°C	19°C	17°C	18°C	17°C	18°C	19°C	21°C	22°C

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall	120.3mm	102.1mm	69.6mm	41.3mm	21.9mm	13.1mm	12.0mm	13.4mm	23.7mm	48.5mm	85.5mm	94.8mm

Days of	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rain	12.1d	10.3d	9.3d	5.0d	3.0d	2.2d	1.9d	1.9d	3.1d	6.2d	10.3d	11.4d

Figure 19.https://weatherspark.com/y/97168/Average-Weather-in-Maputo-Mozambique-Year-Round

Despite variations in the duration of rainy seasons and precipitation levels between the two cities, annual temperature fluctuations range from 17 to 29°C. The calculations for drainage systems and the dimensions of their components vary based on the topography, rainfall duration, velocity, and volume in our project areas; however, sustainable drainage systems adhering to the same principles (blue-green drainage system) and infrastructures have been implemented.

Overview of urban development status and infrastructure of cities;

Figure 20-21. Kampala city roads and buildings. In the city center, the primary pathways consist of concrete-asphalt, whereas the secondary pathways are composed of compacted dirt; in the suburbs, all pathways are entirely compacted soil. Open drainage ditches alongside concrete and asphalt main roadways facilitate swift water release during tropical rainstorms (Erdem, 2024).

Figure 22-23. Local drainage system for Kampala city. (Fig-22 KCCA (Kampala Capital City Authority,2023). City and man during a tropical downpour (Fig-23 The New Times_Emmanuel Kwizera,2020)

Figure 24-25. General view of Maputo city center and its largest suburb, Matola. Although Maputo's city center has a more developed urbanization, the suburbs have the same rural construction of rammed earth and small cottages. (Erdem, 2024)

General design principles of tropical-subtropical zone drainage systems:

Despite the overarching depiction of the cities' housing the projects as underdeveloped, they possess significant data regarding the "Vernacular" and "Indigenous" architecture, geography, and infrastructure of those areas. The useful data is refined and utilized to establish the foundation for the design of the drainage systems in the projects we have undertaken.

- ❖ The drainage system designs derived from "Vernacular" and "Indigenous" data have been upgraded and enhanced using concepts of sustainability. The project serves as a paradigm for sustainable and innovative infrastructure drainage systems in the regions.
- ❖ Permeable ground applications, sometimes perceived only as compacted earth, are enhanced with sophisticated contemporary building materials.

Figure 26. The text and pictures depict the direct drainage of precipitation from the surface onto which it falls, utilizing permeable paving materials. (Atelier GROENBLAUW, 2024)

- ❖ Conventional drainage systems, referred to as "Grey Infrastructure[1]," are diminished, while sustainable infrastructure-drainage systems, known as "Blue-Green[2]" drainage systems, are augmented. These two systems are combined to enhance stormwater management.

([1] Gray infrastructure refers to conventional stormwater systems, including drainage gutters, ditches, drainage pipes, manholes, and retention ponds.)

[2] Blue-green drainage systems are designed to capture rainwater at its point of fall and channel it into the natural water cycle, emulating natural processes. It encompasses a diverse array of system components, including permeable pavements, rain gardens, bio-retention cells, vegetated channels, infiltration channels, green roofs, rainwater collection systems (such as rain barrels or cisterns), and tree canopies.)

Typical sections and construction details of tropical and subtropical zone projects;

This section elucidated the technical specifications and system components of the landscape drainage projects in Kampala and Maputo, accompanied by reference illustrations.

Despite variations in cross-sectional dimensions based on rainfall estimates, site leveling plans, and catchment areas for both projects, identical system components were utilized in their installation.

System components and flowchart;

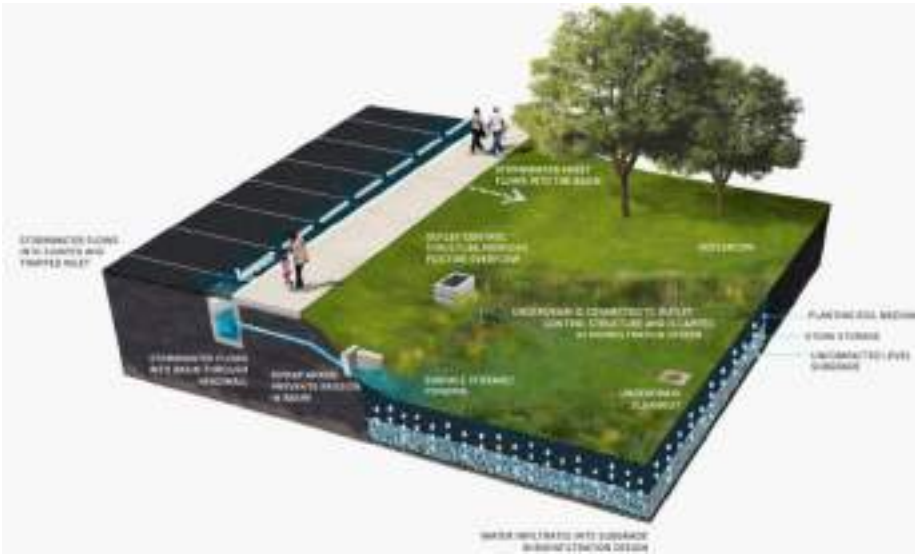

Figure 27. Components of bioretention systems
https://water.phila.gov/development/stormwater-plan-review/manual/

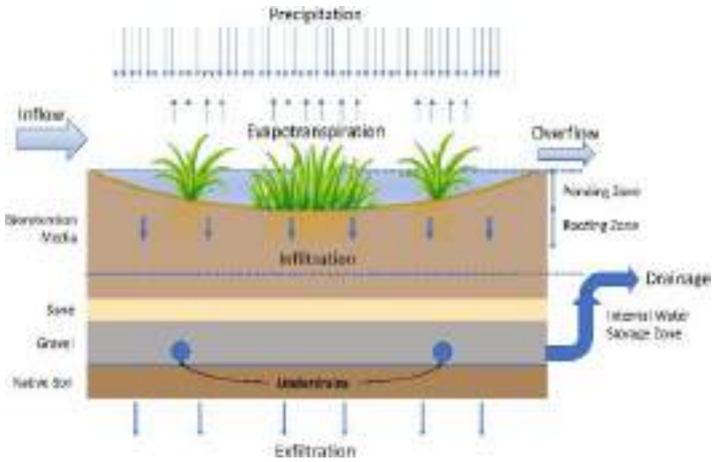

Figure 28. Schematic of typical bioretention cell (adapted from Lisenbee et al., 2020)

- ❖ Drainage from building roofs, impermeable roadways, and parking lot runoff is collected in manholes created following technical specifications.
- ❖ Rainwater from roadways and vegetated zones constructed using permeable paving materials is gathered via an underground drainage pipe network.
- ❖ Rainwater is directed to biological treatment ponds and/or rain gardens enriched with natural plant vegetation.
- ❖ Water from these biological filtration zones designated as bioretention areas connected to the tank / cistern and/or natural ground water.
- ❖ Furthermore, the system is equipped with outlet controls designed to satisfy the specifications for gradual discharge into the sewer.

4. Conclusion

In response to shifting rainfall patterns caused by climate change, the sustainable enhancement and expansion of drainage systems across all nations is a critical answer for safeguarding ecosystems and mitigating flood expenses.

In the projects and drainage system designs of Landscape Architects in urban and rural areas in this process of change; *Blue-green drainage systems that mimic nature, increasing permeable surfaces in structural landscapes, rainwater harvesting and groundwater recharge, sustainable stormwater management, sustainable drainage systems suitable for geographical conditions instead of uniform conventional urban drainage systems, controlling erosion*, will be part of the solution as long as the primary design principles.

Figure 29. Serves as a visual summary to highlight the concepts addressed in this study. (Erdem, 2024)

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Spontaneous Plant Library and Potential Applications in Urban Landscape

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Abstract

Proliferated in urban derelict, vacant land and marginal space, the apparently homogeneous and disorder form of spontaneous plants, conventionally categorized with the term 'weeds', are often associated with negative impression and reckoned as undesirable in the urban environment. Yet, the ecosystem services and resilience of these spontaneous inhabitants, which thrive in the most human-disturbed conditions, are often overlooked and rendered invisible.

This ongoing project aims to re-examine the human-plant symbiosis relationship by investigating the aesthetics, functions and benefits of these unintended plants and scrutinizing our perception of 'weeds' from an ethnographic perspective. There are two major objectives, namely to build up a comprehensive library framework for spontaneous plants in Hong Kong and conduct trials for the potential applications of these plant species also commonly found in major cities in South China. The initial findings have revealed that unlike conventional understanding, many of the 'weed' species considered as invasive are in fact native species with ecological value and often form part of the rural life and vernacular knowledge.

By advocating urban wilderness and incorporating spontaneous plants in landscape design and adaptive horticultural maintenance, this project contends that spontaneous landscape is not only part of the total experience in urban nature intertwined with cultural, economic and social nexus but also crucial to the exploration of co-existence with multispecies in a hyper-dense urban environment and a more sustainable future.

Keywords: Spontaneous plants, unintentional landscape, ruderal ecology, novel ecosystem, urban wilderness

1. Introduction

"At its core, a weed is, quite simply, a plant that people do not like because it is growing where they do not want it to grow. To put it another way, it is the context in which a plant is growing – not the plant itself – that makes a weed."

Peter Del Tredici, Wild Urban Plants of the Northeast, 2010

"If our analytical starting point for marginal spaces is reframed in relation to a closer engagement with spontaneous traces of nature, and their social and cultural significance, this can serve as a basis from which to develop a wider terrain of critical reflection over the concept of landscape itself."

Matthew Gandy, Unintentional Landscape, 2016

Proliferated in urban derelict, vacant land and marginal space, the apparently homogeneous and disorder form of spontaneous plants, conventionally categorized with the term ‘weeds’, are often associated with a negative impression and reckoned to be undesirable and nuisance in the urban environment. Yet, the ecosystem services and resilience of these spontaneous inhabitants, which thrive in the most human-disturbed conditions, are often overlooked and rendered invisible. Landscape studies typically examine different forms of human development based on rational and utilitarian design and planning intentions. Yet, the dynamic of spontaneous and unintentional landscapes, which are ambiguous, complex and difficult to trace the origins and flows, often remain outside the mainstream discourses.

This ongoing project contends that a closer look at these spontaneous landscape may allow us to envisage an urbanism that do not only form part of the total experience in urban nature but also crucial to the exploration of co-existence with multispecies in a hyper-dense urban environment. It aims to re-examine the human-plant symbiosis relationship by investigating the aesthetics, functions and benefits of these unintended plants and scrutinizing our perception of ‘weed’ from an ethnographic perspective. To understand spontaneous landscape as a widespread urban phenomenon in cities is crucial and requires a socio-ecological framework as they are indicators of global connections, heterogeneity of urban life, environmental changes and traces of social, economic and political human activities (Stoetzer, 2018). There are two major objectives in this project, namely to build up a comprehensive library framework on spontaneous plants in Hong Kong and explore trials for the potential application of these plant species also commonly found in major cities in South China.

2. Unintentional Landscape and Spontaneous Vegetation

Unintentional landscape is defined as “an aesthetic encounter with nature that has not been purposively created.” it is not an “idealised landscape that conforms to some pre-existing conception of the innate relations between nature and culture, and it is not a designed landscape allied to particular social or political goals. It is a landscape “in spite of itself” (Gandy, 2016). The concept is connected to other urbanist terminologies, such as terrain vague, urban void, marginal land, loose space and vacant land, and ecological concepts, such as spontaneous vegetation, novel ecosystem, ruderal ecology and cosmopolitan ecology. In natural environment, all plants are propagated spontaneously without human intervention. The term spontaneous vegetation is anthropocentric in nature. It refers to “all plants that develop without intentional horticultural input” (Kühn, 2006). These cosmopolitan plants can be native inhabitants, species that escaped from or were left over in agricultural sites, or unintentionally introduced exotic species. Hobbs refers these patches and corridors of spontaneous vegetation as novel ecosystem which has the potential to change the functioning of ecosystem as a result of human actions but do not depend on continuous intervention or maintenance (Hobbs, 2006). The presence of spontaneous vegetation, therefore, has inherited conflict with mainstream practice of landscape design and management presuming there is a “scientific” approach to instruct interventions and maintenance based on certain order and complete control of “nature”.

3. Perception of Weeds

Our perception of ‘weed’ is culturally constructed and ethnographic. From an ecological perspective, ‘weeds’ are equivalent to spontaneous plants that are adaptive to urban disturbance or artificial landscapes. They may not be the cause of environmental degradation but symptoms of it. If resilience in ecology is the ability of an ecosystem to resist, to recover from, or to adapt to adversity and to maintain its functions and services during and after disturbances, then the performance of ‘weeds’ could outperform many other plants. ‘Weeds’ are tough and can adapt to environmental stress, scavenge nutrients and water in harsh conditions. They are diverse in morphology and can interact with other species and provide eco-system services at places no other cultivated plants could survive. Spontaneous landscape can be deemed as a natural process reclaiming urban voids from human activities with both native and non-native species, the resilient urban spontaneous inhabitants which thrive in the most disturbed urban conditions.

4. Study Area and Methodology

The aim of data collection in this project is to systematically establish a framework and compile an initial record of spontaneous plants in Hong Kong. Majority of researches related to 'weeds' aims to eradicate them from the angle of agricultural production and urban landscape management. The spontaneous plant library in this projects, in opposite, aims to establish a systematic archive for spontaneous plants and analyze their functions and benefits. Desktop research is conducted to identify the spontaneous plants commonly categorized as "weeds" with reference to local and international publications (Lee et. al, 2023; Xu, 2019; CABI Digital Library, 2024). These recorded spontaneous plant species are detailed with the botanical attributes, perniciousness, functions and benefits, ecological value and environmental stress tolerance of the plants for further analysis (Figure 1). Further study may potentially include growth rate, size, ease of reproduction, well being, toxicity etc.

Botanical	**Ecological**	**Functions**
Scientific Name Common Name Chinese Name Family Name Origin Conservation Status Plant Type Maximum Size Flowering Period Fruiting Period Habitat	Nectar Plants Larval Plants Butterflies Birds Bees / Wasps Bats **Perniciousness** Highly Invasive Moderate Impact Low Impact	Edible Medicinal Ornamental Cultural Phytoremediation Erosion Control **Stress Tolerance** Wind Salinity Drought Pollutant Shade

Figure 1. Data attributes in desktop research.

Spontaneous plants commonly found in field which have no signs of human propaganda are recorded. Three plots and two transects were studied to better understand the spontaneous plants in urban settings. The three plots were located at the rooftops of buildings in the Chinese University of Hong Kong, the approximate roof area ranges from 650m^2 to 2,100m^2 (Figure 2). The two transects were surveyed to represent the typical urban development mode in Hong Kong, namely the harbourfront development in Hong Kong Island which extend from the Victoria Harhour to uphill Green Belt marginal to conservation area and new town development centred with transportation hub to rural conservation area (Figure 3).

Figure 2. Survey plots located at the Chinese University of Hong Kong, Hong Kong

Figure 3. Transect surveying routes located in Central and Tin Shui Wai, Hong Kong

5. Results and Discussions

The initial spontaneous plant library has recorded 202 plant species from 62 families of which there are 163 annual / perennial herbs, 16 vines (or climbers), 14 tree species, 4 ferns, 3 shrubs and 2 palm species (in taxonomy, palm can be trees, shrubs or climbers. The curent categorization follows the common categories in landscape / planting design). Out of the 202 recorded plant species, 120 plants species were found in the three plots and two transects surveyed with photographic records. 59 plant specimen records had been collected for further archival processing.

Argument 1: Not all Spontaneous Plants are Exotic and Invasive

The general perception on spontaneous plants is that they are "exotic" and "invasive". However, data analysis has shown that 126 out of 202 recorded plant species are native species, comprising approximately 62.4% of plant library record (Figure 4). Of the 76 non-native species defined by Hong Kong Herbarium, 26 of them are classified as naturalized. A further study on the 91 species classified by literature as medium to high perniciousness, 53 of them are in fact native species. Unexpectedly, 6 of the recorded plant species are classified as species of conservation value protected by local ordinance and/or classified as rare or with conservation concern by IUCN.

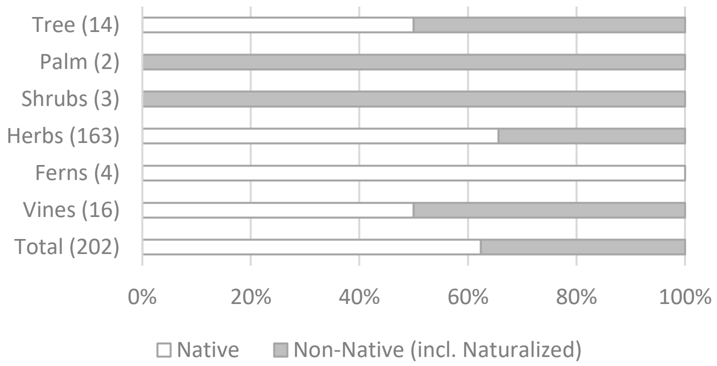

Figure 4. Native verse Non-native species (defined by Hong Kong Herbarium)

Argument 2: Not all Spontaneous Plants are Undesirable and Useless

Based on the initial desktop research, 184 out of 202 plant species have either edible, medicinal, ornamental, cultural, phytoremediation and/or erosion control functions or value. It is worth to mention that around 74% and 40% of plant species have medicinal (150 out of 202 plant species) and phytoremediation functions (81 out of 202 plant species) respectively (Figure 5).

Most people would perceive spontaneous plants as undesirable and without any functions. The traditional human-nature relationship built upon a mutually beneficial basis, forming part of the rural life, has vanished in the urban. Urban dwellers are difficult to establish any connections with plants in their livelihood except for amenity purpose.

Spontaneous vegetation in marginal space and urban voids are started to be recognized as part of the ecological infrastructure of the city extending to roles such as flood control, erosion control, accumulation of organic matter, carbon sequestration, air, water and soil purification, and the mitigation of the urban heat island effect. Not only large green space in urban environment forms habitat, urban derelict, vacant land and marginal space essentially serve their ecological functions and support life (Del Tredici, 2020; Seiter, 2016; Picket et. al, 2008). Yet, there is still a large gap in ecological studies in terms of human-plant symbiosis relationship that worth further researches

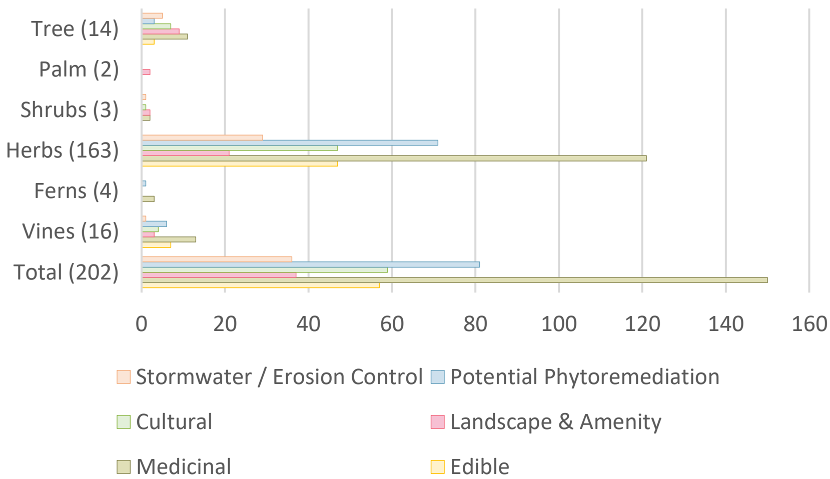

Figure 5. Functions of spontaneous plants

Argument 3: Spontaneous Plants have Ecological Value

There is a presumption and urgent need in landscape design to improve biodiversity amid the environmental challenges. However, there are few local studies on the ecological value of unintentional landscape and spontaneous plants. It is in fact a dilemma that on one hand biodiversity at conservation area without human intervention is celebrated whilst ecological value of spontaneous plants in urban area is ignored. Based on our initial study, 69 out of 202 plant species, i.e. approximately 34% of the recorded spontaneous plants have known connections to fauna, such as butterflies, bees, wasps, bats and birds, as nectar or larval plants or providing food source (Figure 6).

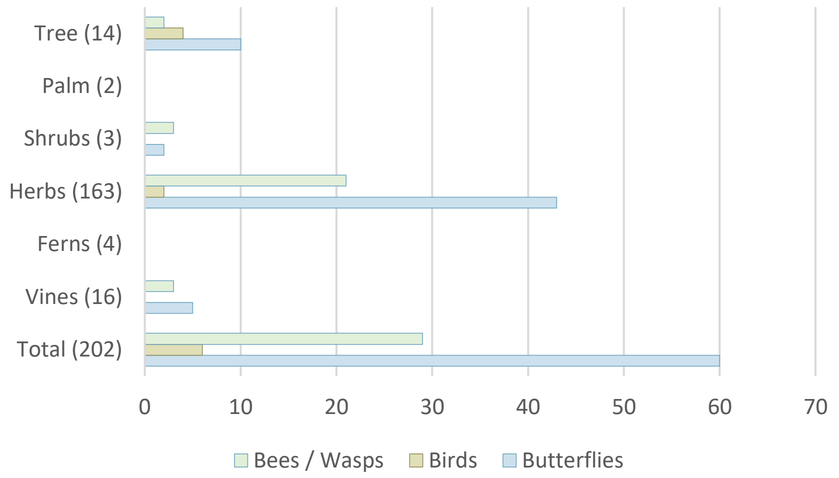

Figure 6. Functions of spontaneous plants

Many of the spontaneous plants, including non-native, interact with native fauna and provide food source. Many of the flowering plants, cultivated, naturalized and exotics are visited by bees and butterflies. For instance, *Melinis repens* attract seed-eating birds, such as the Scaly Breasted Munia, and fruit trees, such as *Morinda citrifolia*, attracts a variety of fauna, from birds to insects. Butterfly host and nectar plants, such as *Lantana camara*, also attract their respective butterfly species to the site (Hwang & Jonathan, 2019). Even the notorious *Leucaena leucocephala*, which is considered as invasive species (despite Hong Kong Herbarium has defined its locality as "cultivated and naturalized"), is found to support a specific psyllid, *Heteropsylla cubana*, and provide major food source for *Phylloscopus inornatus*, as well as other avifauna including Japanese white-eyes, bulbuls and warbles in winter (Corlett, 2005). It is not to give the illusion that all spontaneous plant species have ecological value and are suitable to urban landscape. The aim of the analysis is to reveal the fact that spontaneous plants, whether they are native or non-native do have certain ecological value and should not be overlooked. It is the lack of knowledge and research that make 'weeds' seemingly useless.

Argument 4: Potential of Spontaneous Plants in Resilient Urban Landscape

As one could imagine, spontaneous plants can thrive at the most unexpected locations – disturbed area, wastelands, roadside kerbs, concrete cracks, paving gap, drainage channels and manmade slopes – and tolerate a number of environmental stress. More than 60% of the recorded plants are known to tolerate one or more than one stresses including drought, salinity, pollutant, wind and shade which are common in urban context. 107 species are recorded to be drought tolerant and 80 species are pollutant tolerant. These characteristics are essentially crucial for the design of low maintenance and self-sustaining urban landscape (Figure 7).

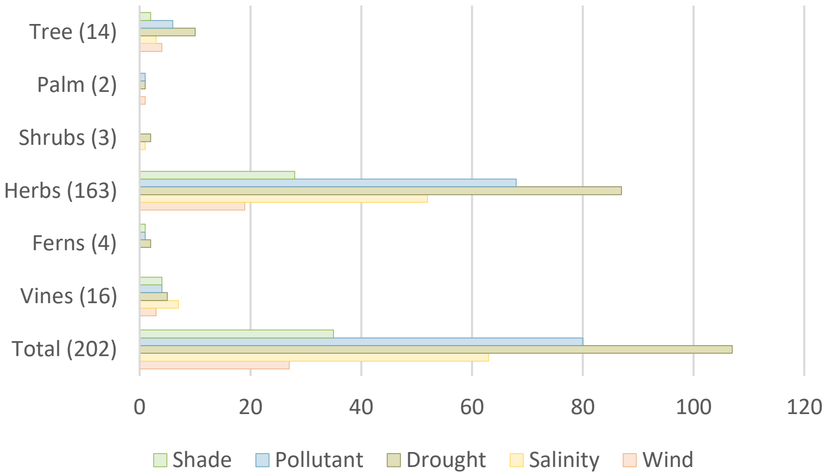

Figure 7. Functions of spontaneous plants

With increasingly rapid urbanization and climate change, hyper-dense urban environment similar to Hong Kong may become more and more common. These "concrete jungles" are habitats unsuitable to most of the ornamental plants in landscape design or woodland species, which require high maintenance input to sustain.

6. Trial Applications of Spontaneous Plants

WEEDsilience is an exhibition installation featured at the 2022 Hong Kong Shenzhen Bi-City Biennale of Urbanism \ Architecture from September 2022 to November 2022. The exhibit was an experiment utilizing spontaneous plants as the main planting palette. The 25m^2 planting area is mixed with 8 species of 'weedy' plants and ornamental Poaceae namely - *Cyperus odoratus, Cyperus surinamensis, Echinochloa crusgalli, Eleusine indica, Panicum maximum, Pennisetum alopecuroides, Muhlenbergia capillaris* and *Setaria viridis*, of which 5 species are exotic and 3 species are native to Hong Kong. Apart from *Pennisetum alopecuroides* and *Muhlenbergia capillaris*, all the plant species are not commonly employed in landscape projects (Figure 8).

Figure 8. Exhibition at Hong Kong Shenzhen Bi-City Biennale of Urbanism \ Architecture

Horticultural Maintenance

The trial has demonstrated that small intervention with minimal maintenance input can change the quality of space significantly, a sharp contrast to the normally maintenance dependent urban green space. It suggests that both native and non-native spontaneous plants can be introduced to the designed landscape without suppressing other landscape ornamental plants if planting design is carefully curated. There was no sign any of the 'weedy' plants are dominating the planting area. Apart from Muhlenbergia capillaris, all the Poaceae were able to establish with minimal maintenance. Except on the first 2 weeks, irrigation was completing absent. No other maintenance was input except grass cutting once for aesthetic purpose only.

Ecological Value

No systematic ecological survey was conducted given the short exhibition period. However, it was observed that the temporary landscaped area had promptly become a hotspot for adjacent butterflies and birds. Parnara guttata was being observed throughout the exhibition period. Apparently, the butterfly species had established its population with larvae food source offered with the Poaceae species. A group of Passer montanus had regularly occupied the space planted with Echinochloa crusgalli for consumption of plant seeds. Other common urban resident birds such as Pycnonotus sinensis and Pycnonotus jocosus. Although these birds and butterflies observed were common species, nonetheless, the spontaneous landscape still served as a temporary refuge for urban wildlife in the otherwise vacant rooftop.

Aesthetic Appreciation

Nearly all the studies on spontaneous landscape focuses on evaluating its ecological value and the economical maintenance aspects. In this discussion, the scope is expanded to aesthetic and spatial experience of human beings which would be crucial to the incorporation of spontaneous plants in landscape design and place making. Apart from exhibition visitors, the trial had attracted uncommon users including couples taking wedding pictures and tango dancing groups to hold event at the space. To explain such unexpected users, it is interpreted that the spontaneous landscape was able to offer certain stimuli which could not be found at conventionally designed landscape. Whilst spontaneity evoked the daily experience of users, its arrangement had certain complexity that induced one to explore and adventure, a sense of appreciation on different kind of aesthetic quality in urban space.

The exhibition is a very small experiment testing the idea. A much more complex processes where spontaneous vegetation passes diverse types of environmental filters and grows freely in urban area are awaiting to be uncovered. That knowledge may give us a new perspective to future landscape.

7. Conclusion

This project has analyzed the spontaneous plant species in Hong Kong and identified potential species for incorporation to landscape design projects. A trial has been carried out to explore the practicability of spontaneous plants. The initial result has demonstrated that incorporating spontaneous plants to landscape design with minimal maintenance requirements is a resilient and adaptive measure for urban landscape. A more comprehensive quantitative experiment with longer time frame, synthesizing interdisciplinary knowledge is under planning to further explore the functions and benefits of spontaneous landscape (Figure 9).

Resilient and adaptive design concepts, such as blue-green infrastructure and nature-based solutions, are celebrated as splendid landscape approaches to tackle climate change. Many of the recent projects claimed to have adapted these initiatives deploy planting with high maintenance input. The essence of these design concepts lie in their abilities to require minimal human input and let the 'nature' to do its own job. In this regard, spontaneous vegetation deserves further researches to cumulate knowledge systematically regarding their unique characters, functions, ecological niches and interactions with other living organisms.

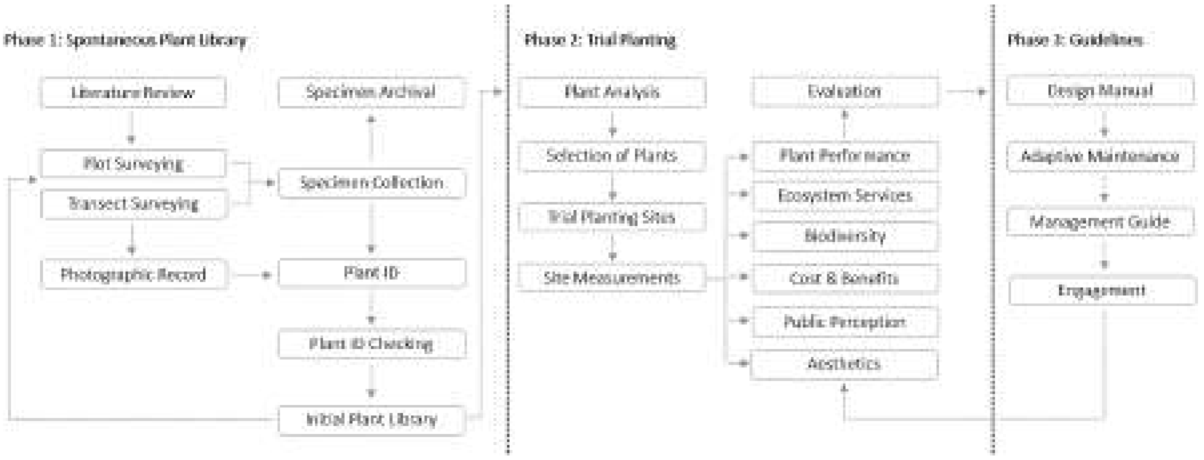

Figure 9. Wayforward for studies of spontaneous plants

Conventional design and planning dissects human-nature and urban-rural relations. The dualities have simplified the complex interactions between human activities and its environment by positioning nature as an outsider. Spontaneous vegetation challenges the perception that nature is something to be managed and utilized by human. It has formed its own system independent to human intention and find the loopholes to claim its existence. This rupture opens up the possibility that "nature" can be an integral part of the city. If the quest of design in this era is to recover an apparatus to pursue co-existence with multispecies in a hyper-dense urban landscape, we have to reframe the understanding of landscape from an epistemological perspective. To recalibrate our perception of plants will allow us to have a boarder imagination in urbanism.

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Coastal Erosion Mitigation: Relationship between Seaweed and the Coast

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Abstract

20,000 kilometers of Europe's coastline faced erosion, with 28% currently affected (Salman et al., 2004). Annual mitigation costs average 5,400 million euros, signaling a "code red" for coastal erosion. Revitalizing coastal vegetation is crucial, as seaweeds stabilize shorelines, absorb wave energy (McIvor, 2012; Silliman, 2013), and aid recovery in erosion-prone areas (Airoldi, 2007). This study investigates the influence of seaweed on coastal erosion, comparing areas with and without seaweed habitats in Türkiye's erosion-prone coastal regions.

Using Species Distribution Modeling (SDM) algorithms, spectral signatures, and spatial modeling, the research identifies seaweed habitats and evaluates erosion rates. Parameters such as shoreline recession and sediment depletion are quantified to predict seaweed's mitigative effects. Comparative analyses between high-erosion and low-erosion regions reveal seaweed's potential to reduce erosion.

The findings suggest that seaweed habitats can significantly stabilize vulnerable coastlines, informing innovative coastal management strategies. Predictive correlation techniques, coupled with logistic regression and bivariate correlation, validate the robust relationship between seaweed presence and reduced erosion rates. This study underscores the role of seaweed in fortifying coastal resilience and highlights its practical applications for mitigating erosion in vulnerable ecosystems.

Keywords: coastal erosion, coastal vegetation, seaweed resilience, SDM algorithms

1. Introduction

Coastal erosion poses a significant threat to coastal landscapes worldwide, including Turkiye. In Europe, 20% of coasts experience erosion, but only a quarter of these areas have adequate coastal protection (Cozannet, 2020). This discrepancy highlights the urgency of adaptive strategies in coastal landscape planning, especially in Turkiye, where coastal erosion can have profound socio-economic and environmental impacts.

Türkiye's coastlines are becoming increasingly susceptible to erosion due to natural processes and human activities such as construction and tourism. The loss or degradation of natural vegetative barriers due to human activities or climate change can significantly increase erosion rates and lead to increased vulnerability of coastal areas (Feagin et al., 2010). For example, Turkiye's Aegean and Mediterranean coasts have experienced serious erosion, resulting in the loss of land, habitat, and infrastructure (Ozyurt, 2010). Addressing this issue is critically important for protecting Turkiye's ecological coastal integrity and biodiversity in these areas.

Coastal vegetation such as mangroves and seagrasses reduce coastal erosion by stabilizing sediment and reducing wave energy, thus protecting coastlines (Mendez and Losada, 2004; Duarte et al., 2013). Coastal areas in Turkiye support the natural growth of seaweed and seagrass. While there are approximately 1,800 taxa of seaweed in Europe, 567 species have been identified in Turkiye (Salman et al., 2004; McIvor, 2012; Silliman, 2013; Airoldi, 2007; Taşkın, 2022) and 6 seagrass taxa (Güreşen, 2019). Seaweed in Turkiye typically lives at depths of more than 5 meters and is less common than seagrass, which grows in denser, shallower habitats (Çınar, 2006). This study explains the distribution and relationship between *Cystoseira, Sargassum*, *Gelidium* and *Ulva* seaweeds and P*osidonia oceanica*, *Zostera marina* and *Zostera noltei* seagrasses in tourism cities where coastal erosion is most common.

2. Material and Method

Data Sources and Selection Criteria

The study categorized materials into two main groups: datasets and key species. To model marine vegetation distribution and its relationship with coastal erosion, a refined standardization approach was employed using the SDM (Species Distribution Model) algorithm and XGBoost (Table 1). Research on marine vegetation and coastal erosion in the Aegean and Mediterranean regions was compiled, leading to the selection of four seaweed species—*Cystoseira*, *Sargassum*, *Ulva*, and *Gelidium*—and two seagrass species—*Posidonia oceanica* and *Zostera*. These species were identified as critical for their role in mitigating coastal erosion.

Table 1. The key parameters, the models or systems used to generate the data

Study name	Material	Numbers	Data description	Rationale
Study 1	Environmental parameters	8 (lat, long, depth, salinity, chl, O_2, wave direction, temperature)	Datasets covering environmental parameters for seaweeds and seagrasses along Turkish coasts.	To understand the distribution of erosion occurrence along the Mediterranean coast according to data ranges and to understand the environmental conditions associated with its impact on erosion.
Study 2	Seaweed species data	7 (lat, long, depth, salinity, chl, O_2, temperature)	Species-distribution Sözer (2024) data on seaweed in Mediterranean coastal areas.	Investigating the distribution of different seaweed species in proximity to coastal erosion sites.
Study 3	Seagrass species data	7 (lat, long, depth, salinity, chl, O_2, temperature)	Species-distribution data on seagrass in Mediterranean coastal areas.	Investigating the distribution of different seagrass species in proximity to coastal erosion sites.
Study 4	Inner join data	8 (lat, long, depth, salinity, chl, O_2, wave direction, temperature)	Analysis of interactions between key species and environmental parameters in the context of erosion control.	Understanding the holistic impact of multiple species working together in reducing coastal erosion.

Dataset Integration and Compilation

Global datasets from Copernicus were used to develop distribution maps and identify parameters influencing coastline changes. A thorough literature review was conducted to standardize erosion characteristics and the contributing factors in the Mediterranean. Key parameters, including wave height, depth, sea-level rise, and temperature, were classified into defined value ranges.

The ecological datasets were sourced from high-resolution satellite data and in situ observations available through the Copernicus library. This process yielded a dataset comprising 70,000 rows specific to the Mediterranean region. The data included oxygen (o2.csv), chlorophyll (chl.csv), temperature (temp.csv), salinity (sal.csv), and wave direction (wav.csv). The datasets were merged into a single cohesive CSV file using an inner join, facilitating analysis of erosion and vegetation patterns (Figure 1).

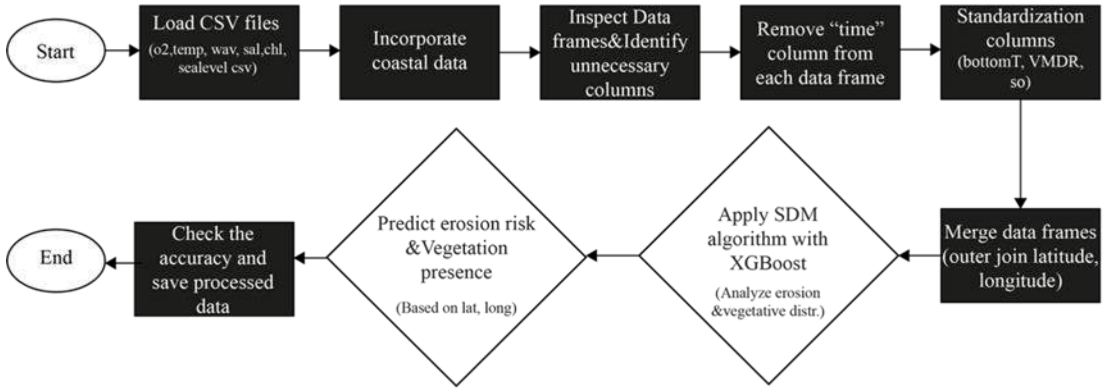

Figure 1. The flowchart of data analysis and prediction process

Additional data included:

- Growth indices and species distribution data derived from the Sözer (2024) computational distribution model.
- Blue Flag beach locations converted to CSV format. Rows with matching latitude and longitude were identified for spatial analysis.
- All datasets spanned from April 6, 2023, to April 6, 2024, rendering the time column irrelevant for this study.

A comprehensive erosion analysis table was created to summarize the key parameters, data sources, models, grid resolution, and vertical levels. This table formed the foundation for understanding erosion risks along Mediterranean coastlines.

Model Development and Parameter Selection

The SDM algorithm was utilized to categorize environmental conditions and predict the distribution of seaweed and seagrass species. Parameters influencing marine vegetation included temperature (15-25°C), salinity (30-35 PSU), depth (0-5 m), and chlorophyll concentration (0.1-10 µg/L). Erosion risks were mapped using varying parameter thresholds, with risk levels decreasing from dark red to yellow on the visual outputs.

Ecological stressors affecting erosion and species distributions were integrated into the model to predict the likelihood of vegetation presence and their potential impact on erosion mitigation. Analysis included 507 Blue Flag beaches across the Aegean and Mediterranean regions of Turkiye. An inner join was applied to categorize erosion risks, tourism density, and coastline changes at these beach coordinates. Eight specific locations demonstrated a correlation between erosion risks and the presence of marine vegetation, highlighting areas of Antalya, Bodrum, Kuşadası, Alanya, and Side as critical zones with high erosion risks Table 2). Tourism activity changes in these locations were added as an explanatory variable, although limited to the erosion and Blue Flag beach correlation analysis.

Table 2. Blue Flag beaches and adaptation potential

City/Region	Coastal Erosion Level	Tourism Intensity	Line Changes	Statistical Value
Antalya (Med)	High	Very High	Significant	Erosion rate: 1-2m/year
Bodrum (Aeg)	Moderate to High	High	Moderate	Erosion rate: 0.5-1.5m/year
Fethiye (Med)	Moderate	High	Moderate	Erosion rate: 0.3-1m/year
Kuşadası (Aeg)	Moderate to High	High	Significant	Erosion rate: 0.5-1.2m/year
Alanya (Med)	High	Very High	Significant	Erosion rate: 1-2m/year
Marmaris (Aeg)	Moderate	High	Moderate	Erosion rate: 0.4-1m/year
Çeşme (Aeg)	Moderate	Moderate to High	Moderate	Erosion rate: 0.3-0.8m/year
Side (Med)	Moderate to High	High	Significant	Erosion rate: 0.5-1.5m/year

** Med: Mediterranean, Aeg: Aeagean

Data Visualization and Analysis Tools

The study employed “kepler.gl" for spatial analysis and map visualization. This tool enabled dynamic filtering and color scaling to analyze ecological parameters in real time, facilitating the examination of vegetative and ecological data as dependent and independent variables (Figure 2). Visualizations captured correlations between erosion risks, marine vegetation distribution, and other environmental parameters.

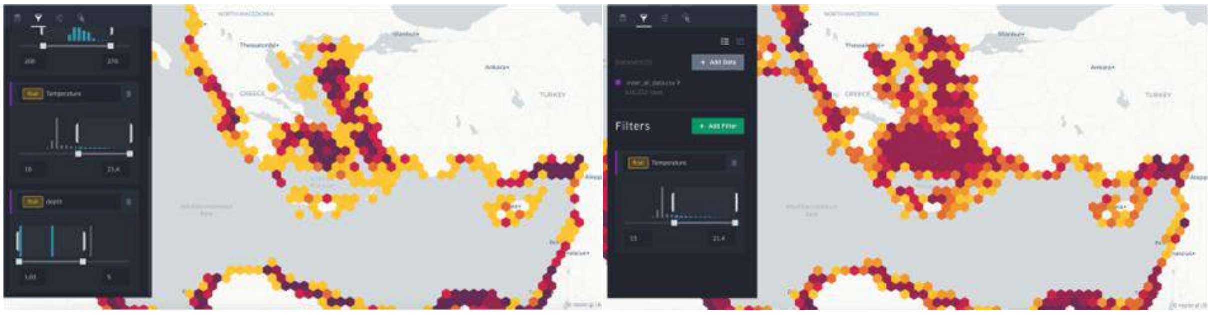

Figure 2. Changes in Kepler maps according to specified ranges

Erosion Risk and Vegetation Mapping

Erosion risk was analyzed using a standardized classification based on wave height, sea-level rise, depth, and temperature. Risk levels were visualized on maps, transitioning from high risk (dark red) to low risk (yellow). The environmental parameters influencing marine species distributions were similarly visualized, highlighting areas suitable for species growth and erosion mitigation.

Limitations and Key Observations

The preliminary analysis identified critical areas with high erosion risks, emphasizing the need for targeted conservation efforts. However, the variable related to tourism activities was only used for correlation analyses with erosion at Blue Flag beach locations and was not expanded into broader model predictions. The comprehensive integration of ecological parameters and high-resolution data ensures robust predictions of marine vegetation’s role in mitigating coastal erosion.

3. Findings and Discussion

The datasets generated using the XGBoost algorithm revealed that 37% of the Turkish Aegean and Mediterranean coasts exhibited significant coastal marine erosion. Noticeable changes were identified in 29% of the coastline, while 34% remained largely unaffected. Marine vegetation and Blue Flag beach locations were subsequently analyzed within the areas experiencing erosion (Figure 3).

Of the 507 Blue Flag beaches in the study area, 15 beaches were found to have high erosion rates, while two non-Blue Flag beaches also exhibited significant erosion. This indicates that without immediate action, these 15 beaches face the risk of losing their Blue Flag status due to increasing erosion pressures (Figure 3).

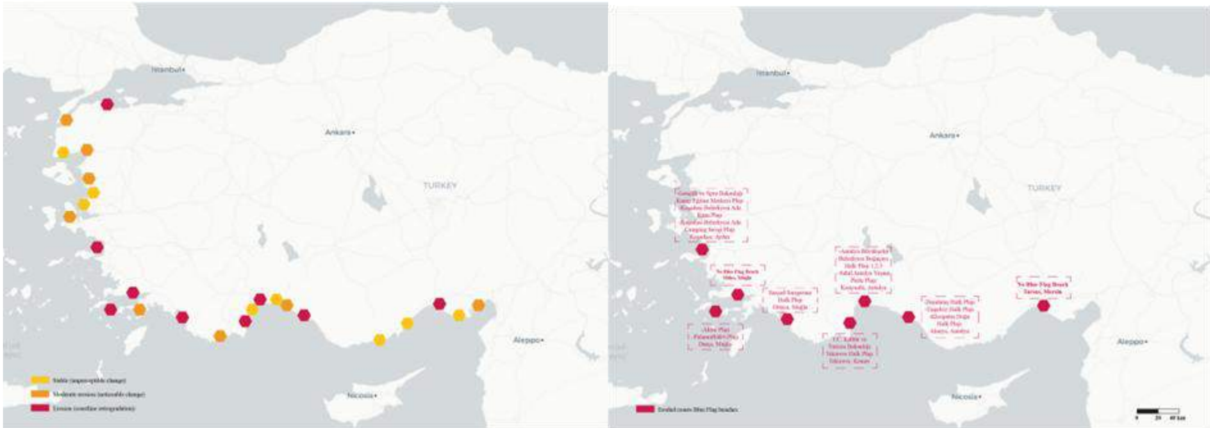

Figure 3. Erosion potential coasts (left figure) and eroted Blue Flag beaches (right figure)

Chlorophyll concentration levels and temperature data were integrated into the model to produce a vegetation distribution map for the Aegean and Mediterranean regions. Chlorophyll concentration was calculated based on temperature and salinity ratios within the dataset. The model highlighted the habitat distributions of key seagrass and seaweed species, including *Posidonia oceanica*, *Zostera*, *Cystoseira*, *Sargassum*, *Ulva*, and *Gelidium*. These distributions were compared against areas with detected erosion.

The analysis identified Kuşadası, Kemer, and Konyaaltı beaches as having the highest rates of coastal change among all studied locations. These beaches not only experience significant erosion but are also found to be suitable for marine vegetative life. For instance: Kemer and Konyaaltı: Both Blue Flag beaches showed conditions conducive to the growth of *Cystoseira* and *Posidonia oceanica*, with temperature and salinity values aligning with optimal habitat requirements. Kuşadası: Exhibited erosion rates of 0.5-1.5 meters annually, with potential for reduction to 0.35-1.05 meters within five years if suitable marine vegetation habitats are established.

Additionally, the analysis identified a significant opportunity in Mersin Tarsus, which is not a Blue Flag beach but exhibits both high erosion and the presence of conditions suitable for marine vegetation growth.

The establishment of seagrass and seaweed habitats in critical regions such as Kuşadası, Kemer, and Konyaaltı has the potential to reduce wave intensity, sediment transport, and chlorophyll loss. Model estimates suggest that the introduction of these habitats can decrease coastal change by 30-50% over a five-year period (Table 3). For example: Annual erosion in Kuşadası could be reduced to 0.35-1.05 meters, ensuring greater coastline stability. Chlorophyll and temperature data suggest similar potential improvements in Kemer and Konyaaltı.

Table 3. Potential application areas and future projections

Location	Temperature change (yearly)	2029 forecast temp.	Chlorophyll change (yearly)	Estimated erosion (5 year forecast)	Erosion reduction with seagrass and seaweed
Kuşadası	1.62 C	27.97 C	-1 mg/m³	2.5-7.5 m	%30-36
Kemer	2.1 C	30.57 C	-2 mg/m³	5-10 m	%30-50
Konyaaltı	1.84 C	29.85 C	-1.6 mg/m³	7.5-10 m	%30-42

4. Conclusion

This study underscores the critical role of marine vegetation in mitigating coastal erosion and preserving coastal landscapes. The integration of data analysis and ecological parameters demonstrates the importance of species distribution mapping in understanding and addressing erosion risks. By establishing habitats for *Posidonia oceanica* and *Cystoseira* in targeted regions, the continuity of coastal ecosystems and landscapes can be effectively safeguarded.

The findings highlight the complexity of underwater research and the necessity of multi-parameter analyses for assessing erosion risks. Future studies should expand on the integration of additional ecological and environmental parameters to enhance the accuracy of predictive models and further inform conservation strategies.

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Conservation, Landscape Enhancement of Agricultural Heritage Site: with VR Technology

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Abstract

Agricultural heritage now is a challenge topic in heritage research. Community participation is key to its conservation. We take the Haizhu high bed-low ditch agro-ecosystem in Guangzhou, China, for an example. Locals developed this system over centuries, adapting to local climate and waterways. This study focuses on social participation. We surveyed local residents and visitors, using VR based eye-tracking technology to gauge their landscape preferences. We quantified landscape elements and tested 60 participants, including villagers, tourists, and experts. In the urbanized Guangdong-Hong Kong-Macao Greater Bay Area, protecting agricultural elements is crucial. Through this research, we aim to find a sustainable tourism strategy for agricultural heritage, fueling the region's cultural revitalization. Meanwhile, in the highly urbanized area in China, how to effectively protect and pass on agricultural elements in urban areas is a tough challenge with certain innovative value. By exploring the characteristics of agricultural heritage, we will explore the sustainable development strategy of agricultural heritage tourism in the future, thus promoting the cultural revitalization of the Greater Bay Area.

Keywords: Agricultural heritage site, high bed-low ditch agro-ecosystem, VR technology, landscape perception

1. Introduction

Agricultural heritage is currently a trending topic in the filed of international heritage studies, As a specific heritage category, agricultural heritage is outlined as a specific type of heritage consisting of farmers' lives, production practices and agricultural activities. As a unique and dynamic heritage, community participation has been recognized as one of the elements that cannot be ignored, and which forms an essential part of the content of agricultural heritage. The Haizhu high bed-low ditch traditional agro-ecosystem is one of the China National Important Agricultural Heritage Sites (China-NIAHS) located in Guangzhou of Guangdong Province in China. The Haizhu high bed-low ditch agro-ecosystem is a kind of agricultural production system with regional characteristics created and developed by local villagers over the centuries, taking full advantage of the natural condition of high temperatures,abundant rainfall and a dense water network. The system includes dike, artificial canal, water gate. high bed and low ditch, crop planing, livestock and poultry breeding, and aquaculture (Zhao et al., 2023).

As the inheritors and guardians of agricultural heritage, the main position of local residents and citizens cannot be neglected, and their participation is the key to the conservation of local agricultural heritage and the enhancement and optimization of agricultural landscapes. Therefore, based on the perspective of social participation, this research takes the Haizhu high bed-low ditch traditional agro-ecosystem as the research case site, and takes local citizens as the main object of investigation, and conducts a questionnaire survey and eye-tracking survey with VR technology on them. In recent years, eye-tracking technology has become an effective method to study landscape preference and public perception, which can accurately identify people's preference for relevant elements (e.g. farmland, water bodies, buildings, etc.).

According to the types and values of heritage, the current status of heritage conservation, and the existing landscape types in the protected areas, we quantified the landscape elements and selected 60 villagers, tourists, and experts to conduct experimental tests, comprehensively exploring the local community's perception and preference of agricultural landscapes. Combining the special background of the heritage site, based on the landscape preferences of the community residents, the conservation core area and development buffer zone should be divided, so as to make the tourism development process more sustainable, efficient and convenient, and to provide reference for subsequent research scholars.

Meanwhile, in the highly urbanized Guangdong–Hong Kong–Macao Greater Bay Area in China, how to effectively protect and pass on agricultural elements in urban areas is a tough challenge with certain innovative value. By exploring the characteristics of agricultural heritage in the Greater Bay Area, we will explore the sustainable development strategy of agricultural heritage tourism in the future.

Due to the different focuses of each field, the macro-conceptual understanding of traditional agricultural landscapes and their components have been characterized by a one-sided perception from a disciplinary perspective. At this stage, the laws and connections between agricultural landscapes and public perception have not been fully revealed, so it is necessary to focus on this topic to carry out additional research.

Comprehensive traditional agricultural landscape feature recognition research is insufficient: current research is often limited to specific disciplinary areas, which leads to the emergence of cognitive differences in the traditional agricultural landscape, the lack of interdisciplinary integration and in-depth exploration. Not only the natural and cultural (material/non-material) elements of agricultural heritage (Min et al., 2019), but also the social perception and landscape experience in the cultural perspective (Albaladejo-García et al., 2023) need to be included in the scope of traditional agricultural landscape feature recognition.

2. Material and Method

As for the study area, the research site is selected as the evaluation scope in Haizhu District, Guangzhou City, Guangdong Province and consists of two areas, the one located around Haizhu Wetland Park in Haizhu District, Guangzhou City is Area A, and the one inside the wetland park is Area B. The production and living category in Area A are mainly characterized by fruit and vegetable crops in different growing seasons, poultry, farming scenes, agricultural facilities, etc.; in Area B, there are fruit trees, poultry and so on. The overall characteristics of the elements of the production and living category are the diversification of crops and tropical attributes, the seasonal nature of the cultivation scene, and the unique raised beds and deep furrows (Figure 1).

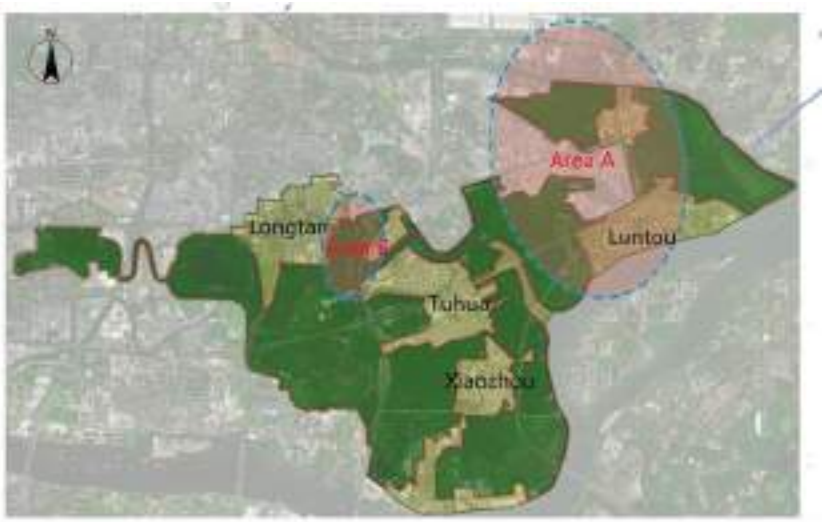

Figure 1. Location of study area

Through comprehensive analysis, it is believed that the semantic difference method combined with VR virtual simulation can be used to carry out this evaluation study. SD method, i.e. semantic difference method, is one of the most classical evaluation methods of psychophysical school, which began to be applied to the field of landscape evaluation in the 1990s, and it has a wider range of cognitive properties (Luo et al., 2022). Its main feature is to respond to people's psychological feelings about the landscape through adjective pairs, and to understand people's feelings from the psychological level. Usually, the subjects of SD method are 20~50 people (Zhu et al., 2024). In this study, through searching the literature in corresponding fields in recent years, we found that college students are the main group to conduct the relavant test, which is a high sample feasibility and representativeness.

Finally, in this study, a total of 60 volunteers, including 10 experts, 20 residents and 30 students, were selected to conduct the SD evaluation and VR experiment. The data were collected according to gender (30 male and female subjects each), different ages, and different professional backgrounds, of which 44, or 73%, were in the age group of 18-39 years old. There were 42 people with education in specialties or bachelor's degree, and 15 people with master's degree and above, accounting for 70% and 15% respectively (Figure 2).

Basic Information	Category	Number	Percentage (%)
Gender	Male	30	50%
	Female	30	50%
Age	18 years and below	3	5%
	18-39 years	44	73%
	40-59 years	12	20%
	60 years and above	1	2%
Education	High school and below	3	5%
	Associate/Bachelor's degree	42	70%
	Master's degree and above	15	25%
Professional Field	Management-related	35	58%
	Agricultural Technology-related	0	0%
	Arts-related	2	3%
	Humanities-related	10	17%
	Research-related	9	15%
	Craftsmanship-related	0	0%
	None	4	7%

vir

Figure 2. Overall statistics of the experimental group

Virtural Reality is a computer simulation system that allows the creation and virtualization of worlds, which utilizes a computer to generate a simulated environment that immerses the user in that environment. And nowadays VR has become a huge industry integrating near-eye display technology, sensor technology, hardware manufacturing, software development, content creation and many other fields. This immersive characteristic makes VR able to simulate the urban environment and bring a sense of immersion, so since the 1990s there have been scholars trying to use VR for planning and design work. The use of VR for public participation reflects the human-centered orientation (Xu et al., 2024).

In this study, Pico Pro 4 was used in combination with VR glasses to guide the subjects to observe the experimental pictures and collect the eye movement data (Figure 3), which were visualized by the position of the gaze point and the average gaze time to indicate the attractiveness of the stimulus materials to the subjects, the influence of the degree of interest, as well as the strength of the visual stimuli of the landscape.

Figure 3. The equipment of the experiment and the test procedure

3. Findings and Discussion

The questionnaire was set up based on the SD method to analyze the results of the landscape point of interest subjective research questionnaire. According to the data, in the survey part of the points of interest of the study site, people are more interested in the agricultural land, plants and the surrounding environment of the agricultural heritage site. Among them, 39 people chose agricultural land, 12 were residents, 20 were students, and 7 were experts.

The comprehensive evaluation of the site showed that the overall data evaluation of the research site was good, with scores above 0 for all indicators (Figure 4). Residents were more satisfied with the vernacular and rural character of the agricultural landscape, tidiness, site regularity, and spatial symmetry in general visualization. The student group and experts perceived the site as having a high vegetation cover, where the student group and experts scored lower in the sense of history and culture of the site, and artistry, indicating that the overall visual perception of history and culture within the site is low and the artistic atmosphere is poor.

When scoring the landscape environment in terms of aesthetics, attractiveness, willingness to stay, and frequency of visits, the agricultural heritage site is aesthetically pleasing but not attractive enough. 56% of them are willing to stay in the study area, and the frequency of visits amounted to 33%. But the landscape environment of the site is not attractive enough, and the landscaping of the environment needs to be strengthened.

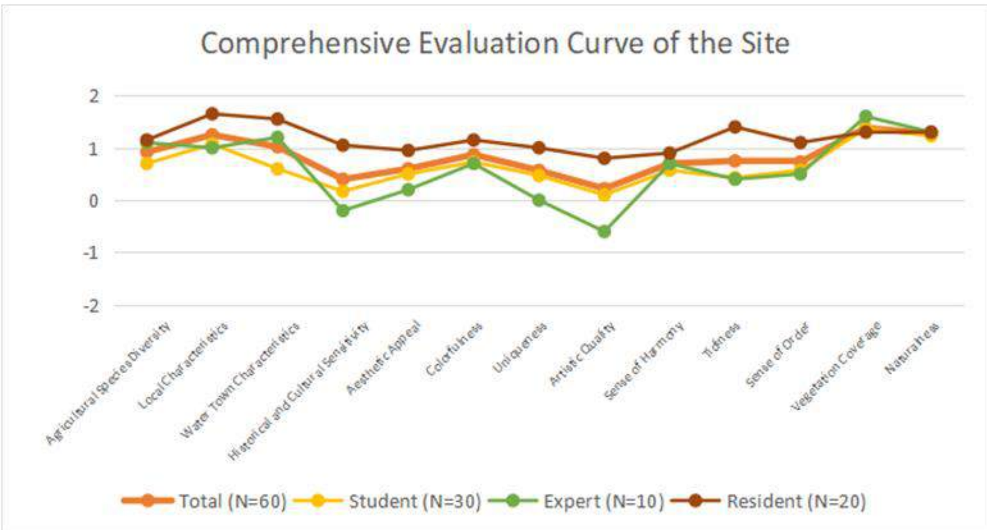

Figure 4. Specific evaluation of the study area by three different groups

For VR statistics, the basic eye movement data investigated includes gaze count, gaze frequency, eye hopping count, eye hopping frequency, eye hopping rate, and eye hopping amplitude. The experiment divides the pictures into three areas (Yang et al., 2022). The red area is garden landscape, the blue area is natural landscape, and the green area is agricultural landscape. From the SD method as well as the eye movement analysis data, the duration of gaze reflects the focus of attention of the subjects.

From the three districts of the sample chart of the length of gaze duration time can be seen, that the hotspot pictures present visual attention and attention time in colors, and the relationship with each other is: red>yellow>green (Figure 5). It can be assumed that the percentage of people paying attention to garden landscapes is relatively high. Based on this result, we can consider that the current agricultural landscape is not rich enough to attract people to pay attention to the agrarian scenery.

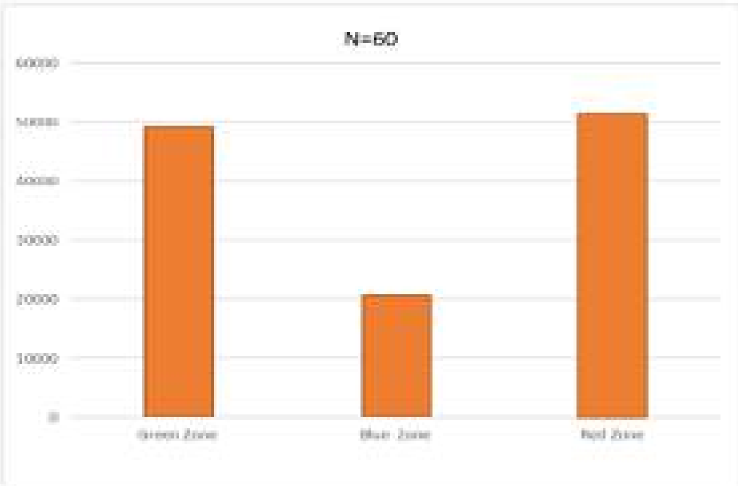

Figure 5. Statistical charts of gaze time in the three divisions

4. Conclusion

The results of the study show that:1) The survey population has a good level of awareness of agricultural landscapes and, in general, presents a positive attitude that recognizes their social and aesthetic value. 2) The attractiveness of agricultural landscapes is generally not as strong as that of garden elements. And there is a lack of cultural and artistic feelings in the study site. 3) Through more systematic statistics, it can be seen that for young people, agricultural landscapes are more eye-catching.

Combined with the questionnaire data analyzed by Excel and SPSS, the results show that people are now aware of the importance of agricultural landscape and are interested in it, but the result shows that the attention is more inclined to landscape gardening, which indicates that the agrarian landscape value is low and not attractive. In addition, young people have a more positive attitude towards agriculture, and the potential of young people should be tapped. The project site is characterized by rusticity, water village characteristics and richer color degree, but the sense of history and culture and artistry are low.

For future tourism development of agricultural heritage sites in the Greater Bay Area, the focus should be more on providing interest programs for youth, thus promoting the social concern of agricultural landscapes. On this basis, more in-depth research should be conducted on how to enhance agricultural landscapes and science popularization, planning and design, as well as visual enhancement.

Note

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Regenerating Post-Industrial Landscapes: Multinational Comparison, Protection, Principles, Evolution, And Design

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Abstract

Post-industrial landscapes, once a reminder of history and industrial development, now pose a conservation problem and opportunity. The preservation of these landscapes is essential for maintaining their relics and evidence of industrial history, creating unique cultural identities. However, the preservation of these landscapes faces challenges and uncertainties due to environmental, economic, and social difficulties. This paper analyzes post-industrial landscape historic sites, covering preservation classification, protecting principles, cross-national comparisons, recent modifications, and design approaches related to protection laws. It examines the historical evolution and theoretical frameworks that influence the preservation of post-industrial landscapes, using a mixed-methods approach, including site visits, interviews, and archival research. The study examines the laws and regulatory systems that protect these unique areas on both national and international levels. Case studies illustrate different approaches to preservation in a global context, addressing differences in guiding ideas. A cross-national analysis reveals advances, similarities, and contrasts in the management of post-industrial landscape heritage, providing a comprehensive view. The research highlights the challenges and potential for preserving post-industrial landscape heritage, emphasizing community involvement and compliance with protection principles. It provides information on existing practices and changes, enabling informed decision-making and emphasizing the need for adaptive solutions to protect sites for future generations.

Keywords: Post-industrial landscape, Industrial heritage, Regeneration, Protection principles, Cross-national comparison.

1. Introduction

Many factories, mills, and other industrial facilities have been abandoned as a result of the transition from industrial to post-industrial societies, leaving behind large areas of abandoned land that present significant physical and environmental problems (Loures & Burley, 2012). This paper examines how different countries approach the regeneration of these post-industrial landscapes, analyzing the design strategies, legislation, and guiding principles that have been used to restore and revive these areas. Multinational comparisons show that post-industrial landscape regeneration has been a global phenomenon, with countries all over the world addressing the problems caused by abandoned industrial sites (Li, 2022). Incentives and cooperation for the cleaning and reuse of these historic industrial areas are frequently used to regenerate brownfields in the United States (Tubielewicz-Michalczuk, 2017). The national land-use database in the United Kingdom aids in locating and monitoring previously constructed land that is currently unoccupied or abandoned. (Harrison, 2006) The IBA Emscher Park program, an international building exposition, gained acknowledgment in Germany for its comprehensive strategy for reviving the Ruhr region's old industrial site (Seltmann, 2007). An example of innovative post-industrial regeneration in China include the conversion of the steel mill of Beijing Shougang and its enormous industrial complexes into parks, neighborhoods, sports venues, and cultural hubs, Comparable principles and design strategies have been used, such as protecting and preserving elements of the site's industrial heritage rather than simply removing all traces of the past, although specific policies and approaches adopted have varied amongst countries (Jin, 2021). Regenerating post-industrial landscapes is a major worldwide opportunity and problem as countries work to address the geographical legacies and environmental effects of deindustrialization (Ge et al., 2020). This paper provides insights into the various ways that post-industrial sites can be reclaimed, reimagined, and reintegrated into modern cities by comparing them across countries and outlining important principles, protections, and developing design strategies that have emerged in response to these problems.

2. Material and Method

Using a mixed-methods approach that includes site visits, interviews, and archival research, this study investigates the theoretical frameworks and historical development impacting the preservation of post-industrial landscapes. It examines the national and international regulations and laws that protect these special places and case studies show various methods of preservation in an international context. Identifying relevant concepts for future regeneration efforts is the aim of the study. To find comparable concepts, efficient methods, and places where post-industrial regeneration methods differ, the study examines case studies from different countries using a literature review methodology.

3. Findings and Discussion

Restoring post-industrial landscapes is spreading around nations, as countries deal with the problems associated with postindustrial areas (Loures, 2014; Canevaro et al., 2019). Similar concepts and design methods have developed amid all of the various laws and policies. Rather than removing all reminders of the past, the goal is to protect and preserve essential elements of the site's industrial history (Feng & Ma, 2021). While maintaining the historical heritage of the site and its previous usage, several projects seek to integrate existing buildings, factories, and warehouses, facilities into contemporary designs. Post-industrial rehabilitation has been characterized by the use of sustainable design concepts, particularly improving polluted soils, promoting the use of sustainable energy sources, and integrating green infrastructures (Guo et al., 2020). According to research, an innovative structure has been developed that involves people, public and private interests, and redefines post-industrial landscapes as communal investments (Heesche et al., 2022). In this way, the regeneration of post-industrial sites is viewed as a means of reviving the local community's social, economic, and environmental well-being.

Multinational comparison

The studied cases demonstrate the diverse range of approaches to post-industrial landscape regeneration internationally (Loures, 2014; Li, 2022). Across nations, emphasis is placed on cleaning up contaminated land and reusing it for new purposes. Abandoned industrial sites are frequently revived as parks, residential areas, or commercial areas. The improvement enables local communities and stakeholders to participate in part in creating the vision. The protection of existing environmental assets and historical legacy is an essential component of post-industrial landscape regeneration. The United States focuses on economic incentives like tax credits and brownfield redevelopment grants to encourage private investment in the reclamation of abandoned industrial lands (Tubielewicz-Michalczuk, 2017). In China, the government has been active in funding initiatives to restore the country's decaying industrial zones and specialized strategies have been developed to address challenges like environmental degradation and community displacement (Wen et al., 2017). The United Kingdom has created national databases to map and monitor its stock of previously developed brownfield sites, facilitating the prioritization of remediation activities (Harrison, 2006).

Key principles and design strategies

Post-industrial landscape regeneration should be guided by several core principles and design strategies. First, it is important to preserve elements of the site's industrial history and legacy, avoiding the complete removal of old infrastructure and buildings. Incorporating existing structures, machinery, and materials into new designs can help tell the story of the site's past and maintain a sense of place. Secondly, sustainable design techniques like renewable energy, soil remediation, and green infrastructure should be emphasized to address environmental degradation and enhance ecosystem services. Thirdly, the active involvement of local communities in the planning and design process is critical, ensuring that the regeneration aligns with their needs and priorities. Finally, the regeneration should aim to create multifunctional landscapes that provide economic, social, and ecological benefits, rather than focusing narrowly on single-use development (Li, 2022; Tubielewicz-Michalczuk, 2017). These principles and strategies can guide the transformation of post-industrial sites into vibrant, integrated parts of the urban fabric that celebrate the past while looking toward a more sustainable future. (Luo & Gong, 2020) The examination of case studies from several countries shows that protecting biodiversity, the environment, and historically important buildings during the restoration process is a common objective. (Vardopoulos et al., 2020) Green infrastructure inclusion, creative utilization of the existing industrial structures, and cooperative strategies that involve local communities are all often utilized to accomplish this goal (Zhang et al., 2021). A framework of guiding principles that emphasize social, environmental, and economic sustainability primarily directs the restoration of post-industrial areas. These principles include sustainable economy concepts, creative reuse of existing structures and facilities, incorporating nature-based solutions, and involving stakeholder participation. Examining simple physical interventions to more comprehensive, operational methods focusing on multiple social, ecological, and economic aspects of post-industrial sites, the design approaches that result from each of these principles change with time (Qu et al., 2020; Loures & Burley, 2012). Creating vibrant public areas, restoring ecosystems, encouraging sustainable economies, and promoting community identity and participation are representations of shared values (Li, 2022). Restoring derelict places and creatively repurposing industrial legacies are two aspects of the complex and multidimensional process of post-industrial landscape restoration (Loures & Burley, 2012). This approach involves finding an appropriate balance between creating new social and economic possibilities and protecting natural and cultural heritage (Chen, 2021). Localities and nations have addressed the issue in different kinds of ways, as demonstrated by multinational comparisons, which provide valuable knowledge and inspiration for other post-industrial contexts. Many communities have focused on conserving and preserving their industrial heritage by transforming old factories and warehouses into cultural centers, innovative workspaces, and lively public areas. Some communities have implemented a more innovative regeneration strategy, using post-industrial lands as a means of promoting community-focused development, green infrastructure, and new sustainable business models (Bolici et al., 2019; Canevaro et al., 2019).

Figure 1. Shougang Park Beijing, China Photo source: (Author)

Shougang, the state-owned iron and steel company in China, was a previous manufacturing site in the Shougang area in Beijing later Shougang moved to Hebei Province in 2005 due to air pollution the activities in the industries caused to the surrounding areas. China won the bid for the 2008 Olympic Games and the Shougang industrial area started its urban restoration in 2010 to preserve its industrial past while establishing greener, friendlier, and accessible areas (Deng et al., 2020).

4. Conclusion

In conclusion, Post-industrial landscape regeneration is a complex and multidimensional process that calls for a comprehensive, principle-driven strategy that considers the social, economic, and environmental aspects of these important areas (Rahbarianyazd, 2020) (Zaletova et al., 2021).

This paper highlights the various approaches and changing opinions that define the evolving field by referencing international examples and a variety of academic sources. It has also emphasized the significance of inclusive, sustainable, and adaptable interventions to revitalize abandoned industrial sites and their surrounding communities (Canevaro et al., 2019). Successful post-industrial landscape regeneration initiatives depend on the restoration and repair of contamination, the application of adequate and sustainable principles, and a variety of uses and activities.

Note

Communities experiencing the effects of industrial decline could benefit from more resilient and regenerative approaches informed by the lessons learned from these multinational experiences. The evaluation of relevant research in this study highlights the need for restoration and regeneration.

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Wastescapes as Landscapes of Care: From Wasteland to Landscape

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Abstract

Wastelands are meant to store human waste or dispose of unwanted material. Are wastelands toxic? Can these 'lands' be restored safely as public spaces? In the past, these spaces were open dump sites close to settlements, rural areas, or on the outskirts of cities. Mixed waste ended up at these places, and its "digestion" produced biogas and leachate, released into the atmosphere, soil, and water, respectively. Communities have been challenged by environmental and health issues affecting people working or living close to these areas. As part of the effort to find better solutions for waste management, wastelands have developed from open dump sites to sustainable landfills. Waste sorting has reduced the amount of garbage ending up in waste sites. Recycling provides material for industry, and separating organic waste (and hazardous waste, e.g., batteries) has significantly reduced leachate and biogas. As settlements grow, wastelands become part of them. Case studies and both qualitative and quantitative research examine how wastelands turn into landscapes of care.

Keywords: Wasteland, wastescape, landfill, landscape of care, circular economy.

1. Introduction

This essay discusses landscapes that store waste, referred to as "wastelands", or when restored, "wastescapes". Both terms have distinct meanings (Elliot, 1922; Burckhardt, 1998). In this context, we define them as spaces that contain human refuse (waste) from settlements and cities. For this study, "wastelands" are defined as landscapes receiving unregulated waste of any type, while "wastescapes" are landscapes designated to receive 'regulated' (separated) waste, with or without organic waste. The term "wastescapes" also includes restored "wastelands." Wastescapes can be recovered, restored, or 'recycled' as landscapes, depending on the type of waste they have received and stored over the decades, the neighboring settlements or nature, and the purpose they serve in their new lifecycle (Diamantouli & Stendardo, 2022). To understand the function(s) and problems of landfill infrastructures, it was necessary to investigate waste management practices by means of visits and studies of operating landfills in different phases (Figure 1). Gaining knowledge required multidisciplinary exchange with sanitary and environmental engineering.

Social anthropologist Patrick O'Hare (2023) explains that "landfilling implies the filling in of human-made pits and natural depressions with discards. As such it can be differentiated from simply dumping on level ground or piling up of materials in middens…Before industrialization and urbanization, rural disposal practices were generally uncentralized and waste was dealt with at a household or village level. It was in the late 19th and early 20th centuries, with the growth of dense urban populations in Western Europe and the United States, and the association of waste with disease, often through a miasmatic framework centered around foul smells and vapors, that pressure grew for the creation of dumping grounds outside of urban areas".

The study aims to identify case studies of transformed wastescapes for landscape fieldwork, to discover, visit, and map wastescapes at different stages (either recovered, restored, or 'recycled'), and to research what children and adults know about wastescapes. The research questions of the overall study are: Are wastescapes toxic? Can these 'landscapes' be safely restored as public spaces? What is the public's knowledge and perception of wastescapes as part of landscapes?

Figure 1. Sanitary landfill in July 2023 at the location Xirokampi, Litochoro, Greece (photos: Diamantouli E.)

Figure 2. Restored non-sanitary landfill in October 2022 at Noale, Italy (photos: Diamantouli E.)

2. Material and Method

The overall research contains primary and secondary research practices (Figure 3). The investigation started with research through the literature review (secondary research) on global case studies of transformation practices of landfills of any stage. The next phase focused on finding cases to investigate closely in Italy, Greece, Germany, and Luxembourg. The aim was to find good landscape architecture practices and planning, urbanism, and ecology on former landfills (wastescapes).

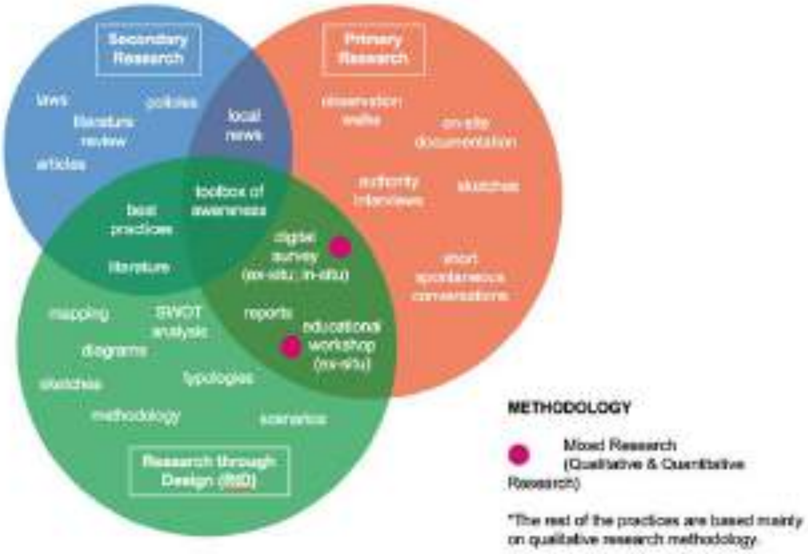

Figure 3. Diagram of research practices and their relation (diagram: Diamantouli E.)

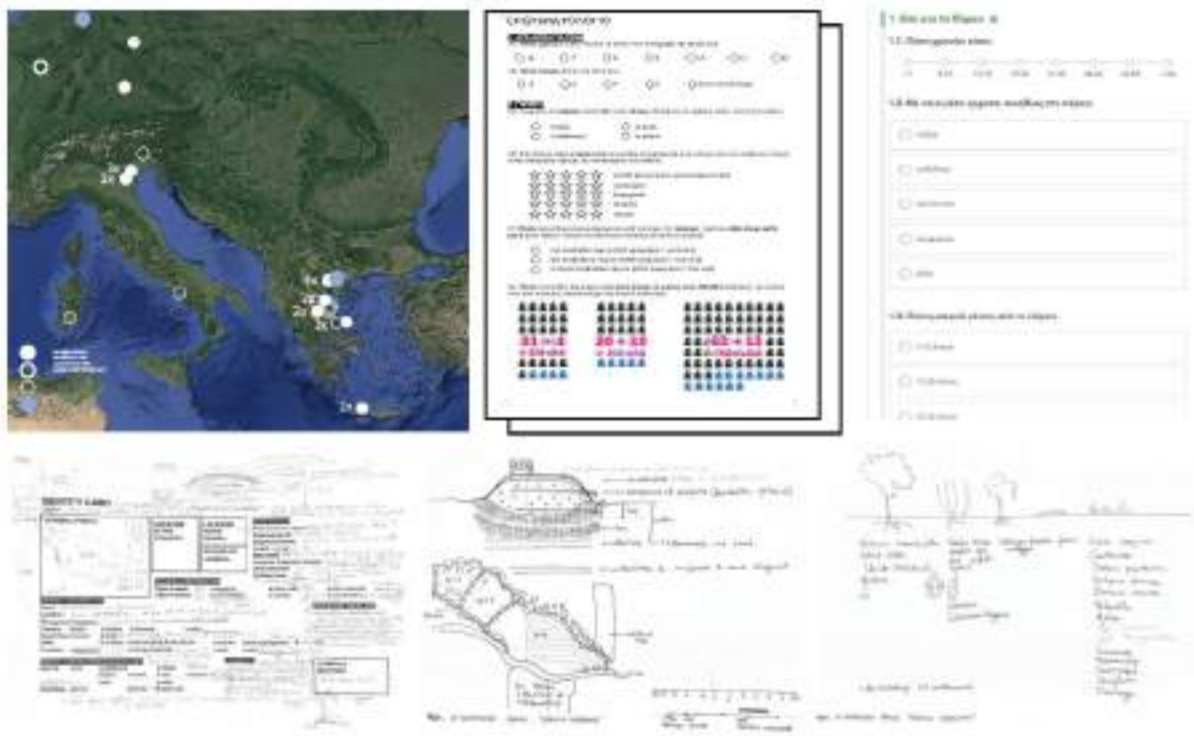

Figure 4. Aerial photo of visited wastescape locations in Italy, Greece, Germany, and Luxemburg (top left), "identity card" of wastescape, sketches in plan, section and plant recording of one landfill (bottom line), interactive questionnaire for primary school children (left) and digital questionnaire for transformed parks from wastelands (right) (mapping, questionnaires, graphic design: Diamantouli E.)

The primary research based on the principles of Research through Design included a mix of qualitative and quantitative methodologies, consisting of fieldwork with wastescape visits, interactive action for children, and online questionnaires on wastescapes. Site visits included photo documentation, sketching, quick mapping, and discussions with the people responsible for each spatial infrastructure. Several locations were visited for documentation in different seasons, mainly for "thick" biodiversity monitoring. In some cases, records of short discussions with inhabitants of neighboring landfills took place. The interactive action for children aimed to research their perception of waste, landscape and wastescape, whereas the online questionnaires investigated the users' perception of public parks that were once wastelands in the past (Figure 4). Both actions were based on the toolbox of public awareness on wastescapes created based on educational tools (Diamantouli et al., 2023).

Around thirty wastelands and wastescapes were visited between 2022 and 2024. As referred to above, most of them were in Italy and Greece (Figure 6: Diamantouli & Stendardo, 2024). Open dump sites are also part of the primary research, observing their relation to the surrounding landscape, as well as the formation of a new type of landscape through ecological succession, creating in-between spaces for daily human and more-than-human practices (urban gardening, small-scale poultry farming, beekeeping, walking).

Landfills in the Metropolitan area of Venice are landscapes between industrial and agricultural lands between managed ditches and canals -restored wetland for agricultural land (in Italian called "bonifica")- and, in two cases, outside urban settlements. Through the primary research, except for transformed urban public parks from landfills, some good examples of landfill 'reuse' practices were identified: pollinator hotspots and beekeeping, stopping places for sheep pasture (transhumance: mobile livestock farming starting from Trentino area till the Adriatic Sea), and energy landscape in combination with stable meadow. Interestingly, two cases close to protected wetlands are characterized as bird biodiversity hotspots (locally called "oases"). In the case of Greece, urban parks with specific opening hours were identified as surprising cases of landfill 'reuse' close to urban areas -without analyzing their architectural implementation.

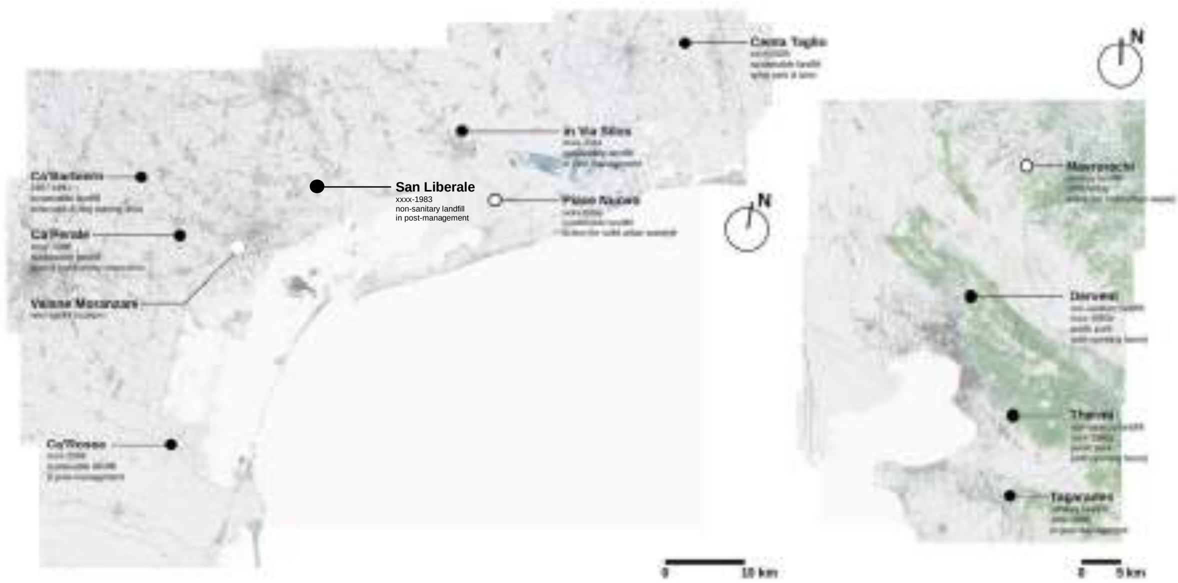

Figure 5. Map of the Metropolitan area of Venice and Thessaloniki with their landfills (revised map of: Diamantouli & Stendardo, 2024; map: Saflekos K.)

On the one hand, the methodology to explain to children what wastescapes are and how they work included sketching in sections with simultaneous explanations, discussing using simple terms, learning by playing and digesting knowledge by making. All these practices were combined with the individual filling of an interactive questionnaire in two parts (Figure 6). Between these two parts, an explanation of waste and wastescapes was given using the upper methodologies. Demonstration of photos was supplementary and not a primary need. From the beginning of the action, it was decided to create an exhibition with the results of the interactive questionnaire and possible group creation during the action to communicate the outcomes to the rest of the school (children, parents, teachers).

Figure 6. First and second meetings in primary schools in Volos, Greece (November 2023; May 2024) for the action of wastescapes (left, middle); Flyers of digital questionnaires for Environmental Parks Derveni and Thermi (former wastelands) in Thessaloniki, Greece (photos: Saflekos K., Diamantouli E.)

The action consisted of two parts, with the participation of fifty-five children between 11 and 12 years old in two converged primary schools in Volos, Greece. The first part of the action was realized twice (once for two 5th and once for two 6th grade classes), and the second part once altogether. There were slight differences in some activities of the first part. Space played a secondary role, but it was still important for the possibility of children moving around freely in the space. The questionnaire focused on their habits with waste and space, their knowledge of wastescapes, and what they learned about wastescapes through this action. Note that Volos is a middle-sized port city on the Greek mainland with a metropolitan area of 139.670 inhabitants (ELSTAT, 2021). The primary schools are located in the peri-urban area of Volos over and close to the peripheral ring road (southwest), surrounded by a densely constructed neighborhood with mainly one- and two-family houses (northwest), built next to each other with small yards. From the southeastern side, the olive trees agricultural landscape is next to this district ("Chrysochoidi").

On the other hand, the methodology of the digital questionnaire for adults, including teenagers, was based on learning by understanding and, in some cases, even by discussing (using both simple and complex terms) and sketching. This research focused on filling out the informative questionnaire and providing them with reports of these results. Seventy-three persons filled out the interactive questionnaire on transformed wastescapes of Thessaloniki (Derveni, Thermi) into parks: twenty-five in Derveni and forty-eight in Thermi. Posters were hung in several parts of the Environmental Parks, and flyers were distributed to people on one weekend in November 2023 (Figure 6). Both parks are located in the suburban area of Thessaloniki. Derveni Park is between a highway, industrial area, and 'natural' landscape. In contrast, Thermi Park neighbors a human-made 'natural' landscape on the outskirts of Thermi City, a fast-growing satellite city of Thessaloniki.

3. Findings and Discussion

Figure 7. Pictures of different kinds of wastelands in the interactive questionnaire for primary school children (operating sustainable landfill, open dump site, covered sustainable landfill) (photos & graphic design: Diamantouli E.)

The children's survey revealed that half of the participants dispose of their waste outside of spaces they consider their own, such as the family garden. Spaces these children use to throw waste are mainly in anthropized foreign spaces (more: road, neighbor, playground; less: beach, abandoned space; not in the landscape). The children understood what a landfill is after explaining it with sketches and showing them pictures of wastescapes (Figure 7). The difference between an open dump site and a regulated wasteland, such as a landfill, became clear to them. It was more complicated to explain to them the difference between a non-sanitary, sanitary, and sustainable landfill. Bio-waste separation is not operated in Greece but only in pilot projects. So, most of the landfills in Greece are sanitary ones with some exemption, where bio-waste gets separated from the municipal services.

During an in-between activity, each child got three stickers and had to place them on pictures of landscapes that were possibly former wastescape. Most of the images were shot by one of the authors (Italy, Greece, Germany, Luxembourg) and one from online (Frédéric-Back Park) and represented parks, 'natural' landscapes, agricultural fields (agroforestry), lake from clay extraction, pine growing forest in succession. They were shot in different seasons and weather conditions (sunny or not). The children could imagine that wastescapes can be restored and covered with soil, but they could not understand that nature can restore itself, meaning natural succession even in contaminated soils. The photos they placed the most stickers on were the restored dump site of Skiathos island pictured on a sunny day in August (responsible for a severe fire in the mid-2000s that burnt part of the island) and a 'natural' landscape next to the Environmental Park of Derveni northern of Thessaloniki (restored dump site) that from the dumpsite closure is in an ecological succession of mainly pine species. This area served as a borrowing chamber of earthen material for daily soil cover of waste.

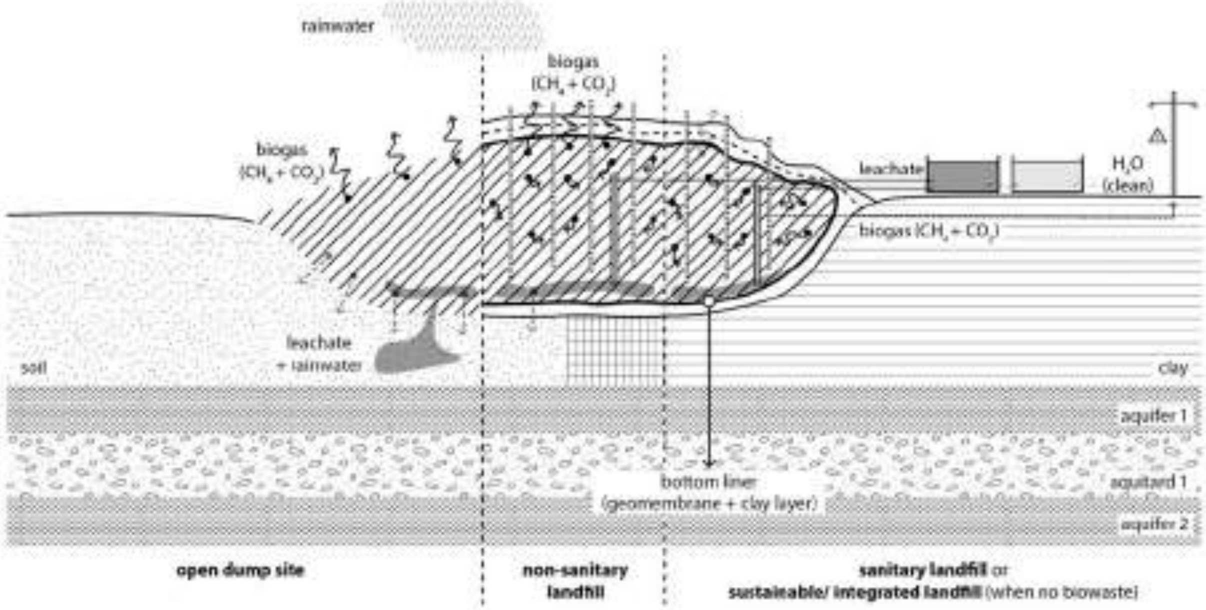

Figure 8. Section of ‘wastelands’ (open dump site) and ‘wastescapes’ (a sanitary/ sustainable landfill (diagram from: Diamantouli & Stendardo, 2024; diagram: Diamantouli E.)

Kennen and Kirkwood (2015) explain that "landfills are one of the most commonly used methods around the world of managing and disposing of the many forms of waste generated through human settlements and industrial processes, including daily municipal household wastes as well as hazardous wastes and demolition and construction wastes." Different typologies were identified by analyzing wastescapes in sections (Figure 8; Diamantouli & Stendardo, 2024). Depending on the type of waste, these produce biogas and leachate. Landfills of inert materials are dry wastescapes and can be 'reused,' especially when non-hazardous waste is placed in them. Landfills of non-hazardous and hazardous waste may contain wet material; therefore, their digestion produces leachate and biogas. Depending on the waste separation system, there are different treatment methods for biogas, leachate, and rainwater collection.

Mapping of wastescapes in north and central Italy showed their relation to settlements and water bodies, both 'natural' and human-shaped (Figure 9). The outcome of the 'thick' landscape mapping is that the landfills tend to be bigger through the decades since the waste is treated more centralized and regionally. Landfills were smaller in the past since the municipality had its dump site. They are usually placed away from settlements, with some exceptions. Moreover, landfills in the Metropolitan area of Venice are mainly close to water bodies (rivers, canals, ditches, sea).

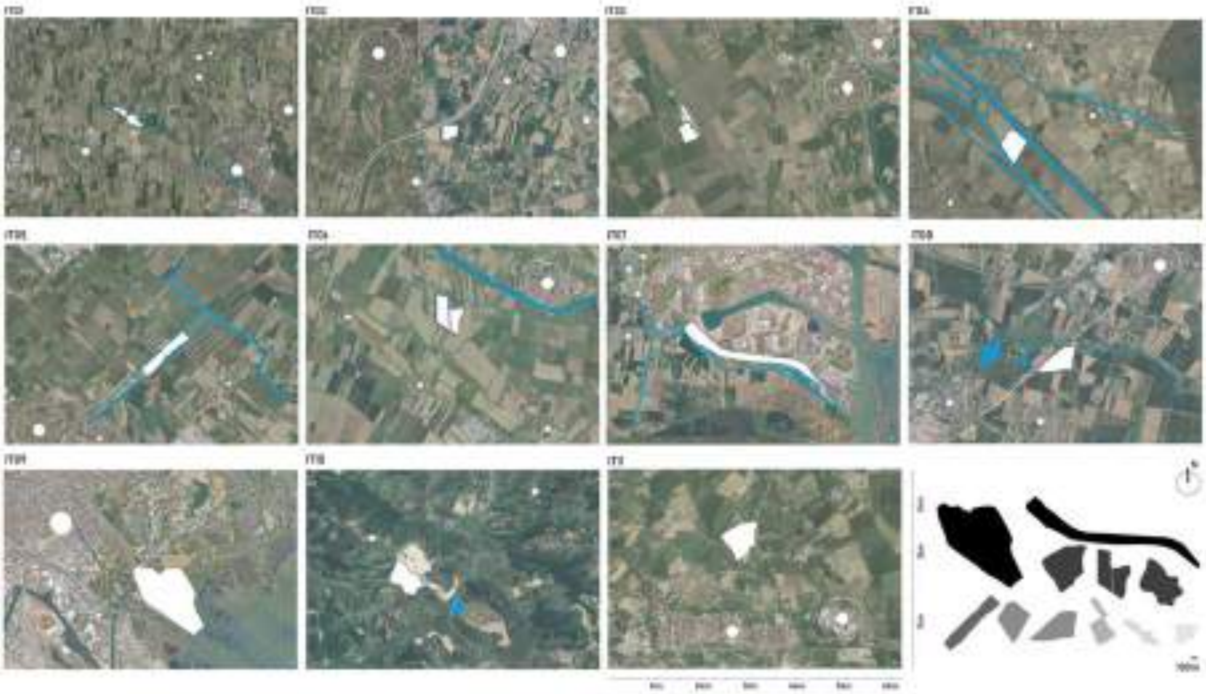

Figure 9. “Thick” mapping analysis of landfills in Italy in relation to water bodies, settlement centers and infrastructure (background-aerial photos: Google Earth Pro)

Each wastescape has different landscape characteristics and relation to its surrounding environment. The 'thick' mapping goes further into each landfill as a site-specific case. It brings up a remark while studying the good practices of 're-inhabiting' the landfills after their lifetime as waste landscapes. In this area of Italy, landfills next to water bodies serve as eco-corridors for the regaining and strengthening of biodiversity loss due to intensive agriculture and pesticide use (EC, 2023). Professional and amatorial insect experts claim the decrease in the diversity of flora and fauna in the area because of the extensive cultivation of the Padan Plain (cereals, grapes) with insecticides and herbicides (Ghion et al., 2024). In particular, insects use open landscapes and water as movement, incubation, and reproduction spaces. In some cases, the care practices made it clear that waste landscapes can be bio-managed spaces with cow or sheep pastures, either local or passing ones (transhumance)**,** for less management expenses.

Archival research and oral testimonies are essential for waste landscapes, especially in designing spaces to be open to the public. In some cases, data were not found either because of not being recorded or due to loss. From this point of view, local narrations are important for "picking up the thread" of where to research. Waste landscapes can hide unwanted but sometimes dangerous materials, or the combination of some materials can cause chemical reactions, and so are "sensitive spaces" to look at. The waste landscapes of Skiathos, Volos, and Giannouli are three cases that show this fragility in combination with fire and water (Figure 10).

Fires are common in wastelands because the anaerobic digestion of waste increases the temperature in the cell. The soil covering covers the waste to reduce the odors and prevent the fire from starting on days when wind transmits oxygen in the waste cell (Sperling et al., 2023). There are more reasons that a fire can start in a waste hip, especially when temperatures are pretty high, waste is mixed, and air is blowing. As referred above, Skiathos island had a waste hip where a severe fire in 2007 burnt around 2,2 hectares (Markou, 2010).

In September 2023, sudden and continuous rainfalls in the area of Thessaly were the cause of two severe flooding events within a span of two weeks. Volos City, situated in the catchment areas of three torrents (Xerias, Krafsidonas, Anavros), faced serious problems in bringing materials from the upper to the lower catchment areas (Dimitrakopoulou et al., 2024). Next to the Xerias torrent, a wastescape is situated and restored from a dump site to a non-sanitary landfill. For years, on the latter side of the restored dump site, part of the trash and leachate was carried away by the torrent (Pavlou, 2023; Palaiodimopoulou, 2023). With the floods of the torrents, even more significant amounts of rubbish and soil got carried away, creating serious hygiene problems for the residents living in the area beneath.

The same rainfall events created issues at the neighboring city of Larissa that had, since the 1980s, split Pinios River into two parts to decrease the danger of flooding the city. For each bank, anti-flood dykes, both single and double, were created that are nowadays part of the urban, suburban, and rural landscapes as landmarks that inhabitants walk on or drive on. The dyke between Giannouli town and the displaced Pinios river was the former dump site of Larissa city and the surrounding settlements. In the days after the extreme rainfall, vast amounts of water came from the mountainous areas to pass the flatland and reach the sea. The river level increased significantly with the danger of flooding Larissa city (146.337 inhabitants; ELSTAT, 2021). It is supported that the dyke that was a former wasteland was intentionally breached to explode from aerial actions so that the city of Larissa would not further flood. The result was that 930 social housing in the neighboring town of Giannouli flooded. These were wrongly built in a flooding area, but the dyke would have probably protected them from this event. The Council of the State is currently investigating this case for further investigation.

Figure 10. Restored non-sanitary landfills of Skiathos (08.2023), Volos (09.2023) and Giannouli-Larissa (09.2023), Greece (from left to right) (photos: Diamantouli E., Vaxevanopoulos M.-middle)

From these three cases, it becomes clear that none of these events was expected to happen. In some cases, scenarios that were of high risk could also have been prevented. In the last few years, it has become increasingly common to have sudden and heavy rainfalls and more extended drought periods. These conditions might be new due to the climate change crisis, and therefore, we have to consider more and more when planning to change the existing 'nature' to a landscape infrastructure.

In the case of waste landscapes, extensive floods can be a reason for water to carry soil away and waste material, as we saw in the Volos restored wasteland. In Giannouli, the waste is carried, but the waste landscape was "broken" due to emergency decisions in a high-risk situation. This restored wasteland had a double function of "storing and digesting" trash and holding the water as a dyke in the flooding case of the close by river. The risk of wildfires bursting, and human-caused fires is difficult to stop, especially in dry and windy periods. In this period of climatic changes, dry periods are more extended, and it becomes harder to extinguish them. Wildfires are a necessary part of the natural circle and reinforce biodiversity (primary and secondary ecological succession), bringing more than humans and humans at risk of life. When fires come from anthropogenic actions, it is an unnecessary risk. Skiathos Island has faced several fires over the decades, and the one in 2007 was a significant forest loss that needed years of recovery (Markou, 2010).

4. Conclusion

Therefore, Nature-based Solutions (NBS) can be a good low-tech curing/ caring solution that needs time but costs less than high-engineered projects (EEA, 2021; Kennen & Kirkwood, 2015). Waste infrastructures are safe when no leachate leakage and/or biogas are released into the atmosphere. This was and is part of planning newer landfills (sanitary, sustainable) forms. Older wastelands -often unlined- even restored- can cause environmental contamination or health issues to people around. Especially for the older ones, phytotechnologies, and microbiological systems can be good examples for reducing severe problems from climatic and other factors (Gebbert, 2022; Morita et al., 2023; Ndanga, 2015). Plantations to avoid soil erosion on the waste landscape, as well as hedgerows or trees at the boundary, are simple solutions that can reduce natural contamination in the long term (Kennen & Kirkwood, 2015). From the perspective of a more-than-human care, this planning, restoration and/ or after lifecycle approach of an infrastructure takes into consideration all the organisms and microorganisms of soil and atmosphere (Puig de la Bellacasa, 2017).

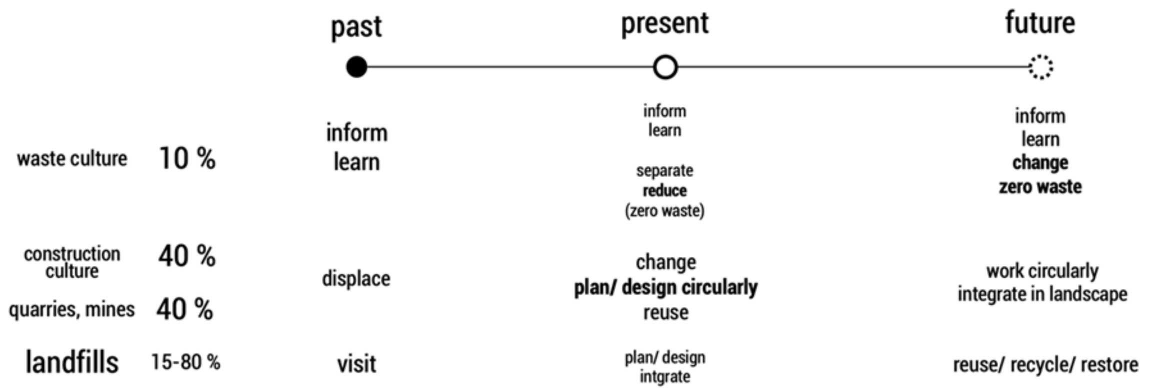

Figure 11. Diagram of care practices for the restoration of infrastructural landscapes, such as wastelands, about waste production and the past, present, and future (diagram: Diamantouli E.)

While landfills can be toxic, this is not always the case. Each landfill requires thorough study to identify potential issues and determine appropriate solutions. Creating a universal image of the overall situation of waste landscapes worldwide is difficult. When studying these infrastructures, it is important to study the waste culture, the waste management system of the specific place, and the quantities of the different waste types that reach these spaces. To understand these landscapes, research is needed and will need to communicate, educate, and inform society and politics. Waste landscapes are spaces in-between that require perfect planning -considering scenarios-, public participation, correct implementation, and constant monitoring for a good restoration in either urban or rural landscapes. So, constant information and complete transparency are crucial for the collective "cure" and care of shared spaces, especially "anthropized nature," including wastelands.

Note

The authors are responsible for the content of their papers.

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For further information, visit: www.wastelandscape.wordpress.com

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Method Approach to Landscape Design of Child-Friendly Green Space for Post Disaster Children's Recovery /A Case Study: Elementary School Environment in Cianjur Earthquake-Affected Areas West Java Indonesia

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Abstract

Natural disasters, particularly earthquakes, can have severe and long-lasting impacts on children, affecting their physical, emotional, and social well-being. This research investigates the role of landscape design, specifically child-friendly school green spaces, in supporting children's recovery after such disasters. Focused on the aftermath of the 2022 Cianjur earthquake in Indonesia, this study aims to develop guidelines for designing schoolyard environments that enhance resilience and recovery in children. Using a mixed-methods approach, the research combines qualitative data from interviews and focus groups with quantitative data from surveys and observations, conducted across elementary schools in the Cugenang District, a region severely impacted by the earthquake. The findings are expected to provide evidence-based recommendations for creating therapeutic and restorative green spaces within school environments, contributing to the development of resilient communities in disaster-prone areas. The study highlights the need for integrated landscape design that considers children's emotional and social needs as part of disaster recovery and resilience strategies.

Keywords: Child-friendly green spaces, landscape design, school environments, resilience, post-disaster recovery.

1. Introduction

Natural catastrophes, such as earthquakes, can profoundly and devastatingly affect communities, leading to extensive damage, fatalities, and forced relocations. This traumatic event can have a profound and lasting impact on children's well-being, academic achievement, and physical and social development (Norris et al., 2002; Greca, 2006; Pfefferbaum et al., 2012). As defined by the United Nations Convention on the Rights of the Child (1989), a child is anyone below the age of 18, unless the age of majority is reached earlier under national legislation (Nations, 1989). Children comprise the majority of individuals impacted by disasters (Gaillard & Pangilinan, 2010; Muzenda-Mudavanhu, 2016; Amri et al., 2018). Children can interact with peers in a secure and supportive school setting, participate in educational activities, and receive emotional support from teachers and parents (Prinstein et al., 1996; Franks, 2004; Dombo and Sabatino, 2019). By offering opportunities for social interaction, outdoor play, and physical movement, well-designed schoolyards can enhance the therapeutic and restorative benefits of educational settings (Uslu & Körmeçli, 2016). Despite their significance, the design of school environments is often overlooked in broader discussions on disaster recovery. However, it represents a critical yet understudied opportunity to promote resilience, disaster mitigation, and recovery process.

This Research addresses a significant gap in existing knowledge by investigating the impact of landscape design on the recovery of children in school environments following natural disasters. By expanding the understanding of how well-designed environments can enhance children's recovery (Mooney et al., 2021; Atmodiwirjo et al., 2023), this study has the potential to shape policies and practices for the development of more resilient communities.

Although there is an increasing recognition of the importance of schoolyard design for the well-being of children, there is limited understanding of the specific contribution of landscape design in facilitating the recovery of children from natural disasters. Current studies on schoolyard design primarily focus on its impact on children's physical activity and social interactions, overlooking a thorough exploration of its potential therapeutic and restorative benefits (Bell & Dyment, 2008; Health, 2017; Russo & Andreucci, 2023). The absence of evidence-based guidelines for designing school environments in the context of recovery post-natural disaster poses a challenge for educators, landscape architects, government, and related stakeholders involved in the planning and design process. Ensuring that schoolyards are adapted to facilitate children's recuperation and resilience following natural catastrophes (Taylor et al., 1998; Dadvand et al., 2015) is challenging without clear guidelines.

This research aims to develop landscape design criteria, modelling and guidelines for child-friendly school green spaces in areas of Indonesia vulnerable to natural disasters. Using a case study approach, the research will examine the impact of school green space design on supporting children's recovery in the aftermath of natural disasters in Indonesia. Employing a mixed-methods approach, the data collection will be conducted in two phases: initial qualitative data collection followed by a second quantitative data collection (Creswell, 2014). The data collection will commence by gathering secondary data before fieldwork. Subsequently, it will involve observations, surveys, and workshops with children, as well as focus group discussions with parents, teachers, community members, and various stakeholders directly affected by the repercussions of natural disasters. The research findings aim to contribute to the development of evidence-based guidelines for designing school environments that effectively support children's recovery and resilience in the aftermath of natural disasters.

2. Material and Method

This research employs a case study approach with a mixed-method design. The case study aims to assess the effectiveness of landscape design in identifying suitable green space sites for post-natural disaster recovery within elementary school environments. Elementary schools, centrally located within communities, provide accessible locations for children and integrate research activities into their curriculum, enhancing educational experiences and preparing children for recovery. This study aims to illuminate children's needs and the potential of landscape design in facilitating post-disaster recovery. The findings will refine landscape design models and provide recommendations for creating child-friendly green spaces.

Focused on the landscape design of child-friendly school green spaces for post-disaster recovery, the case study is situated against the backdrop of the 2022 Cianjur earthquake in West Java, highlighting the impact on children's well-being and the importance of green spaces, particularly within elementary schools. A UNICEF report emphasizes the urgency of this research, indicating that 37% of the total deaths in Cianjur were children under 15 years old, underscoring the significance of the study.

The selection of the case study location is based on criteria for observation and surveys to collect qualitative and quantitative data. The Cugenang District, with a high-risk index and proximity to the earthquake's epicenter, is chosen due to its intersection with the Cugenang Fault. The district encompasses 52 public and 3 private elementary schools across 16 villages.

One elementary school will be selected to represent the earthquake-affected environment. The research specifically focuses on elementary school children, whose age range falls within middle childhood, from a psychological perspective.

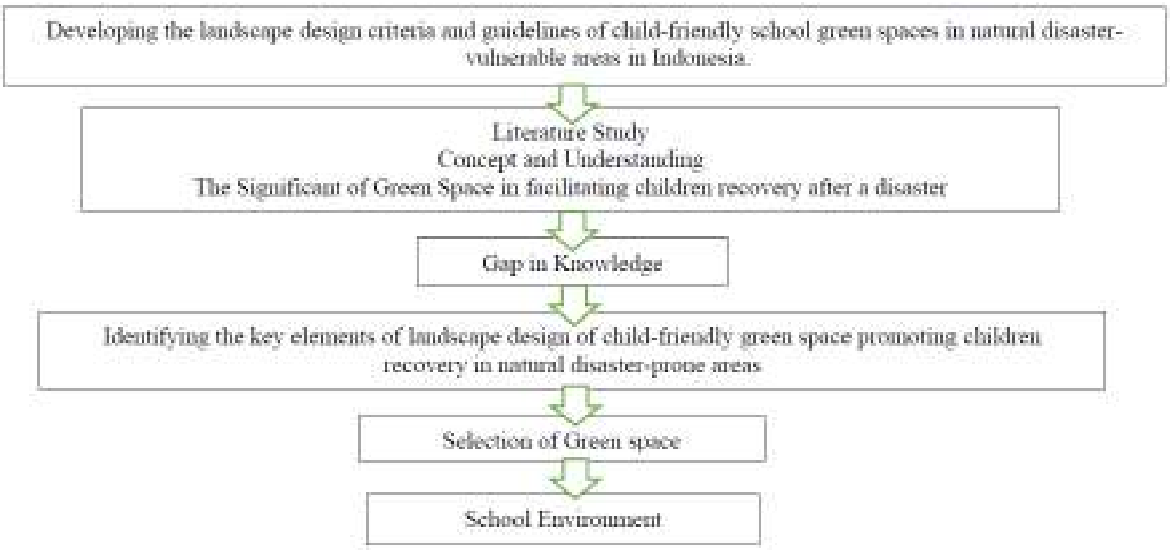

Figure 1. Research framework

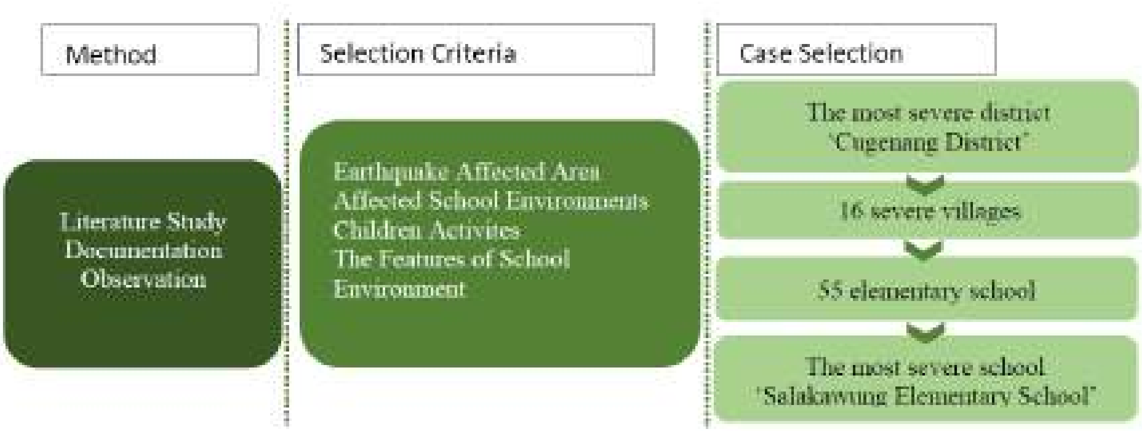

Figure 2. Case Study selection

To achieve the research objectives, this study will employ a mixed-methods approach for data collection. The data collection process for this study involves a diverse set of participants, including students, parents, teachers, members of communities, and various stakeholders who have directly encountered the repercussions of natural disasters. To gain a comprehensive understanding of experiences and preferences related to green spaces in child-friendly schools for post-disaster recovery, this study begins with qualitative data collection. Employing a qualitative phenomenological approach, the research aims to investigate the experiences, perspectives, and needs of children in the aftermath of natural disasters.

Phenomenological studies, as explained by Creswell & Poth (2018), aim to elucidate the shared meanings individuals attribute to their lived experiences of a concept or phenomenon. In this context, the focus is on delineating shared elements among participants as they navigate the aftermath of a natural disaster, constructing meaning from their subjective experiences (Mooney et al., 2021). The study specifically investigates children's varied perspectives within their school environment, striving to capture the nuanced effects of a disaster across various age groups.

To ensure a comprehensive understanding, data will be gathered not only from the children but also from their parents, teachers, and stakeholders. This multi-perspective approach not only enriches the information gathered from the children but also enables cross-referencing of data between participants (Mooney et al., 2021). Recognizing the diverse circumstances and perceptions of different participants affected by disasters, Lei (2014) underscores the importance of considering this diversity in experiences and perspectives. This approach ensures a thorough exploration of the impact of disasters, acknowledging the unique perspectives brought forth by each participant group.

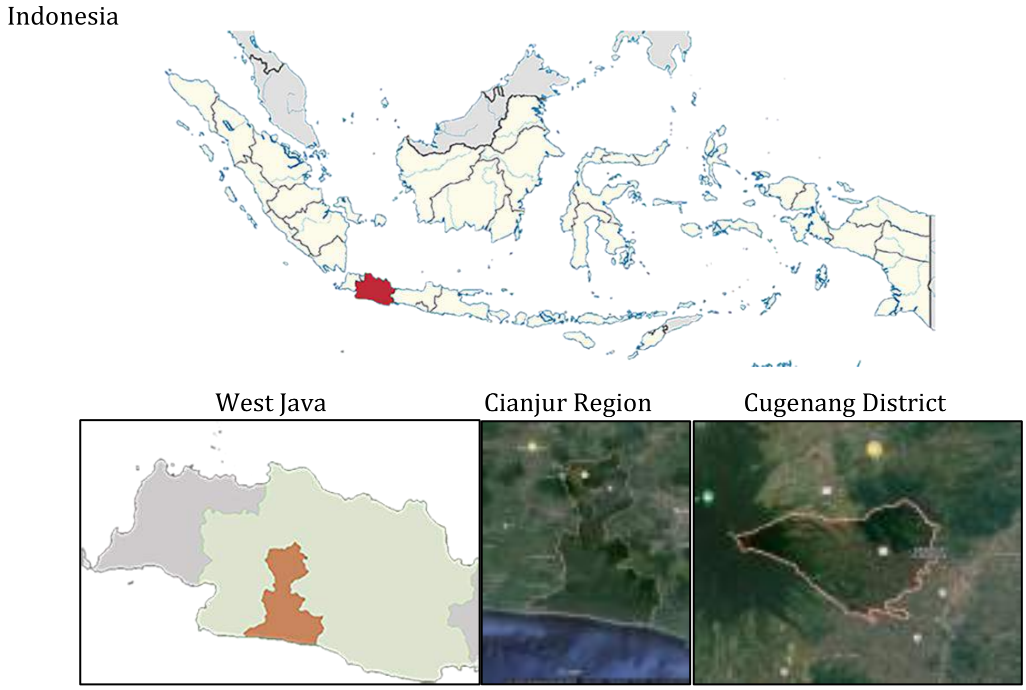

Figure 3. Case study location (google map, 2023)

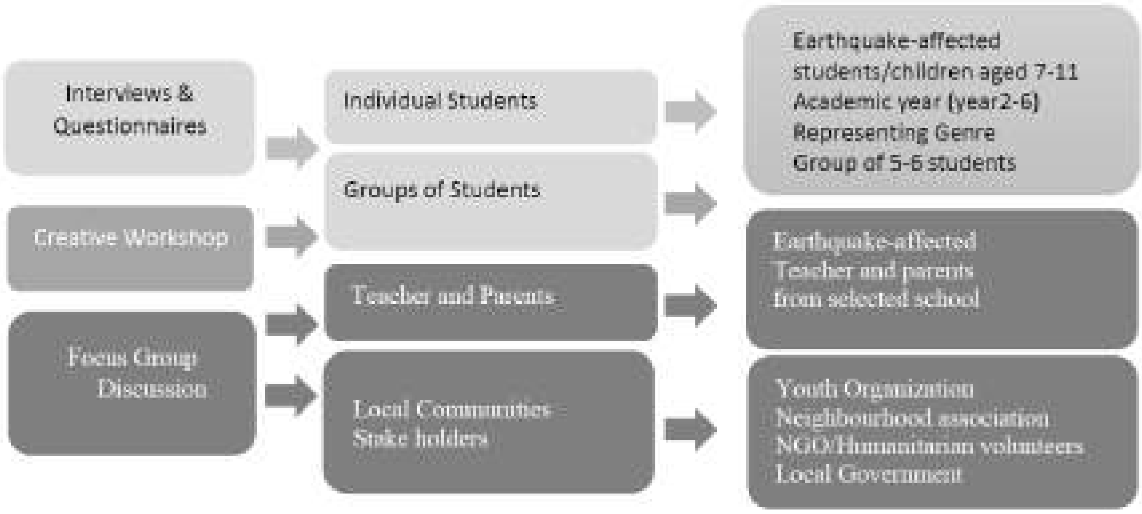

Figure 4. Participant's selection

Figure 5. Data collection method

3. Findings and Discussion

The results from the methodology outlined above would likely include findings related to the effectiveness of landscape design in identifying suitable green space sites for post-natural disaster recovery within elementary school environments. These findings may evaluation of the identified green space sites, integration of research activities into the curriculum, children's needs and the potential of landscape design, specific insights from the chosen case study location, and recommendations for future child-friendly landscape design guidelines for recovery in elementary schools. Overall, the results would provide valuable insights into the role of landscape design in promoting children's recovery from natural disasters and contribute to the development of evidence-based guidelines for creating resilient and child-friendly environments in disaster-prone areas.

The discussion section of the research could delve into various aspects and implications based on the outlined methodology. Firstly, it could analyze the efficacy of landscape design in identifying suitable green space locations for facilitating recovery after natural disasters within elementary school settings. This analysis would examine how well-designed green spaces contribute to children's overall well-being and resilience in the aftermath of such events. The research explores the integration of research activities into the elementary school curriculum and its impact on children's educational experiences and preparedness for recovery. This aspect would investigate the potential benefits of incorporating research-based learning activities into the curriculum to enhance children's understanding of disaster preparedness and response strategies. Furthermore, this could address the identified needs of children following natural disasters and how landscape design can effectively address these needs. This analysis would shed light on the role of green spaces in providing avenues for social interaction, play, and emotional support for children who have experienced traumatic events.

Moreover, it is focus on refining existing landscape design models and developing evidence-based guidelines for creating more effective and child-friendly green spaces. This aspect would offer specific recommendations for enhancing design criteria and implementing strategies based on the research findings. Additionally, reflections on insights gained from the chosen case study location, particularly in the context of the Cianjur earthquake in West Java, could provide valuable contributions. This would involve discussing the specific challenges and opportunities encountered in supporting children's recovery within the affected community, emphasizing the significance of green spaces within elementary schools for facilitating this process. Finally, the result might offer recommendations for future research endeavors and practical implications for landscape design projects aimed at supporting post-disaster recovery in similar contexts. This could include suggestions for further studies to explore additional factors influencing children's recovery and strategies for implementing evidence-based design guidelines in disaster-prone areas. Overall, the discussion section would provide a comprehensive analysis of the research findings and their implications for theory, practice, and future research directions in the field of landscape design for post-disaster recovery in elementary school environments.

4. Conclusion

The research findings underscore the critical role of landscape design in promoting children's recovery and resilience in the aftermath of natural disasters. By integrating research activities into the curriculum, refining design models, and addressing children's specific needs, the study offers valuable insights and recommendations for creating more effective and child-friendly green spaces in elementary school environments.

Acknowledgements

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Mugnone River Contract: A Tool for Landscape and Territorial Development

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Abstract

The Mugnone River is a vital common good for the Florence metropolitan area, with significant historical, cultural, ecological, and recreational value. The "Lungo il Mugnone" participatory research project envisions a 17.5 km continuous public corridor connecting parks and green spaces with pedestrian and bicycle paths, as well as water access points. The initiative seeks to revitalize the river by fostering environmental protection, urban planning, and community engagement through the establishment of a River Contract.

This collaborative framework, defined by Italy's National Charter of River Contracts, brings together local authorities, residents, and stakeholders in a shared commitment to restoring the river as a living environment and collective resource, in line with the European Landscape Convention.

The project is guided by four goals: creating a safe and connected corridor, making the river accessible and inclusive, restoring ecosystems and improving water quality and preserving the river's ecological and cultural heritage for future generations. By raising awareness and mobilizing resources, the Mugnone River Contract aspires to become a pilot project integrated into the Pact for the Arno river, promoting the river as a driver of landscape infrastructure development and community identity.

Keywords: Landscape infrastructure, river, public space, community engagement, social and ecological history

1. Introduction

The Mugnone Creek, a right-bank tributary of the Arno River, is a historically, culturally, and ecologically significant resource for the metropolitan area of Florence. Originating in the hills of Fiesole and flowing for 17.5 kilometers through rural landscapes, suburban areas, and the city of Florence, the creek connects diverse environments and communities (Figure 1). Despite its strategic location and historical importance, the creek has become increasingly undervalued, with urbanization and anthropogenic activities reducing its ecological, cultural, and recreational potential.

In response to these challenges, the Mugnone River Contract was conceived as a strategic tool to revitalize this vital watercourse, fostering a new relationship between the community and the river. River Contracts are voluntary, participatory agreements that integrate environmental, social, and territorial planning to promote sustainable management of water resources. Defined in Italy by the National Charter of River Contracts, they aim to build bottom-up processes that bring together local authorities, community stakeholders, and environmental organizations to address shared goals, including hydraulic risk mitigation, ecological restoration, and territorial development.

The Mugnone River Contract emerged from a collaborative effort started in 2020, supported by Le Curandaie APS, an association in Florence's Le Cure neighborhood. This initiative sought to promote the creek as a shared asset and build a sense of belonging among residents. Through a petition and a series of participatory processes, the foundation was laid for the contract, officially signed in April 2024. The contract's vision encompasses environmental protection, urban planning, and sustainable development while enhancing the creek's value as a natural, cultural, and social resource.

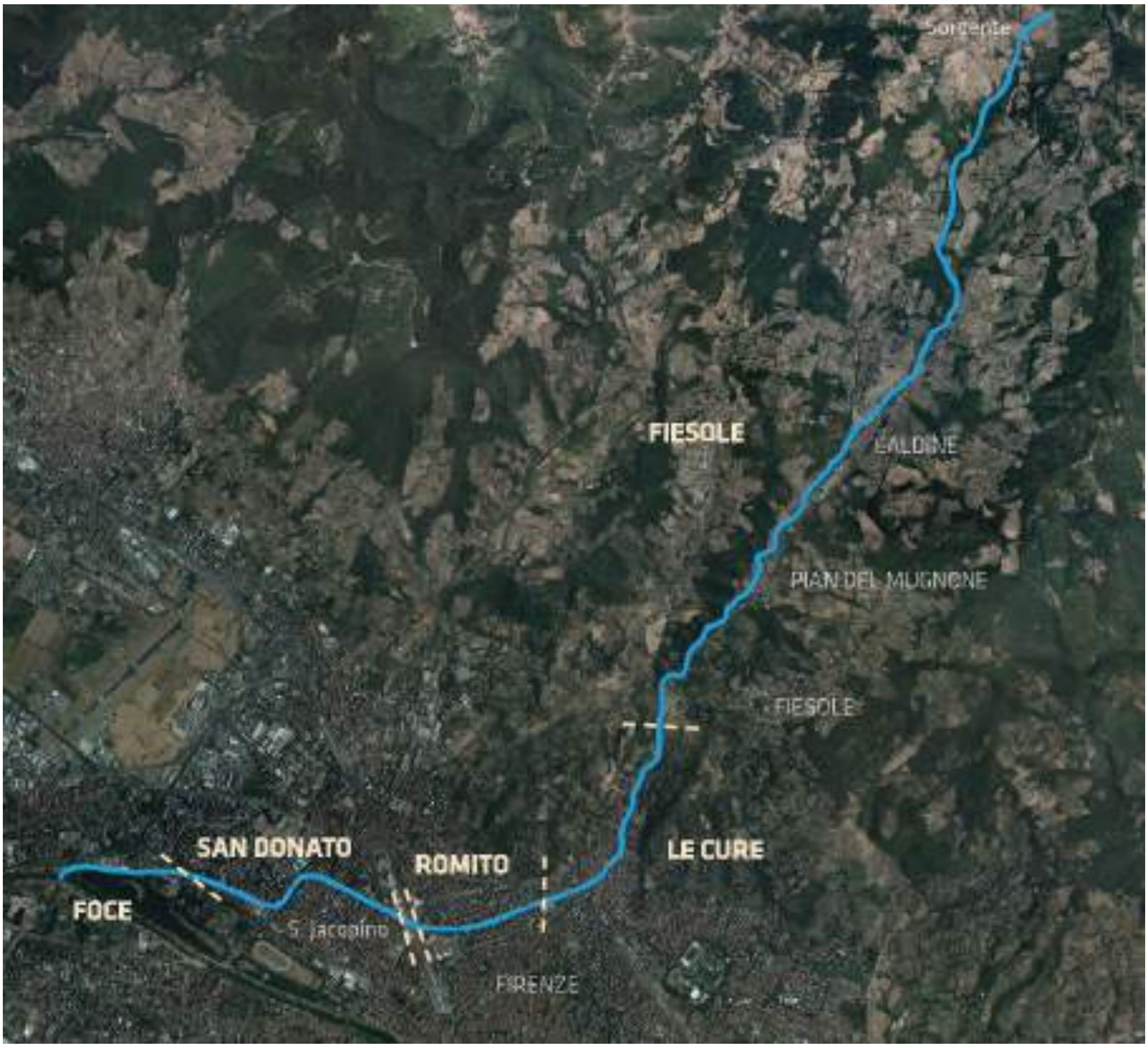

Figure 1. The Mugnone creek and the river Arno

The Mugnone River Contract is guided by four overarching objectives, each addressing critical aspects of the creek's potential as a corridor for connectivity, a shared public space, an ecological refuge, and a cultural legacy. These objectives form the basis of a comprehensive framework translated into actionable strategies and specific interventions along the creek's course.

1. A safe and connective corridor

The contract envisions the Mugnone as a "slow line," promoting sustainable mobility and connectivity between Fiesole and Florence. Inspired by Paolo Pileri's concept of "slow lines" (Pileri, 2021), this objective prioritizes investments in pathways for pedestrians and cyclists, integrating existing green spaces and creating water access points. The strategies include nature-based solutions (NbS) to conserve water and soil resources and enhance the creek's resilience to climate change, while also developing an effective communication system to engage the community.

2. A common good for all

As a shared resource, the creek is reimagined as an inclusive space that addresses the diverse needs of the local population. Public spaces along the Mugnone are designed to promote accessibility and inclusivity, ensuring that they serve as gathering places for all, regardless of age or ability. Strategies focus on strengthening the green and blue infrastructure, connecting heritage sites, and fostering social cohesion.

3. An ecological refuge

Restoring the creek's ecological function is a core priority. The Mugnone is envisioned as a thriving habitat for flora and fauna, with strategies to enhance biodiversity, establish an ecological corridor, and adopt landscape practices that balance environmental protection with public access (Buoro, 2023). Differentiated management approaches aim to create a mosaic of habitats that support resilience and sustainability.

4. A living legacy for future generations

The contract recognizes the Mugnone as a repository of cultural and natural heritage, emphasizing the need to preserve its memory while fostering new forms of interaction. Initiatives include promoting artistic projects, educational activities, and sports to strengthen the community's connection to the river. By integrating cultural narratives and contemporary uses, the Mugnone becomes a living legacy for future generations.

The Mugnone River Contract exemplifies the power of participatory governance in addressing complex environmental and social challenges. The process brought together a multilevel network of stakeholders, including the municipalities of Florence and Fiesole, the University of Florence, local organizations such as Legambiente Toscana, and community groups. Funded by the Tuscan Regional Authority for Participation, the project engaged citizens in envisioning the creek's future, fostering awareness of its ecological and cultural significance.

Figure 2. The Mugnone creek and the river Arno

In 2023, key partnerships have strengthened the contract's implementation, with support from organizations like the European University Institute, local cultural and recreational groups, and environmental associations. Together, they have developed strategies to enhance the creek's functionality as a public space while addressing pressing issues such as flood risk and biodiversity loss.

The Mugnone River Contract represents a shift towards integrated landscape infrastructure where infrastructure is seen as an opportunity to enrich ecological, social, and cultural dimensions. This approach emphasizes the interdependence of natural systems and urban environments, designing spaces that are not only functional but also regenerative. By reimagining the Mugnone as a dynamic, multifunctional space, the project seeks to create

active, resilient landscapes that support biodiversity, enhance well-being, and foster a sense of belonging.
In conclusion, the Mugnone River Contract is more than a planning tool; it is a platform for collective action and a model for sustainable development. By addressing the interconnected challenges of ecology, mobility, and community, it transforms the Mugnone into a catalyst for landscape revitalization and a symbol of shared stewardship for future generations.

2. Material and Method

The participatory project aimed to foster awareness and understanding among citizens and local associations, leveraging a collaborative and proximity-based approach. The goal was to reframe the perception of the Mugnone creek, transitioning from a narrow focus on hydraulic risks to recognizing its role as a cultural and territorial resource. This process started in 2020 and culminated in the promotion of a River Contract (Aprile 2024), integrating activities by public entities, local administrations, and associations to ensure comprehensive and sustainable territorial development.

The methodology followed the principles of the Place of Proximity (PoP) model, developed by the University of Florence (Caruso, 2024). PoP emphasizes citizen involvement in decision-making through reciprocal learning, transforming grassroots communities into organized networks capable of engaging with institutions. The five stages of the PoP model (initiation, engagement, organization, collective learning, and visioning) structured the participatory process to mobilize citizens and stakeholders effectively.

Efforts were directed at ensuring inclusivity and representativeness. Stakeholder groups included local residents, younger generations, elderly citizens, new residents, shopkeepers, economic operators, and vulnerable populations. The association Le Curandaie, instrumental in initiating and coordinating the process, engaged its network to reach diverse community segments. To promote gender balance and accessibility, events were scheduled at convenient times and included family-friendly activities.

The participatory process was facilitated by experts from the Department of Architecture (DIDA), University of Florence, ensuring professional support, neutrality, and effective communication. Facilitators provided tools and techniques to guide participants, offering sociological insights and communication strategies tailored to the territory's unique dynamics.

Figure 3. Key moments of the Stage 1 (in Mugnone River Contract - “Preliminary Overview”)

The participatory process unfolded in several interconnected stages:

1. Preliminary engagement

Originating in 2020, the project began with a signature collection campaign to secure regional funding under the Tuscan Regional Law 46/2013 on participation. This phase mobilized a network of local actors, fostering initial interest and collaboration.

2. Promotion and community activation

Awareness campaigns leveraged both traditional and digital communication channels, such as dedicated social media pages and public meetings, to engage a wide audience. Field activities, including creek walks and thematic workshops, played a crucial role in fostering community cohesion and involvement. This phase was essential for laying the foundation of the project (Figure 3).

Figure 4. Results of the Stage 3 (graphic by Elisa Mastrangelo in Mugnone River Contract - “Preliminary Overview”)

1. Territorial identity and community mapping

In 2023 workshops and surveys identified the Mugnone’s environmental, cultural, and social assets. A collaborative map was created, highlighting historical landmarks, green spaces, and potential areas for intervention. This mapping exercise (Figure 4) served as a foundation for subsequent project development and fostered a shared vision of the creek's identity.

2. Co-design and visioning

Co-design workshops integrated the findings from the mapping phase to develop a usability plan for the creek. This phase emphasized environmental quality, biodiversity, accessibility, and recreational potential. Stakeholders collaborated on targeted pilot projects addressing critical access points and mobility improvements. Supplementary activities, such as SUP excursions and guided walks, enriched the process and provided actionable insights.

3. Formalization and action planning

The project concluded on April 2024 with the signing of a Memorandum of Understanding, formalizing the Mugnone River Contract. Key deliverables (Preliminary Overview, Strategic Plan, and Action Program) outlined actionable steps for 2024 - 2025. The closing event, ‘Lungo il Mugnone in Festa’ (Figure 5), symbolized the community's commitment to the creek's revitalization and marked the start of long-term collaborative efforts.

Figure 5. Key moments of ‘Lungo il Mugnone in Festa’

3. Findings and Discussion

The participatory process undertaken for the Mugnone River Contract has yielded significant impacts across various thematic areas central to the project's objectives. Among these, the development of an action and intervention framework stands out, entailing the design of a comprehensive set of actions aimed at transforming the creek into a safe and connective corridor. This framework was the result of collaborative input from multiple participants and stakeholders, leading to a shared and prioritized order of interventions. The process also fostered a heightened sense of awareness and community among stakeholders, emphasizing water accessibility as a shared resource and strengthening communal bonds. Equally important was the formulation of a vision-strategy for the ecological and environmental restoration of the Mugnone creek, recognizing its value as a sensitive ecosystem requiring targeted preservation efforts. Another key achievement was the definition of an adaptive model for interpreting the cultural landscape associated with the creek, offering an integrative approach that can be embedded into planning and maintenance practices. Finally, the participatory process culminated in the formulation of a strategic vision to guide the programmatic document and action plan for the Mugnone River Contract, laying a robust foundation for the project's implementation.

Figure 6. Mugnone river park, starting point at the creek source, design map (in Mugnone River Contract - "Strategic Document")

The cultural impact of the participatory process has been profound, extending its potential for long-term effects on local communities and administrative bodies. For riverside populations, the process has reclaimed a sense of community and territorial identity, fostering a renewed interest in public affairs and a deeper concern for common resources. It has also led to a greater public engagement in community activities and heightened awareness of civil protection, emphasizing collective responsibility in addressing environmental and societal challenges. For the entities involved in water management and land governance, the participatory approach has catalyzed a redefinition of interaction methods with citizens, highlighting the need for horizontal and vertical integration in territorial and water management. It has also facilitated the incorporation of guidelines from the Arno River Contract into broader management frameworks, ensuring a cohesive approach to governance.

The participatory process involved several organized activities, including thematic seminars, design walks, and coordination meetings held in different sections of the creek. These activities enabled the creation of community maps and fostered dialogue among stakeholders. The culmination of the process was marked by a celebratory event on April 13, 2024, titled "Lungo il Mugnone in Festa," which was organized to celebrate the achievements of the Mugnone River Contract. This event, which coincided with a satellite event of the New European Bauhaus Festival, featured a collective walk along the creek from its source in Fiesole to its confluence with the Arno in Florence. The day included diverse activities such as sports, citizen science, landscape studies, historical and botanical tours, artistic events, and workshops, showcasing the multifaceted nature of the project. The event concluded with the signing of the "Memorandum of Understanding," signaling the collective commitment to advancing the Mugnone River Contract.

As part of the Mugnone River Contract, several documents were prepared with the contribution of landscape architects from the Memoscape studio. These included a "Preliminary Overview," which serves as an atlas of planning and programming at the watershed scale, and a "Strategic Document" that proposes the creation of a Mugnone River Park. This strategic vision emphasizes slow travel along the Mugnone Valley, ecological balance, and enhanced connectivity. The accompanying "Action Plan" offers a well-organized compilation of initiatives and projects designed to promote collaboration among all the entities and local communities that have endorsed the Mugnone River Contract. Additionally, the "Memorandum of Understanding" outlines a commitment to continuing the process, expanding the scope to a broader watershed scale, and implementing actions during the 2024-2027 period.

Figure 7. Mugnone river park, new access area at the creek source, design view (in Mugnone River Contract - "Strategic Document")

The Mugnone River Park is envisioned as a multimodal landscape infrastructure that makes the creek accessible to all, linking Fiesole and Florence while fostering transversal connections within the city. This proposal seeks to establish the park as a spine that reconnects urban and rural landscapes, creating an ecological corridor that enhances biodiversity and ecosystem services through differentiated maintenance practices. Beginning at the creek's source, the project includes the creation of a new access area and restoration of historic routes, while enhancing connections to regional trails such as the Via degli Dei. Communication systems, including signage and co-branding, will be implemented to guide visitors and promote a shared identity for the creek.

The project also envisions enhancing connections between the creek and significant landscapes, such as the Medici Park of Pratolino, UNESCO site, and the agricultural areas of exceptional beauty in the Mugnone Valley (Figure 7). Efforts to promote high-quality local products and activate networks of producers and farmers are integrated into this vision. The ecological functions of the creek will be preserved through natural management of the riverbed and experimental renaturalization practices, allowing the river to reclaim its space and evolve dynamically. In sections where pedestrian and cycling paths already exist, such as between Caldine and Pian di Mugnone, the project seeks to enhance these areas through interventions like natural playgrounds and active learning spaces. These spaces aim to blend environmental education with cultural storytelling, transforming the creek into a natural classroom that bridges history and nature.

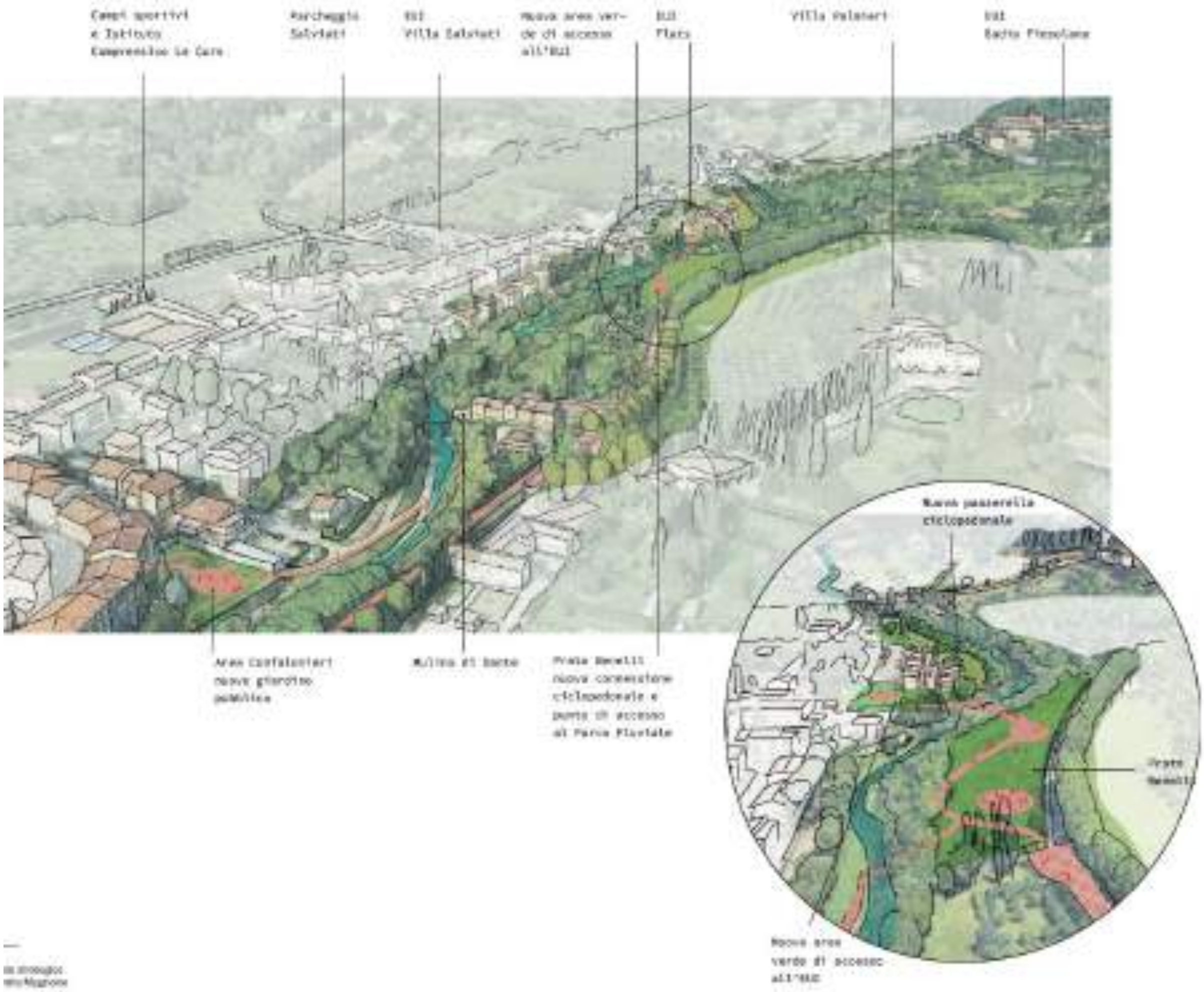

Figure 8. Mugnone river park, Le Cure, design views (in Mugnone River Contract-“Strategic Document”)

In urban sections such as Le Cure (Figure 8), the proposal includes creating accessible pedestrian and cycling paths that link neighborhoods and reconnect fragmented green spaces along the river. The activation of new routes, including potential pedestrian and cycle bridge connections, is aimed at improving neighborhood accessibility and integrating additional green areas into the urban fabric. The project also addresses existing architectural barriers on bridges in the Le Cure neighborhood, ensuring safety and inclusivity. Further downstream, where the Mugnone takes on an artificial form, the focus shifts to enhancing ecosystem services and creating refuges for flora and fauna, while improving visual and physical accessibility to the river.

The final stretch of the creek, from Piazza Puccini to its confluence with the Arno, presents opportunities to expand riverbank sections near public spaces, facilitating connections to the River Park and nearby recreational areas. This section also aims to improve access to the service path and create new areas for public enjoyment, reinforcing the role of the Mugnone as a strategic link in regional green infrastructure. The Mugnone River Park is thus envisioned as a vital axis for slow tourism, linking the Sentiero degli Dei with the Arno cycle path and serving as a linear ecosystem that bridges the urban and rural environments between Fiesole and Florence. This integrated approach underscores the potential of the project to enhance environmental sustainability, community engagement, and cultural heritage, positioning the Mugnone as a model for river corridor regeneration.

4. Conclusion

The "Mugnone River Contract" project has provided profound insights into the complexities of landscape management, community engagement, and collaborative governance. The initiative, focused on enhancing the ecological, cultural, and social value of the Mugnone creek, demonstrates how strategic planning and stakeholder involvement can be harmonized to create a sustainable and inclusive river park. This case study offers valuable lessons that can guide future efforts in landscape and territorial development, particularly those centered on riverscapes and their communities.

One of the central lessons of this project is the importance of multi-scale planning. By integrating local, regional, and municipal perspectives, the project created a holistic framework that addressed both immediate needs and long-term objectives. The combination of specialized sectors ensured that ecological, social, and infrastructural considerations were aligned. This approach facilitates the development of river systems that are sustainable, resilient, and responsive to the needs of both the environment and the local population. Multi-scale planning also fosters a sense of ownership among various stakeholders, as it ensures that all relevant actors, from local communities to governmental authorities, have a stake in the process.

A second key takeaway is the role of participatory engagement. The Mugnone River Contract was designed not just as a planning document, but as an active tool for collaboration. Involving diverse stakeholders, including local residents, experts, public institutions, and private entities, through workshops, collaborative tables, and public walks ensured that a wide range of voices were heard. This participatory approach contributed to a deeper sense of ownership and responsibility, which was critical for the project’s success. Stakeholder engagement also helped in prioritizing actions that received broad community support, ensuring that the interventions were both feasible and widely accepted.

The development of a clear, strategic vision has also proven to be an essential component of the project's success. By integrating feedback from participatory processes, the vision was crafted to be flexible and adaptable, balancing ecological integrity with human accessibility. A strategic vision that responds to community input creates a plan that is not only grounded in local realities but also capable of adjusting to changing needs and conditions. The success of the "Mugnone River Contract" underscores the necessity of long-term planning that is flexible enough to evolve alongside the territory and its people.

Equally important was the production of actionable documentation. The creation of clear, detailed documents, such as the “Preliminary Overview,” the “Strategic Document,” the “Action Plan,” and the “Memorandum of Understanding”, helped translate high-level goals into specific, implementable actions. These documents provided a concrete framework for organizing interventions, ensuring that the project’s goals remained focused and actionable. They also acted as a guide for future development phases, ensuring continuity in the project’s implementation and allowing for the monitoring of progress over time.

The ecological and community benefits of the project are substantial. By integrating green and blue infrastructure within a broader landscape infrastructure, the initiative aims to enhance both ecological function and public accessibility, presenting a model for sustainable river park development. This dual approach fosters biodiversity conservation, supports sustainable tourism, and stimulates local economic growth. Additionally, the management of riverbeds and banks preserves natural spaces, safeguarding the creek's ecological processes while offering visitors enriching experiences. These efforts highlight how ecological restoration can be aligned with public enjoyment, resulting in both social and environmental benefits.

The project also highlights the importance of effective communication. A robust communication strategy was essential for creating a unified identity for the project and guiding public understanding of the river's significance. By creating a consistent narrative, the project strengthened its identity and supported the long-term viability of the river park.

Accessibility and inclusivity emerged as additional critical components of the project. Overcoming physical barriers, such as improving the accessibility of pathways, bridges, and public spaces, ensured that the river park could be enjoyed by all users, regardless of physical ability. Such interventions are vital for ensuring that public spaces are inclusive, enabling equitable access for a diverse range of people.

Equally important is the integration of sustainable use with conservation. The project not only sought to preserve and restore the river’s natural functions, but also aimed to foster sustainable recreational activities. Initiatives such as natural play areas, as well as support for local agriculture, helped promote conservation while enriching the local community. This balanced approach demonstrates that sustainable development can be achieved when environmental goals are aligned with social and economic objectives.

However, the project also faced significant challenges. Resistance from certain segments of the local population, who were skeptical about the feasibility of the project, highlighted the difficulty of implementing large-scale transformations in territories that have historically been shaped by human interventions. Overcoming this skepticism requires sustained dialogue, transparent communication, and tangible outcomes that demonstrate the project’s potential to bring real benefits to the community. The project also faced the challenge of securing sufficient funding, which is critical for advancing from planning to implementation. Without adequate financial resources, it will be difficult to carry out detailed designs, implement infrastructure, and maintain ongoing stakeholder engagement.

The key to the project's success will lie in securing investments that allow it to move forward with both its ecological and infrastructural goals. Funding will also be necessary to continue the participatory processes, ensuring that the community remains involved throughout the life of the project. Therefore, establishing financial sustainability is crucial to maintaining momentum and ensuring the long-term success of the initiative.

In conclusion, the "Mugnone River Contract" is a powerful example of how landscape and territorial development can be shaped by a collaborative and participatory process. The project underscores the importance of integrating ecological restoration, community involvement, and strategic vision into a cohesive and adaptable framework. By leveraging the collective knowledge and aspirations of stakeholders, the project has laid the groundwork for a river park that will not only preserve the ecological health of the Mugnone creek but also enhance the social and cultural value of the surrounding territory. This collaborative approach to landscape management offers a promising model for future projects, particularly those focused on river systems and their communities, highlighting the crucial role of participatory governance in creating resilient and sustainable landscapes.

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Simulating Mangrove Biomimetic Landscapes For Coastal Defense in Capiz, Philippines

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Abstract

Mangroves play a key role in coastal defense. Despite this, mangrove forests are among the most threatened ecosystems globally. The Philippines is visited by an average of 20 typhoons annually, and yet almost 50 percent of our mangroves have degraded and need urgent rehabilitation. Faced with frequent storms and a retreating shoreline, the local community of Barangay Agojo in Capiz constructed a T-shaped bamboo fence on their coast. The bamboo fence attenuates waves and traps sediment, creating a secure base and shield for mangrove plantings. This study aims to remodel the Agojo Bamboo Fence based on mangrove biomimetic parameters and assess its resulting water wave percent velocity reduction. First, 36 permutations of varying bamboo diameter, height, and density were digitally modeled and subjected to computational fluid dynamics (CFD) simulation. Second, the optimal fence permutations were configured into different shapes and again subjected to CFD simulation. Lastly, the optimal fence shape configurations were CFD simulated with mangroves of different ages. The results of this study validated the Agojo Bamboo Fence Project and provided a promising approach to the simulation of bamboo fences for coastal defense and mangrove rehabilitation. With simulation data on optimal bamboo fences, the community of Barangay Agojo, Capiz can improve current practices, increase institutional support for mangrove rehabilitation projects, and encourage the adoption of bamboo fences in other coastal areas.

Keywords: Mangroves, coastal defense, biomimetics, bamboo fence, computational fluid dynamics

1. Introduction

Figure 1. Key maps of the Philippines (Left) and Capiz (Center); Barangay Agojo (Right) (GADM, 2018; Google Earth, 2022)

Agojo is a coastal barangay in the municipality of Panay, province of Capiz. Inherent to its location, Agojo is susceptible to coastal hazards, such as typhoons, storm surges, tsunamis, coastal erosion, and coastal flooding. In fact, in the aftermath of Super Typhoon Yolanda, 200 out of 200 houses in Barangay Agojo were reported to be totally damaged (UN OCHA, 2013). More recently in 2019, Barangay Agojo was also among those most badly hit by Typhoon Ursula (NVC Foundation, 2020). The Agojo Seawall, which was built to protect the coastal community, corroded within just five (5) years of construction and could no longer protect them (Figure 2). The local fisherfolk community of Agojo soon turned to more adaptable and ecosystem-based solutions in the form of mangrove rehabilitation, coupled with the construction of a T-shaped bamboo fence, or *T-Fence*, in 2022.

Figures 2. Barangay Agojo is highly exposed to strong winds, waves, and typhoons; The Agojo Seawall corroded within five (5) years of construction (Tagle, 2022)

The T- fence is a mangrove rehabilitation and coastal defense structure that provides physical protection to infrastructure near the shore and young mangroves planted behind it; and acts as a sediment trap by capturing fine particles carried by water currents, which over time builds up around the base of the T-Fence, reclaiming lost shore and creating a substrate for mangrove seedlings to take root and grow (Primavera & Loma, ZSL, 2018; Winterwerp et al., 2020; Albers, 2018; Albers, Dinh & Schmitt; 2013; von Lieberman GmbH, 2011).

This study investigated the computational fluid dynamics (CFD) of the Agojo T-Fence for design optimization.

Figures 3. The Agojo T-Fence (Tagle, 2022)

2. Material and Method

Maps of site conditions, on-ground primary data, and mangrove species properties from related literature were processed to obtain parameter values for digital modeling and simulation of the bamboo fences. A summary of parameters and values are as follows (Table 1):

Table 1. Fence parametrization parameters

Data Category	Data Type	Parameter	Values
Geographical (Google Earth, 2022; NAMRIA, 2015)	Topographic map	Shoreline distance	5m back of fence
	Bathymetry map	Wave break distance	10m front of fence
	Soil type map	Soil type	Sandy loam environment
		Depth in soil	1.5m below ground
Hydrological	Water bodies map	Water type	Saltwater environment
	Tidal Data	Average daily height	0.4-0.5m

(World Wave Data, 2022; Allen Coral Atlas, 2022; Meteorologix, 2023; CADS PAGASA, 2022; Project NOAH, 2022)	Storm surge susceptibility	Water wave velocity	10 m/s
Mangrove (Murray et al., 2022; Primavera et al., 2004; Bautista, Garciano,& Lopez, 2021; Reimann et al., 2023)	Mangrove extent	Forest density	10-25% (low) 25-50% (medium) <50% (high)
	Species inventory	Average Root height / Bamboo height	1.5, 2.0, 2.5m
Agojo, Capiz (BAFA, 2022; SIKAT Inc., 2021)	Fence design, Photographs	Average Diameter at Breast Height (DBH) / Bamboo Diameter	0.06, 0.07, 0.08m

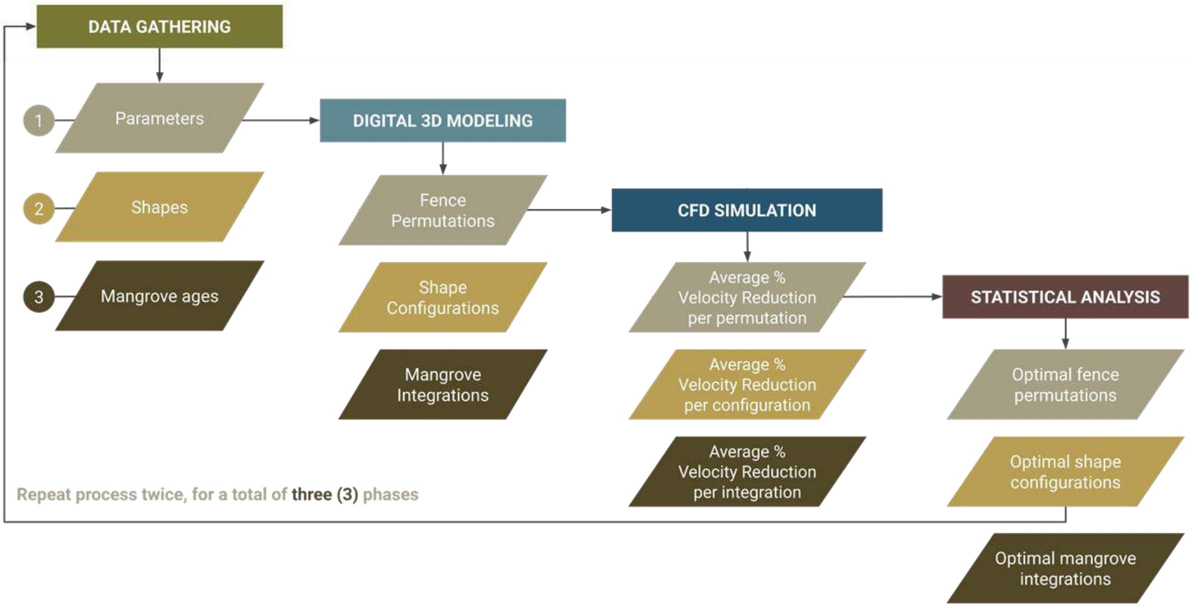


Figure 4. Simplified Methodological Framework for Simulating Mangrove Biomimetic Landscapes for Coastal Defense in Capiz, Philippines

Permutations (P) of varying bamboo diameter, height, and density were digitally modeled and subjected to computational fluid dynamics (CFD) simulation with the identified parameters set. The resulting optimal fence permutations were configured into different 3-segment shapes and again subjected to CFD simulation. Lastly, the resulting optimal fence shape configurations were CFD simulated for a final time with mangroves of different ages.

3. Findings and Discussion

Fence Unit Permutations (P). 36 fence unit permutations of varying bamboo diameter, height, and density were digitally modeled and subjected to CFD simulation (Figure 5). Table 2 shows the calculated rates of wave water velocity (m/s) as it passed through each fence unit permutation. Average percent (%) Velocity Reduction was calculated from maximum initial velocity to resulting minimum final velocity (Max to Min) and along 15-point data line (Point 0 to 15). Permutations P6 and P26 were identified as optimal permutations with average 100% Velocity Reduction.

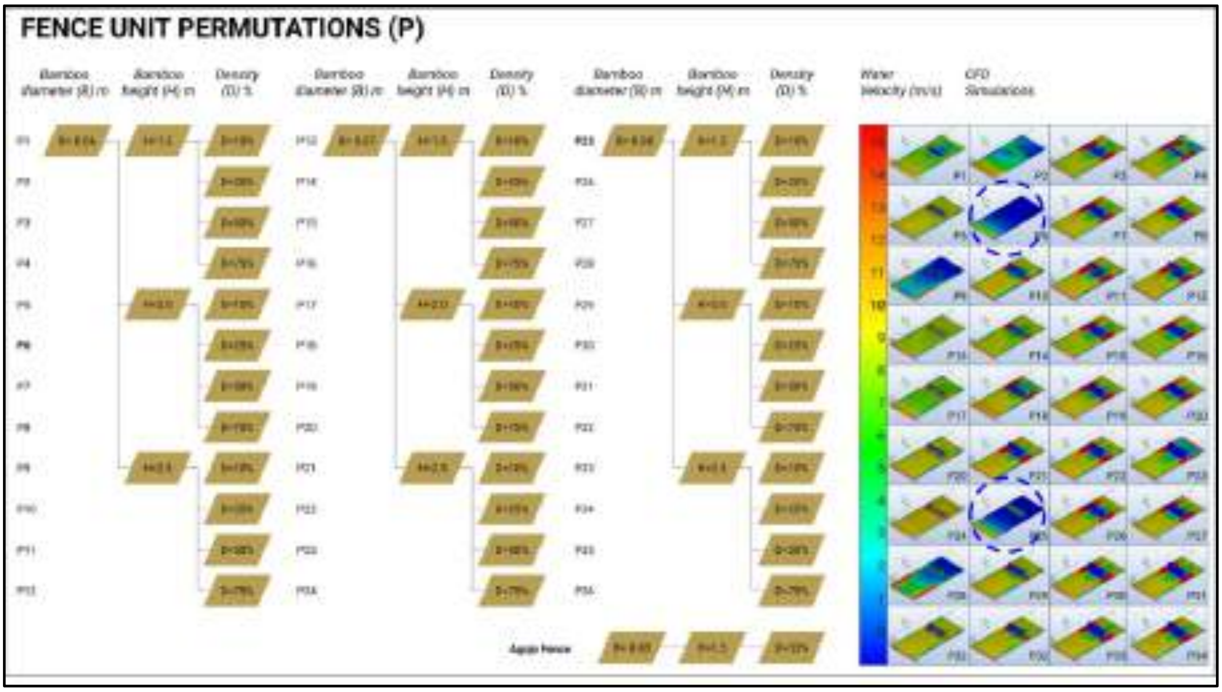


Figure 5. Fence Unit Permutations (P) and resulting CFD Simulations

Table 2. Optimal fence unit permutations

Permutation	Bamboo Diameter (B) m	Bamboo Height (H) m	Density (D)%	%Velocity Reduction		
				Max to Min	Point 0 to 15	Average
P6	0.06	2.0	D25	100 %	100 %	100 %
P26	0.08	1.5	D25	100 %	100 %	100 %
Agojo Fence	0.08	1.5	D33	100 %	15 %	57 %

Shape Configurations (C). P6 and P26 were then modeled into 3-segment shapes (Chipofya et al., 2015) and subjected again to CFD simulation (Figure 6). Table 3 shows the resulting %Velocity Reduction per shape. All configurations resulted in a 100% Velocity Reduction from maximum initial velocity to resulting minimum final velocity (Max to Min); however, simulations revealed acceleration of water past the fence unit.

Considering the % Velocity reduction along the 15-point data line (Point 0 to 15), T-shaped configurations C1 and C2 resulted in the highest average %Velocity Reduction and hence were considered to be the optimal shape configurations.

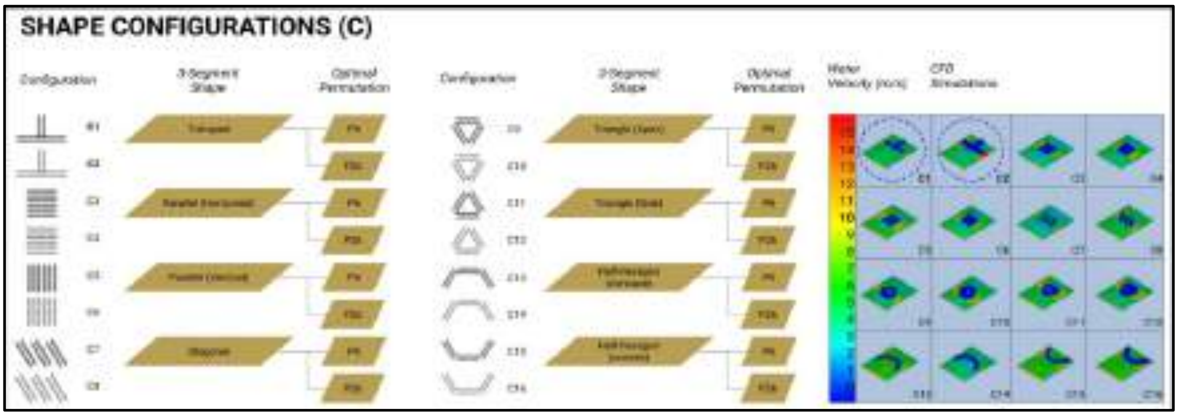


Figure 6. Shape configurations (C) and resulting CFD Simulations

Table 3. %Velocity reduction of simulated shape configurations

3-Segment Shape	Configuration	Fence Unit Permutation	%Velocity Reduction			
			Max to Min	Point 0 to 15	Average	Average per shape
T-shaped	**C1**	**P6**	100 %	86 %	93 %	88%
	C2	**P26**	100 %	65 %	83 %	
Half-hexagon (Concave)	**C10**	**P6**	100 %	39 %	69 %	67%
	C9	**P26**	100 %	31 %	66 %	
Triangle (Apex)	**C13**	**P6**	100 %	41 %	71 %	67%
	C14	**P26**	100 %	28 %	64 %	
Half-hexagon (Convex)	**C11**	**P6**	100 %	22 %	61 %	66%
	C12	**P26**	100 %	43 %	71 %	
Triangle (Side)	**C15**	**P6**	100 %	30 %	65 %	64%
	C16	**P26**	100 %	25 %	62 %	
Diagonal	**C7**	**P6**	100 %	26 %	63 %	62%
	C8	**P26**	100 %	22 %	61 %	
Parallel (Vertical)	**C5**	**P6**	100 %	23 %	61 %	59%
	C6	**P26**	100 %	14 %	57 %	
Parallel (Horizontal)	**C3**	**P6**	100 %	12 %	56 %	58%
	C4	**P26**	100 %	19 %	59 %	

Mangrove Integrations (M). For a final time, the T-shaped fences were modeled and simulated with mangroves of ages 0, 3, 5, and 10 years (Figure 7). The root height, tree height, diameter at breast width, and root spanning width were based on the parametrization studies of Mori et al. (2022). Average final velocities were calculated, showing a consistent decrease as mangroves matured over time.

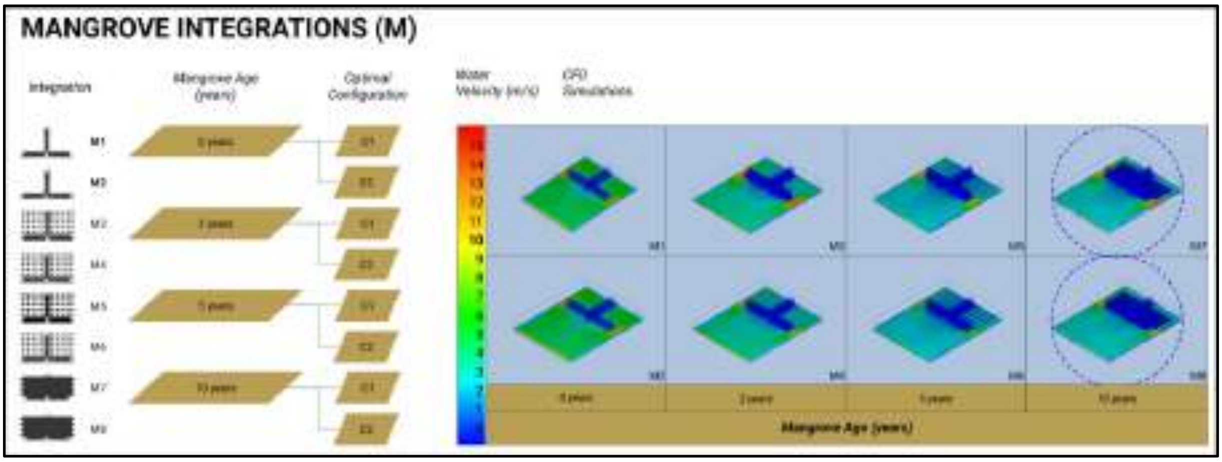


Figure 7. Mangrove Integrations (M) and resulting CFD Simulations

Table 4. Average final velocity of simulated mangrove integrations

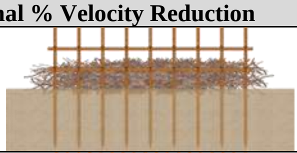
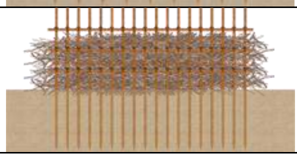
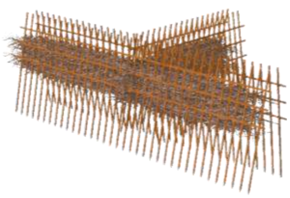
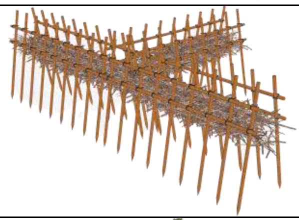
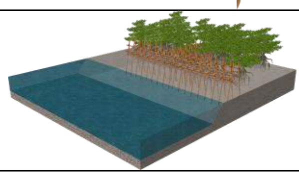
Mangrove Age (years)	Average Final Velocity (m/s)			
	Integration	**Shape Configuration C1**	**Integration**	**Shape Configuration C2**
0 years	**M1**	8.60 m/s	**M5**	8.16 m/s
3 years	**M2**	7.46 m/s	**M6**	7.06 m/s
5 years	**M3**	6.64 m/s	**M7**	6.94 m/s
10 years	**M4**	6.63 m/s	**M8**	6.58 m/s

4. Conclusion

This study systematically explored the optimization of bamboo fence designs for coastal defense, moving from defining parameters to simulating permutations, shape configurations, and ultimately, mangrove integrations. The results of each simulation phase are summarized in Table 5.

For Fence unit permutations, the identified optimal permutations are Permutation 6 (P6) and Permutation 26 (P26), with dimensions that closely resemble the design of the current Agojo T-Fence, validating the community's original approach. Moreover, the T-shape was identified as the optimal shape configuration. Water acceleration was observed past the fence; hence, mangroves of different ages were incorporated into the simulations and results demonstrated that wave velocity decreased as mangroves matured. The most reductions observed were from simulated 10-year-old mangroves, likely due to their extensive root systems and larger canopies.

Table 5. Optimal Mangrove biomimetic landscape parameters

Simulation Phase	Optimal % Velocity Reduction		Parameters
Fence unit permutation	**P6**		Bamboo diameter (B) = 0.06m Bamboo height (H) = 2.0m Percent density (D) = 25% (0.2m spacing)
	P26		Bamboo diameter (B) = 0.08m Bamboo height (H) =1.5m Percent density (D) = 25% (0.5m spacing)
Shape configuration	**C1**		Shape: T-shape Fence unit permutation: P6
	C2		Shape: T-shape Fence unit permutation: P26
Mangrove integration	**M4** **M8**		Age: 10 years

While the simulations provided valuable insights, it is essential to acknowledge the limitations of digital models, which are inherently simplified representations of reality. Factors such as sedimentation dynamics, local hydrology, and variations in storm intensity were not fully captured in this study. As technology advances and additional data becomes available, iterative modeling will continue to enhance the accuracy and applicability of such simulations. Nevertheless, this study had several significant implications in the recognition of local knowledge. The Agojo T-Fence's design and efficacy were validated, highlighting the value of community-driven, nature-based solutions. This study also provided a foundational framework for optimizing bamboo fence designs and integrating mangroves, offering adaptable strategies for other coastal areas facing similar challenges. Furthermore, the promising results can bolster institutional support for mangrove rehabilitation and encourage the broader adoption of bamboo fences as a sustainable coastal defense strategy.

In conclusion, the combined presence of T-Fences and maturing mangroves reduces wave velocity and contributes to enhancing coastal resilience. Although these findings are theoretical, they provide a robust starting point for further research and practical applications in coastal defense and ecosystem restoration.

Note

This study was initiated in 2022 as an undergraduate thesis for the Bachelor of Landscape Architecture program at the University of the Philippines Diliman, Philippines. Further studies, journal publication, and related project implementations are currently in progress.

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CULTIVATING RESILIENCE

A Review of Los Angeles Sustainability Plan for Sustainable Olympic Urbanism

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Abstract

This paper demonstrates City of Los Angeles Green New Deal (pLAn): Sustainable City plan's contextual alignment with sustainable urbanism (SU) design principles. The essay uses seminar in sustainable urbanism knowledge structure to understand the principles. Objectives are set to identify coherence and disparity between LA sustainable city plan and SU design principles, then put out critics and suggestions in the process of fulfilling SU principle requirement.

Keywords: Sustainability, Olympic, Los Angeles

1. Introduction

Drawing inspiration from Paris, we continue to see pLAn evolves and get implemented over these years with targets. This review studies possible urban design desciplines we can implement towards realizing the sustainability goal bearing the milestone 2028 Olympic Games which largely influence urban planning.

2. Material and Method

With every 4 years publishment of a new sustainability plan, City of Los Angeles keeps the public updated regarding the sustainability targets and programs across the city, to identify the implementation process down to scale, internet research, case study as well as related sustainability urbanism literatures was relied for this assessment.

3. Findings and Discussion

Four years after, pLAn was updated in 2019. The pLAn structured out from "EEE" tables but kept, extract and inserted topic areas, finally organized into 13 chapters concluded with "led by example". There was little evidence showing new chapter sequence's similarity between the former version (Figure 2), but chapters' phrasing were slightly modified. For instance, Urban Ecosystems & Resilience can be traced back from "Urban Ecosystem" 4 years ago and the emphasis can be clearly implied. Meanwhile, "Zero Emission Vehicles" and " Food Systems" are new chapters that could not find origins in earlier pLAn. Indicating a growing trend of vehicle transformation and food system issues.

Figure 1. Program Comparison with UNSDG (Jiang, 2022)

The pLAn also hardly showed logical change of scale as a city plan. A localized LA urban boundary is missing before setting up goals for its sustainable future. Hence, the prioritized layer of chapters can be brought out according to emergency significance of each chapter.

Figure 2. Localized Los Angeles Boundary (Jiang, 2022)

“Clean and healthy building“ and “zero emission vehicle” chapters scaled down to project scales to reduce carbon footprint. But the flaw of single focus on energy usage instead of considering their production, construction, operation and maintenance cycle is obvious.

From building perspective, the concrete life cycle rather than merely electric consumption can be further demonstrated. The zero emission cars’ manufacturing including structures, parts and battery life cycle may require a mature establishment to achieve circular buildings and circular vehicles.

The pLAn did not mention the change from urban built-environmental fabrics and change of life habits, expressing by goals and their corresponding actions of changing less raised the standpoint of urban planners and designers’ skill set as well as perception of fabric system changing.

	City & Region	District & Neighborhood	Block	Project & Parcel	Venue & Campus
Renewable Energy	Renewable Energy Plan; Energy Resource & Distribution Plan; Transit System Plan; Land Use Plan;	(Pedestrian and Transit friendly) Street System Plan; Energy Resource & Distribution Plan; Transit System Plan; Land Use Plan (Code, Density); Infill Development Plan	Pedestrian and Transit friendly Street; Parking Plan; Utility Plan	Parking Plan (EV charging stations); Pedestrian and Transit friendly Streetscape Design; Pedestrian and Transit friendly Streetscape	Parking Plan (EV charging stations); Pedestrian and Transit friendly Space; High Performance Venue; Energy Usage Plan
Local Water	Water Recycle Plan; Compact Development; Water resource and Preservation Plan	Robust Stormwater Networks; Green Open Space Plan; Green Infrastructure Plan; Permeable Surface Plan	Green Infrastructure Plan; Permeable Surface Plan; Drainage Plan	Green Infrastructure Plan; Stormwater Facility; Planting Plan; Drainage Plan;	Green Infrastructure Plan; Stormwater Facility; Planting Plan; Campus Permeable Surface Plan; Drainage Plan;

	City & Region	District & Neighborhood	Block	Project & Parcel	Venue & Campus
Mobility & Public Transit	Transit System Plan; Street System Hierarchy; Slow Traffic Plan; Transit Oriented Street Design Guideline	Transit System Plan; Land Use Plan (Code, Density); Slow Traffic Plan; Transit Oriented Street Design Guideline; Safe and Complete Streets	Transit and Pedestrian Friendly Streetscape Design; Safe and Complete Streets; Street Interactive Building Design	Transit and Pedestrian Streetscape; Street Interactive Building	Venue Oriented Development; Transit and Pedestrian Friendly Campus
Environmental Justice	Point Source Pollution Plan; Tree Canopy Plan; Heat Plan; Vegetation Coverage; [illegible] Open Space Plan; Amenity Plan	[illegible]; Point Source Pollution Plan; Tree Canopy Plan; Open Space Plan; Amenity Plan; Mixed Housing Typologies; Streetscape Design	Tree Canopy Plan; Amenity Plan; Mixed Housing Typologies; Streetscape Design	Tree Canopy Plan; Infill and Mix-use Development; Streetscape Design	Open Space and Tree Canopy Plan; Mix-use Development; Transit and Pedestrian Friendly Streetscape Design
[illegible]	Point Source Pollution Plan; Balanced Planting Coverage	Point Source Pollution Plan; Tree Canopy Plan; Balanced Planting Coverage	Tree Canopy Study; Planting; Pollution Study	Tree Canopy Study; Planting Plan; AQ Plan	Tree Canopy Study; Planting Plan; AQ Plan; Utility Plan
[illegible]	Robust Ecosystem Networks; Urban Development Boundary; Dark Sky Plan; Noise Plan	Robust Ecosystem Networks; Storm Water System Networks; Urban Development Boundary; Dark Sky Plan	Permeable Surfaces; Tree Canopy Plan; Planting Plan;	Native Planting Plan; Wildlife Corridors; Lighting Plan	Native Planting Plan; Wildlife Corridors; Lighting Plan

Figure 3. Change of Scale: Sustainability Plan to sustainable Urbanism Design Practice (Jiang, 2024)

In realization of sustainable Olympic urbanism, change of scale down to: Transit System Plan;

Land Use Plan (Code, Density); sharing Pedestrian and Transit friendly Street; Shared Parking Plan; Green Open Space Plan; Green Infrastructure Plan; Planting Plan, Point Source Pollution Plan; Tree Canopy Plan, Transit Oriented Street Design Guideline, Venue Oriented Development, Transit and Pedestrian Friendly Campus etc. Invisible education investment will need to be included in the process.

For Olympic venue planning, establish "infrastructure oriented" development, improve and synthesize functionally and spatially for all ages:

Transit Infrastructure: Stations, Terminals, Ports, Vehicle

Sports Infrastructure: Stadiums, Arenas, Fields, Studios, Trails

Healthcare Infrastructure: Hospitals, Clinics, Studios, Parks

Education Infrastructure: Schools, Universities, Institutions

Recreation Infrastructure: Parks, Wetlands, Rivers, Theatres, Shopping Centers, Markets

Cultural Infrastructure: Heritages, Landmarks, Legacy

4. Conclusion

Los Angeles pLAn is overall a well organized and explicit system target framework, but the major intention is still on the way of achieving sustainable development targets rather than setting sustainable urbanism to be the ultimate destination.

It integrates well with 17 UNSDGs in each of localized chapter, showing the responsibility of climate leader and city actions. In achieving the urbanism practice, the pLAn still calls for additional actions such as organizing the chapters with scale and hierarchy, bearing an urban boundary concept such as capacity in mind and designing systems with circular strategies and coordinate with each systems to realize active balance.

Since targeting the 2028 Olympics and further, a sustainable Olympic urbanism implementation plan regarding all scales of action is being necessary.

Emphasis on collaborative responsibility is valued at all times.

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Coastal Rescue-Vision for coastal city community development for New Orleans, USA and Bangkok, Thailand

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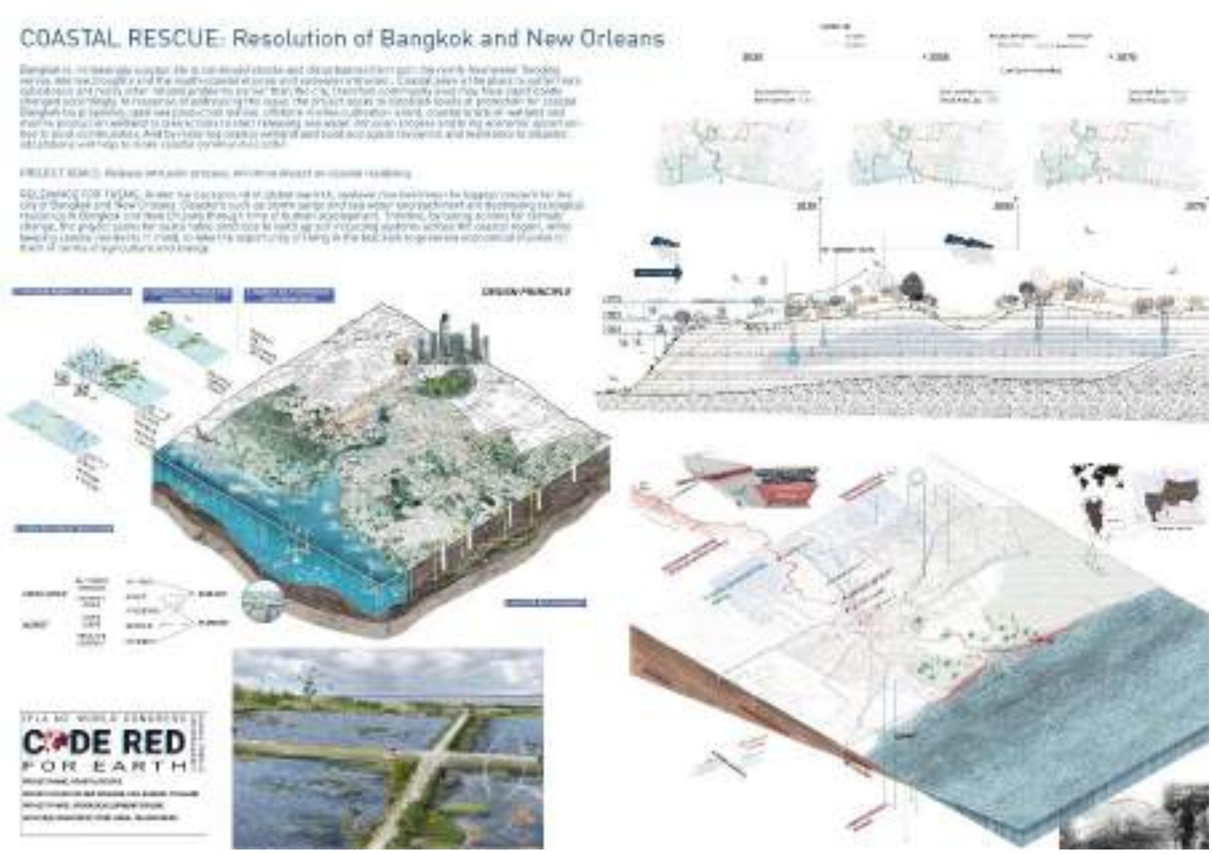

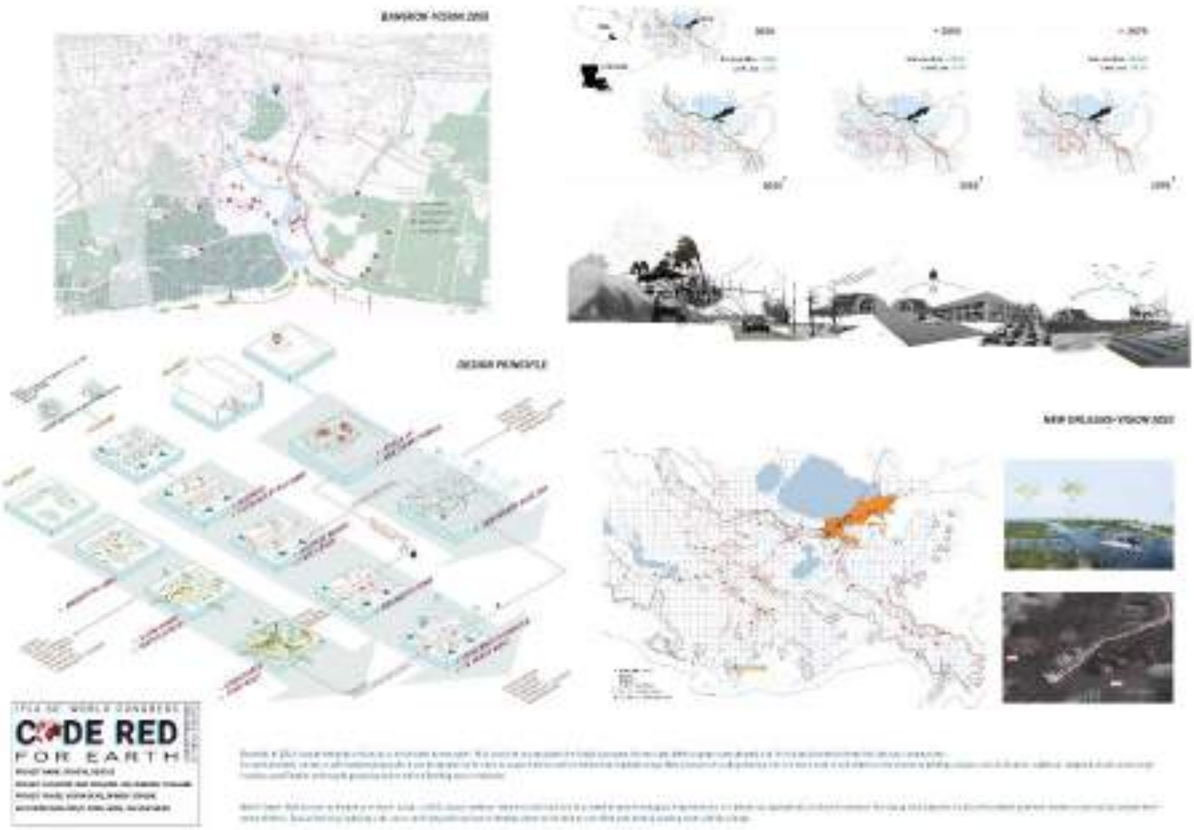
CODE RED
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Desakota and the Possibility for a Wet Electricscape

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Abstract

Looking at recent prospects of development, some scholars expect that desakota will represent large shares of future world urbanization. Born out from research about large urban regions in Asia, this seems to be a modality of urbanization based on the compresence of 'in-situ urbanization' and persistent wet agriculture. Although highly debated, it actually portrays a landscape where urban and rural land uses mix together. Such a condition defies Western interpretative models. Indeed, it not only hosts advanced socio-economical communities but also frames an interplay of human and natural dynamics much more flexible than in normal urban areas or Western suburbs. It is produced by the overlap of centenary landscaping for wet agriculture, modern colonial infrastructure, and late but sudden urbanization dynamics animated by disruptive mobilities. Anyway, first and foremost, it generates a unique landscape, i.e., a spatial heritage defined by a fine-grained and decentralized matrix of social, technical, and natural networks.

This landscape has entangled spatial qualities, although the local administrations hardly see them. In their eyes, the recent tendencies of urban primacy, the trust in Western planning models, and the governance challenges posed by the need for restructuring infrastructure and energy systems today -often dealt with blind faith in the liberalization of the public utility market- make them a developmental constraint. Holding no disciplinary habit for projective studies, the research and planning disregard such qualities and their potential. Finally, critical and non-interdisciplinary approaches are somehow preferred in the debate. These are often despatialized or do not consider multiple sites or structures in terms of their potential interdependence.

Against this, the paper adopts a projective approach to showcase how the progressive miniaturization of the hydropower technologies let imagine that Asian mixed urban-rural land use areas might offer conditions for the public sector to develop a diffused initiative of distributed generation by hydropower. By this, the compresence of urban-rural infrastructure and urban-rural land uses may well find reasons to be strengthened rather than obliterated and the local spatial qualities change their institutional understanding in light of decarbonization.

Keywords: Desakota, miniaturized-hydropower, distributed generation, resilient landscape urbanism.

1. Introduction

Looking at world prospects by the United Nations (UN DESA, 2024), Asian urbanization is central in light of the sheer quantities at stake. Also, it is because considerable shares of the population have been lifted out of low living standards, but many countries have failed to take on a sustainable development pathway (Ponzi, 2019). Today, whether we consider or not the critical debates emphasizing the need for a shift out from neoliberal development models, there is general agreement that the challenges of Asia are wide open. Indeed, not only are the sustainable pathways hard to set in place when the development has already taken momentum (Berkhout et al., 2009), but also what is Asian urbanization is yet to be adequately understood (McGee, 2013; Cairns, 2016).

A critical aspect is the compresence of urban and rural populations (UN DESA, 2018). This is such that it questions fundamental notions of planning, i.e., the 'urban' and 'rural,' precisely. Born out of specific conditions of Western development, it has been a while since these two seem incapable of representing the happenings (Brenner, 2013). So, if by 2030, half of the world's population might reside in mid-size settlements with both urban and rural characters (Cairns, 2016), we might say there is very little knowledge to handle the future of humanity.

A few decades ago, a notion was drafted in a pioneering attempt to overcome the *impasse*, i.e., the *desakota*, named by blending two Indonesian terms (McGee, 1991). While this remains a topic of debate, it was developed to describe a unique pattern of urbanization that has come to characterize a large share of the inhabited areas in Asia (Cairns, 2016). Currently, *desakota* is understood as the byproduct of *in-situ* urbanization (Johnson & Woon, 1997) that took place amidst highly productive wet agriculture areas managed by smallholders and featuring highly sophisticated hydrologic networks (McGee, 1991; Cairns, 2016). In this context, during the last quarter of the 20th century, the sudden availability of disruptive mobility -e.g., two-stroke motorbikes- (McGee, 1991) and the presence of vast infrastructure networks -i.e., those left by the modern colonizers of Asia- (Dick & Rimmer, 1998) have helped a very large number of small to medium enterprises (Wang, 1997) to engage in the growing dynamics of the local urban agglomerations (Ginsburg et al., 1991).

The distinctiveness of *desakota* can be identified through the urban form, too, given that this refers to the spatial configuration of land use in the inhabited areas (Anderson, 1996). Indeed, *desakota* can be described as an extensive patchwork of small land plots with a wide range of uses -e.g., including agriculture, various factories, shopping centers, retail parks, leisure areas, housing- (Cairns 2008) and population densities higher than those of suburban North America (Qadeer 2000). Moreover, if the informal nature of *desakota* hinders regulatory restructuring (Cairns, 2002; 2008), the characteristic *mixité* is often created and maintained in opposition to conventional planning models. In some cases, it may even be strengthened by infrastructure development, as illustrated by recent pathways of rural electrification in China (Bhattacharyya & Ohiare, 2012; Bie & Lin, 2015).

Figure 1. Human-eye-level and aerial view of *desakota* in Taiwan island (right, in Taoyuan county, by the author, and left, in Yilan county, by Ming-Ming Chen).

That said, in addition to the magnitude of the phenomenon and the developmental persistence, the multi-layered history of *desakota* provides it with another dimension of relevance. Indeed, in the most direct experience, *desakota* presents itself as a distinct landscape characterized by a decentralized system of social, technical, and natural networks, where the interaction of the human and natural dynamics is way more flexible than in any urban center or Western suburb. This can be said regardless of whether *desakota* is listed among those landscapes that deserve recognition according to Western standards (see Figure 1). Not by chance, in some countries, its occurrence has been associated with developing social and political narratives of relaxation from strict planning, capitalist anxieties, as well as the rigid customs of traditional agricultural societies, and, as such, it has contributed to the development of the local identities (Martinelli, 2020; 2024).

Despite all this evidence, the debate still revolves around whether *desakota* is a distinct reality or, more precisely, whether it is an *interim* occurrence -destined to align with what happened in the West, finally- or not, thus deserving dedicated planning (McGee, 2005; Denis, 2015).

However, some scholars have resorted to arguing how *desakota* brings to mind those utopian proposals for decentralized agrarian urbanism that were drafted around the mid-20th century as alternatives to the urban sprawl of the West (Cairns, 2016). By this, they have inaugurated an alternative approach to the debate. This, that we can define a projective approach, suggests that if the *desakota* is properly steered, it may offer room for sustainable development and, by this, new disciplinary consensus could arise. Indeed, the possibility of extracting sustainability out of it may well offer developmental advantages clear enough to finally tip the debate into acknowledging the distinctiveness of Asian urbanization, urban forms, and landscapes.

We subscribe to this approach and we believe it is therefore crucial to investigate the potential embedded in the *desakota*, instead of land development pathways only. Although it may seem like a biased move, we believe this approach is way more viable than denying the peculiarities of Asian urban-rural areas or taking on the unrealistic task of predicting the ultimate outcomes of urbanization before implementing any action.

In particular, we believe that, if the key characteristic of *desakota* resides in decentralization and its connatural flexibility (Cairns, 2016), the emergence of decentralized energy concepts helps to bring its potential to light. As a matter of fact, decentralization has taken momentum in the energy sector since the transition to renewables and the total electrification encouraged a shift towards distributed generation -or, at least, a rising interest of the energy leaders (IEA, 2018; WEC, 2019). That said, miniaturized hydropower is not only among the key developing technologies at the nexus of renewables and distributed generation, but is also highly pertinent to the way in which the water streams define *desakota* and its socio-economic systems (Opitz-Stapleton et al., 2008). Moreover, if we look at the development of miniaturized hydropower *per se*, the generators are increasingly affordable, easy to install, able of high energy intensity -up to make profitable the dispatching by the grid- and to tap into feeble energy sources -up to yield from as little as 0.7 m high water drops (Rahman et al., 2017)- thus they are increasingly adequate for the *desakota*. That is, the key condition for installing generators is now reducing to the presence of water streams, which the *desakota* is rich in. Also, given that we expect to be increasingly reliant on feeble energy sources, the distribution challenges will become more pronounced. However, this is precisely where the decentralization of the *desakota* emerges as a potential worth exploring.

2. Scope and Objective

In light of the above, the paper will present the outcomes of research on the Taipei-Kaohsiung MUR - Mega Urban Region, which is understood as a relevant case study for the debate. A MUR is an interconnected and economically integrated system of settlements spanning over a vast territory. Usually, it hosts 10 million inhabitants or more in ways conducive to integrated economic, political, and cultural developments (McGee, 1995). Typical of Asian urbanization after World War II, it is a type of urban agglomeration in which *desakota* was first identified alongside four other more conventional urban forms, i.e., the urban centers, the suburbs, the densely populated rural areas, and the sparsely populated rural frontiers. Here, *desakota* was distinctive since out of reach for daily commuting practices in and out of the urban centers but sprawling alongside arterials, that is what first suggested understanding it as an autonomous urban form (Lin, 2001). Within the case study, which occupies quite the entirety of Taiwan island inhabited land, *desakota* has been recorded since the very first research on the topic by Terry McGee (McGee, 1991) and, since then, it has been variously investigated (Shih, 1999; Wu, 2009; Shih & Chi, 2012; Wu & Sui, 2015).

In particular, the paper will present comparative assessment of *desakota* and the urban centers of the case study. This will be done with respect to the spatial organization of water streams, power grid, and population. Indeed, if the spatial organization of water streams is correlated to the presence of generation opportunities, that of the grid to the ease of energy distribution, and the one of population to the spatial distribution of the energy demands, their interplay is key to defining the feasibility of any decentralized hydropower-based energy system. This is because the implementation of miniaturized hydropower generators is sensitive *per se* to grid connection costs (Forouzbakhsh et al., 2007) and the spatial incoherence of generation sites and end-users can devalue distributed generation in light of the transmission losses (Ichikawa et al., 2002).

Through an integrated assessment, the paper will therefore discuss whether *desakota* offers a developmental advantage in terms of implementing a decentralized hydropower-based energy system, here understood as a relevant contribution to achieving sustainable development.

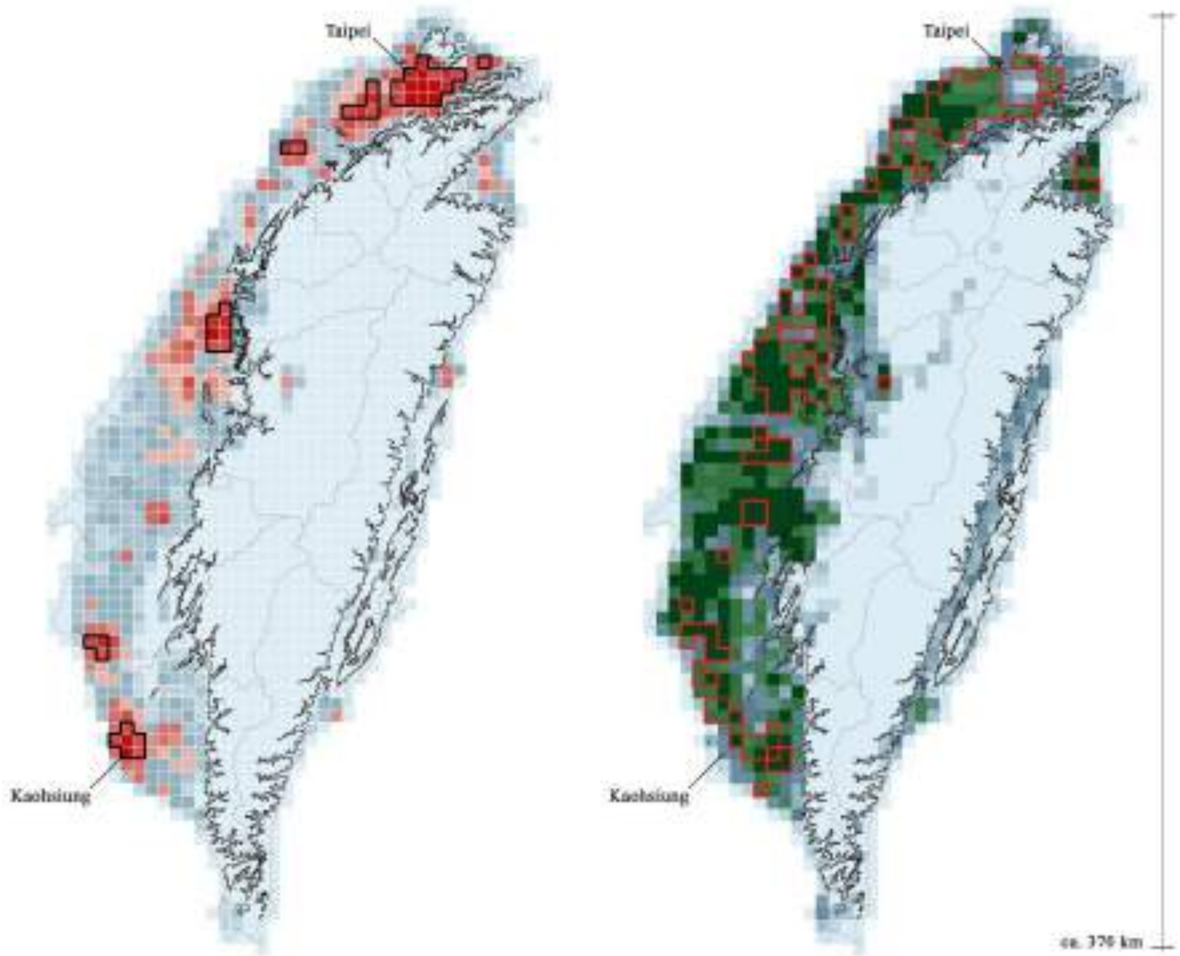

Figure 2. On the left side, the population density of Taiwan island displayed through a 5x5 km grid, where more intense colors represent higher values. On the right, the urban density similarly represented. The black boundaries define the urban center areas, while the red boundaries indicate the *desakota one*s. The darker contour represents the +350m level, helping to illustrate the relationship between inhabited land and geography, and the thin lines finally indicate the administrative subdivisions through which the territory is structured.

3. Structure of the Research Paper

The paper will first present the investigation, detailing the materials and methods used, i.e., a set of geospatial data obtained from various public databases, later analyzed using geographic information systems techniques. Then, it will presents the outcomes, including a definition of urban forms within the case study and a comparison of the spatial organization of hydrologic and electric networks. Finally, it will concludes with concise discussion of such outcomes

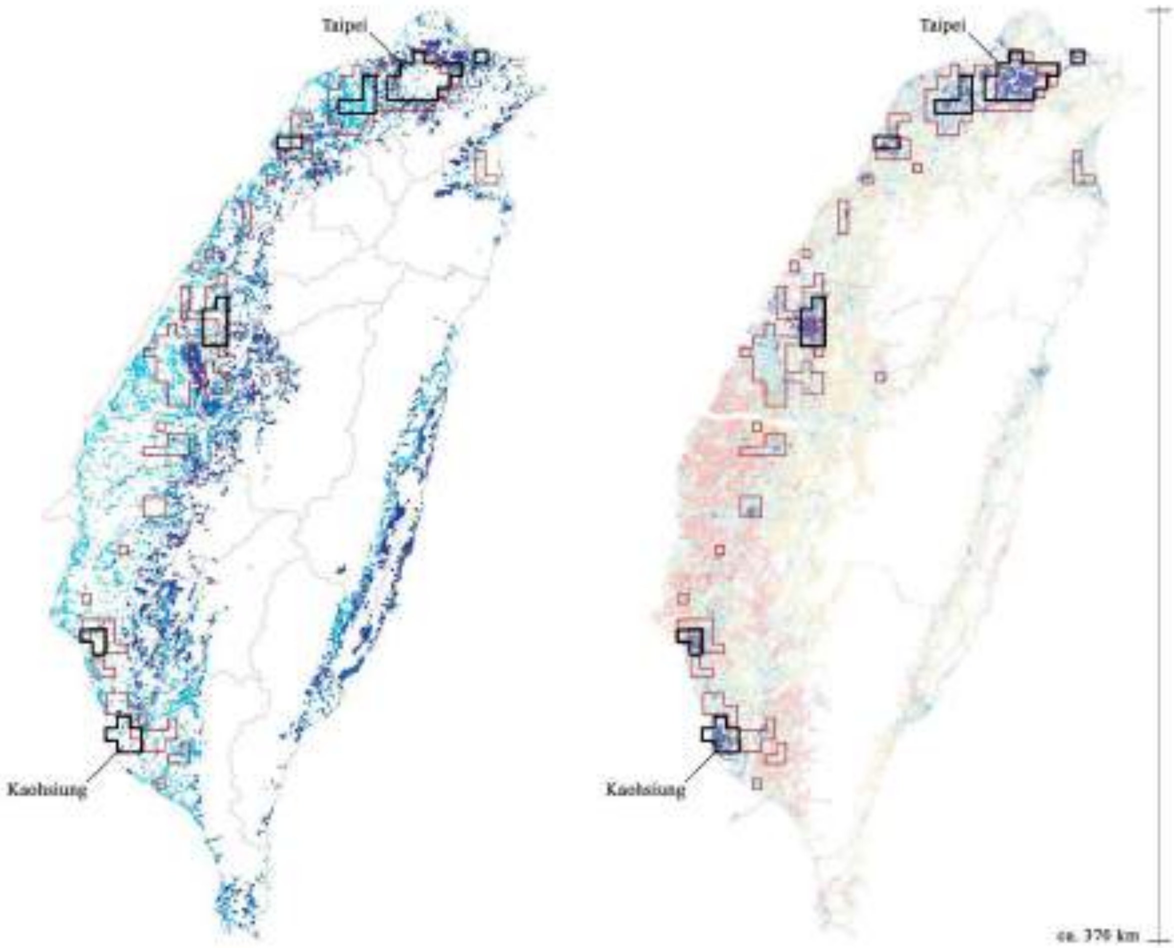

Figure 3. On the left side, the car accessible <u>water drops</u> on public land, represented by light or dark blue spots indicating heights of more or less than 5m. On the right, the <u>power grid</u> displayed with color intensity ranging from red to blue, which corresponds to grid capacities from 0 to 10 MW. Urban areas are marked with thick black lines, *desakota* ones by red lines.

4. Material and Method

The research was conducted throughout the entire island of Taiwan to provide context for the case study. After gathering the data, the analysis included a spatial assessment of land use in both urban and rural areas, as well as an examination of the population density. This approach enabled the identification of various urban forms. Then, the research involved measuring the water streams -encompassing natural waterways, regulated streams, and constructed channels- and the water drops as indicators of opportunities for generation in consideration of the trends in technological innovation. Finally, the spatialization of power grid coverage and capacities were investigated to determine the ease of connection.

Specific data sources included topographic data from 2016, obtained from the National Land Surveying and Mapping Center, Ministry of the Interior, census data from 2018, acquired from the Directorate General of Budget, Accounting and Statistics, the Executive Cabinet, land use data from 2017, sourced from the Center for Land Use Investigation, Ministry of the Interior, water stream data from 2020, provided by the Water Resources Agency, Ministry of Economic Affairs, and then power grid data from 2019, provided by Taiwan Power Company. These data were retrieved in geospatial format and structured into a coherent database.

To develop such a database, the whole island was divided into cells through a 5x5 km square grid aligned with the boundaries of the National Topographic Survey grid. This facilitated the spatialized storage and representation of the data on a map that was both legible at the level of the whole island and informative of the urban scale, as defined by the center of Taipei -the main city- that is effectively framed by a 5 km distance.

The area of the urban centers was then defined according to the spatial distribution of the cells compliant with the "urban sustainability" of the 15-min-city concept, i.e., the density of 5,000 pp/sqkm (Moreno et al. 2021); that of *desakota* areas, by the cells compliant with a population density higher than the suburban threshold of 1,000 pp/sqkm (Qadeer, 2000) and a restrictive interpretation of the *desakota* standards set by the literature at the range from 22 to 58% of the urban density (Heikkila et al., 2003; Wu & Sui, 2015), i.e., the share of urban over rural land use within a certain area. In particular, since the detailed spatiality of *desakota* was of major interest for the research, this last condition was turned into the compliance with a minimum 70% chance that any plot of a cell was within 200 m from an urban and a rural land use (Figure 2).

Next, hydrologic network data was compared with the water surface category of land use data to maintain consistency with earlier assessments. Any incongruences were manually corrected. Once these corrections were made, the length of water streams within each cell was analyzed and, by comparison with the topographic and land use data, accompanied by an accounting of the car accessible water drops on public land. Lastly, the power grid data had to be interpreted since available as a raster dataset, each pixel measuring 33x33 meters. Here, the power grid was represented by lines approximately 100 meters wide, sort of a 50-meter range area from the power lines, which was interpreted as a space characterized by some ease of connection. Notably, the data included information about the capacity of each segment of the power grid. So, within each cell, the areas within range were calculated as a share of the total area of the cell and the capacity expressed as a share of the areas within range (Figure 3).

Table 1. Summary of the outcomes of research, with higher values emphasized in bold.

	The data on the right refers to the avg. value in related cells.		**Car accessible water drops on public land** (occurences where the road is within 5m from the drop)			**Water streams** (lenght of stream axis)	**Grid coverage** (area 50m within grid)	**Grid capacities** (avg. % of grid)		
	pop. (M)	area (sqkm)	avg. drop x sqkm	2-5m drops	>5m drops	avg. km x sqkm	avg. % cov. x sqkm	0-2 MW	5 MW	10 MW
Whole territory	23.57	39,850	1.2	0.4	0.9	0.96	21	**54.7**	31.1	14.2
Centers > 5,000 pp/sqkm	4.88	975	1.8	**1.2**	0.6	1.13	**69**	4.3	29.3	**66.4**
Desakota > 1,000 pp/sqkm	9.84	3,125	**2.8**	0.6	**2.2**	**1.92**	62	22.2	**52.4**	25.4

5. Findings

A first interpretation of the research outcomes suggests that, if *desakota* areas represents 7,8% of Taiwan island territory, or 29,4% of the inhabited land, it hosts 9.84 million people. That is, 42% of the total population lives within, or 201% of the population of the urban centers. So, *desakota* is confirmed to be a quantitatively relevant urban form within the case study. Also, it is mostly located within 7 km from the highway system, but partly displaced from larger power plants (see Figure 4). This hints to the connectedness of the MUR and the pressures that the power grid may withstand.

Main research outcomes are then indicated in Table 1. If the total territory scores an average of 0.96 km per sqkm of water streams, the urban areas score better, but *desakota* doubles the value. This is reflected in the number of water drops. Also, these are markedly higher in the desakota, and thus potentially capable of generating higher energy intensity. That said, it is anyhow worth mentioning the number of small water drops in urban areas, that suggests the presence of opportunities of lower energy intensity. Possibly, these may be an effect of the interplay between pre-existing topography and the developmental demand for flat land, that may have brought a disjunction of levels as a result of larger works of rectification. At the same time, the relative absence of smaller water drops in the *desakota* gives evidence to the peculiarity of the local topography that the overdiffuse system of wet agriculture is based on in concomitance with the monsoon climate.

Then, if we look to the grid coverage, it is striking the similarity of the average value in urban centers and *desakota* areas, i.e. 69 and 62%, that offers clear evidence not only to the ease of connection but also to how *desakota* is accompanied by an over-extensive development of the electric infrastructure, often built at historic times. In the case study, for example, 99.7% of the communities were connected to the power grid before the 70s (Ho, 1975), a time when the population was even more evenly distributed across the territory than today. That said, even though it is understandable the presence of grid capacity at higher wattage in urban centers, it is striking the capacity at medium wattage in the *desakota* areas, especially if we ponder the relatively low density of population and thus end-users. This suggest not only the urgent need for rethinking the power grid in the *desakota*, but also let imagine the possibility for a prompt transition towards distributed generation without the need to develop a burdensome extension of the power grid.

In conclusion, the diffuse presence of opportunities for generation and a medium wattage grid coalesce into indicating a developmental advantage of the *desakota* against the urban centers in terms of implementing a decentralized hydropower-based energy system. Not only but also, this advantage has to be valued with respect to the large share of population currently residing in the *desakota* as well as the extraordinary amount of power grid heritage lying within and putting forward a question concerning the meaning and the maintenance of such infrastructure.

6. Conclusion

The research presented in the paper cannot be understood as a comprehensive study, either the attempt at setting out a pathway for sustainable development within the case study. This is out of reach. Also, it is unreasonable to imagine a single solution to the problem of sustainability. What the research aims to do, instead, is showcasing a set of peculiarities of a case study that is representative of Asian urbanization. In particular, it aims to do this through a point of view that embodies a projective approach, so that the case study may be seen not only in the current state but also in relation to the potential development that it could undergo.

This way, established interpretative frameworks are questioned since neglecting the actuality of Asian urbanization to focus on urban centers that are not only less relevant in terms of the population but also hold conditions and potential different from those of the commonest urban form instead. It is not a discovery that interpretative frameworks are constructs of social kind and, as such, they result from practices and debates that might have little or no relation with the peculiarities of a place. Anyhow, this is especially true of Asia, that has been subjected to various forms of colonialism, cultural ones included.

The paper, thus, offers evidence to disturb the current disciplinary culture and its narratives, that disacknowledge Asian urbanization and might thus undermine a sustainable development pathway for the same. To understand the relevance of the problem, it is enough to contrast the organization of urban and *desakota* areas within the Taipei-Kaohsiung MUR (Figure 4).

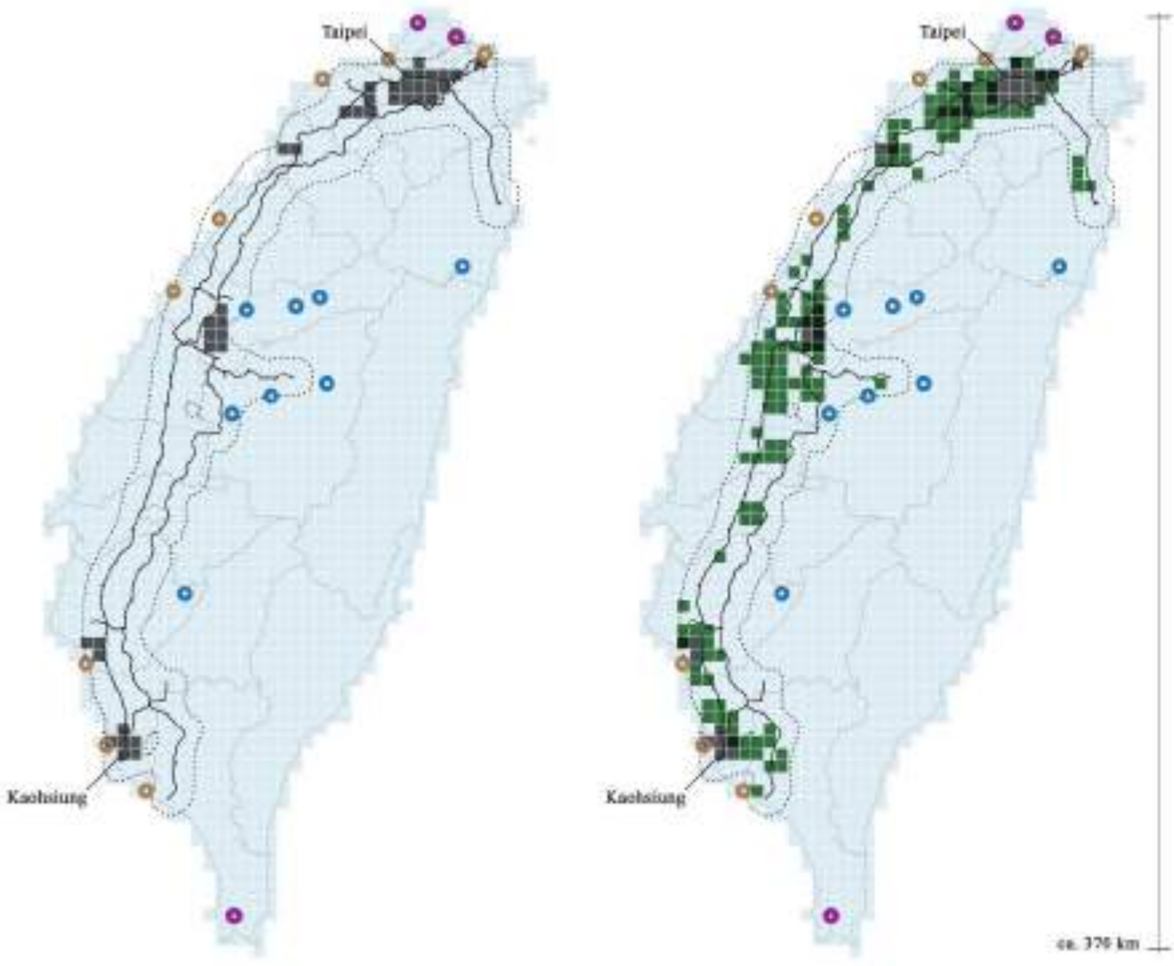

Figure 4. Urban center areas, on the left side, and urban center with *desakota* areas, on the right side, contrasted with the whole territory, the highway system (with 7 km distance range), and the location of larger power plants, by empty dots, the color of which indicates different power sources. This representation provides an intuitive understanding of the implications of planning measures that favor either urban areas or urban areas in conjunction with *desakota*.

Suppose we neglect the *desakota* -regardless of the quantitative relevance and potential- and indiscriminately support a certain primacy of urban centers in light of the supposed advantage in sustainability versus diffused settlements -as encapsulated by Western concepts such as the 15-min-city, here used as a reference of assessment; within the context of the case study, this might well bring high-intensity power demand issues, power distribution issues, abandonment of infrastructure, abandonment of agriculture, alienation from nature, and so on, i.e., several issues that the *desakota*, with its overabundance of networks and messy *mixité,* might well be able to keep at bay.

So, in conclusion, the research outcomes intend to be a reminder that, especially in light of the current demands for sustainability, the debate should stop questioning the reality of *desakota* and the Asian mixed urban-rural land use areas, more in general. Instead, it should address as soon as possible their peculiarities and possible performances, since they are urban forms and landscapes that shape the present and imminent future of large shares of the world population.

Note

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Japanese traditional dike "Waju" with multiple and multifaceted-uses in Nobi-Plain

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Abstract

This study aims to clarify the composition and spatial features of high-foundation houses and shrines on dikes in the flood-prone Nobi-Plain, Japan. Through the field survey, interview survey, and mapping analysis by using aerial photographs and historical documents, houses on high foundations of the dike crest are observed as a feature. The materials of the foundation wall can be classified to five types as a result. The walls on the dike road are more often composed of piled stone. In addition, the study highlights a series of bamboo forests of the settlements on outer dike slopes. Historical maps show continuous planting, with some areas retaining this feature today. Field surveys reveal diverse adaptations in the design of high-foundation houses, including varied foundation materials and the strategic use of dike slopes. Bamboo forests on outer slopes further demonstrate how steep terrain and ownership influence land use, reflecting the ingenuity embedded in traditional flood resilience and settlement practices.

Keywords: Dike design, dike house, flood control, GIS analysis, multifunction

1. Introduction

The Nobi Plain in central Japan is a flood-prone area where representative rivers in Japan are concentrated in one region. Since early modern times, the area has constructed dikes that surrounded settlements and farmland, known as “Waju”. It can be seen that some residents have built their houses and Mizuya (flood-resistant warehouses) that are placed on higher foundations inside the dike, those who could not have afforded it created communal evacuation spaces on the dike and a natural levee (Ando, 1975). Some of the settlements on the dike have enclosed forests surrounding the houses, which offer a function as a windbreak (Ōgaki City, 2008).

While studies have focused studies on Mizuya (Mizutani & Oodake, 1995), the spatial composition of enclosing forests and settlement relationships in the Nobi Plain (Otsubo & Ono, 2019), the communities within “Waju” (Ando, 1988), and the relationship between the height of Mizuyas, elevated houses, and Waju dikes (Nakajima, Tanaka, & Akiyama., 2005), there has been few researches on the spatial design of the dikes themselves. Furthermore, previous research (Nakazawa, 1970) indicated that the top of the dike was more exposed to adjoining outer river currents, making it vulnerable to river flow impact. This study analyzes residential locations on the Waju old dike to clarify these spatial patterns.

Figure 1. Elevated shrine on the Waju old dike serving as an evacuation site

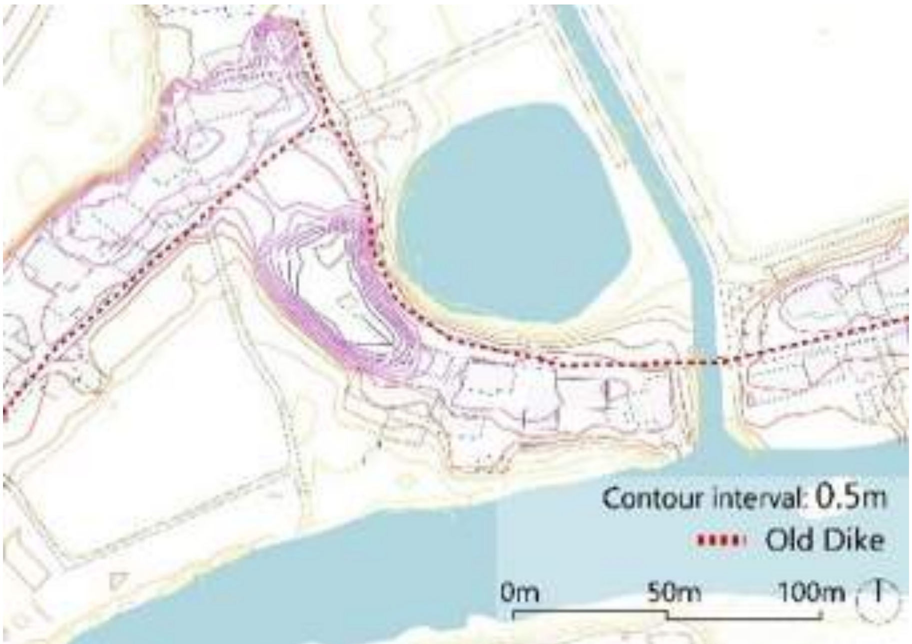

Figure 2. Topographic map around the shrine.
Data source: Geospatial Information Authority of Japan, Basic Map Information (2024).

2. Material and Method

In this research, we identified the old dike using historical maps from Konjaku Map (Tani, 1891–1898), generated the specific GIS data sets for analysis, and compared with aerial photographs from GSI (1961-2009) and Google Maps (2024) to observe changes over time. To identify the old dike, we overlaid the method of using topographical maps for collecting elevated landforms with the historical map analysis approach referenced in previous studies (Okada & Nakamura, 2018).

Spatial features were also measured through field surveys and the current topographical maps. The existing old dike and areas elevated 2 meters higher than the dike road, considered high foundations, were plotted on the GIS datasets. For this study, we define a dike as a continuous dike, referring to the flood control facility designated in the Landform Classification Map for Flood Control (Geospatial Information Authority of Japan, 2024).

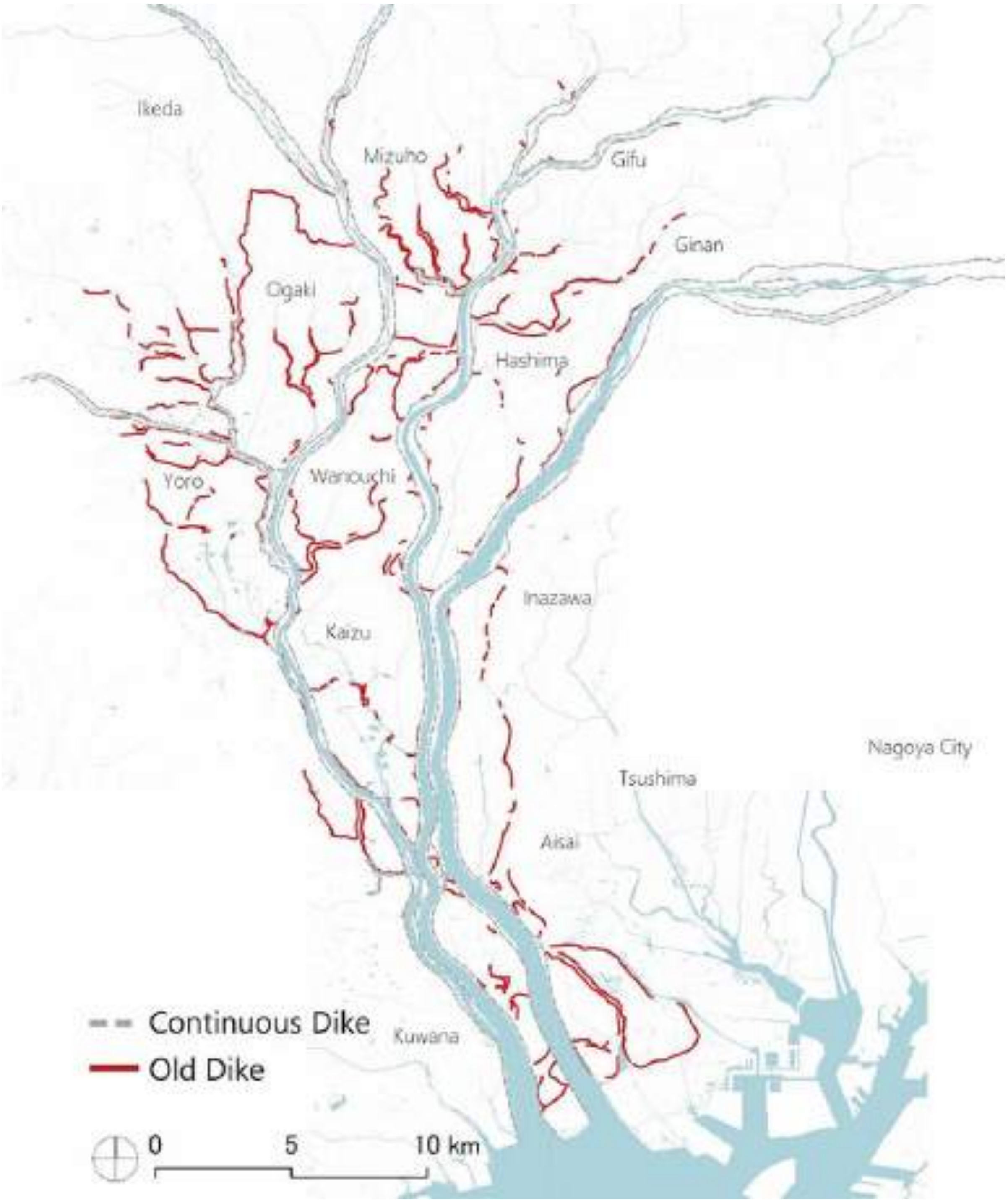

Figure 3. Plot of continuous dikes and existing old dikes
Data sources: Geospatial Information Authority of Japan (2024) and Konjaku Map (Tani, 1891–1898, retrieved 2024).

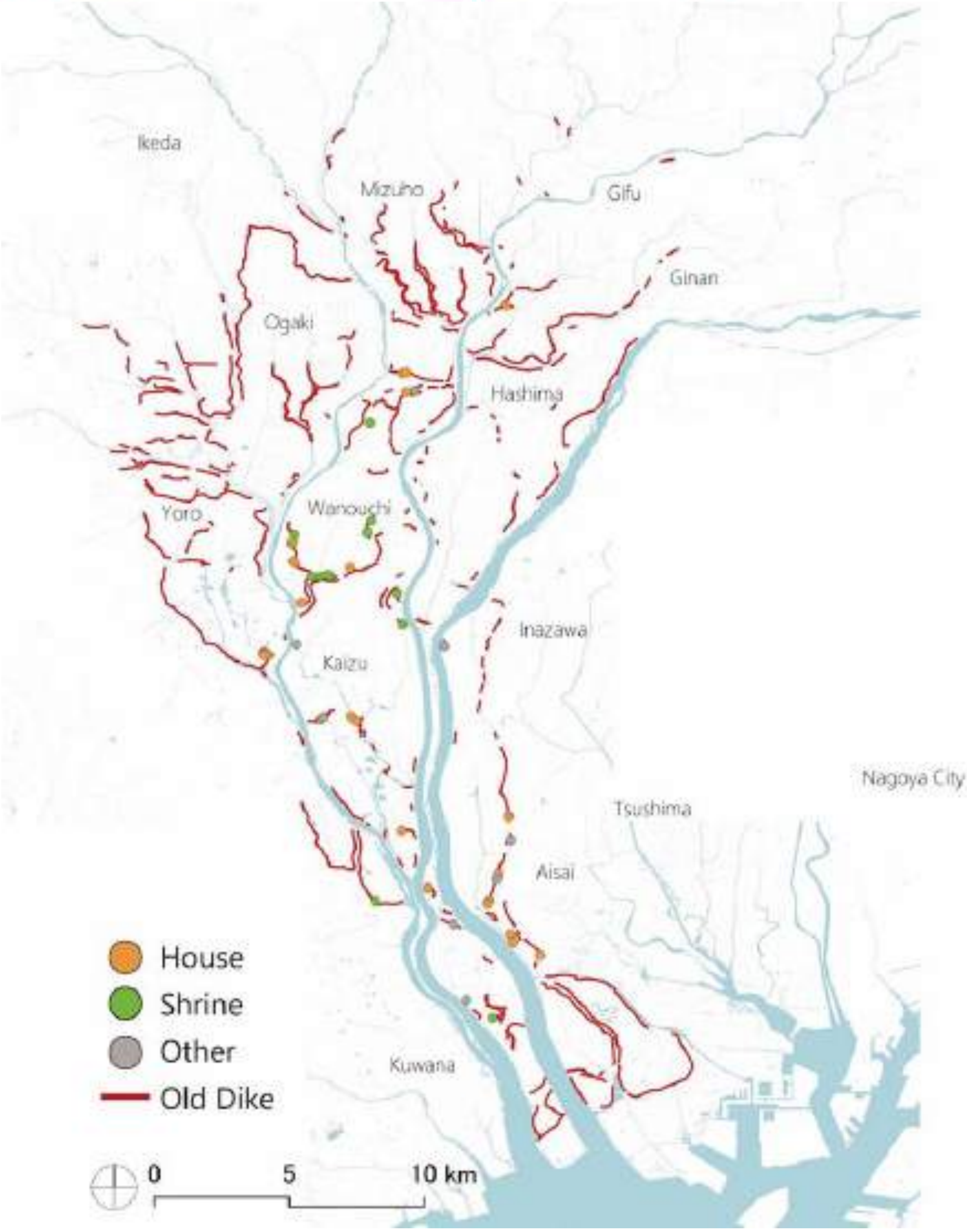

Figure 4. Plot of areas elevated 2 meters higher than the dike road
Data source: Geospatial Information Authority of Japan, Basic Map Information (2024).

3. Findings and Discussion

1. Land use on the dike crest

45% of the dike crest is used for housings, shrines, and temples in the area. Housing use occupies with 40% of the land-used area (Fig.5). These residences mainly manage dikes. Some shrines and houses are located on elevated foundations exceeding 2 meters above the dike road. As the height of these elevated foundations increases, shrines are more prevalent than houses (Fig.6), suggesting that the shrines offer evacuations for the local community in the inner area surrounded by dikes.

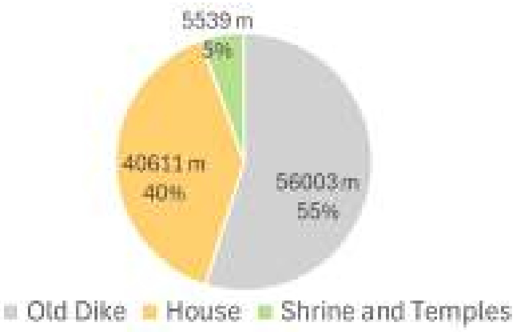

Figure 5. Land use by Housing, Shrines, and Temples

Figure 6. The percentage of land use by height of the high foundations

2. Locations in relation to the dike crest

Housings: 40% of housing use is placed on the outer slope of dikes to the rivers (Fig.7).

High Foundations: The study examined the location of houses and shrines that were placed on the high foundations observed on the old dike. Out of 36 cases of houses with high foundations, 12 cases are located on the inner side of the dike, while 18 cases were on the outer side. (Fig.8) For shrines, out of 17 cases, 11 were located on the inner side of the dike. (Fig.9)

Figure 7. The housing use which is placed on the slope of dikes

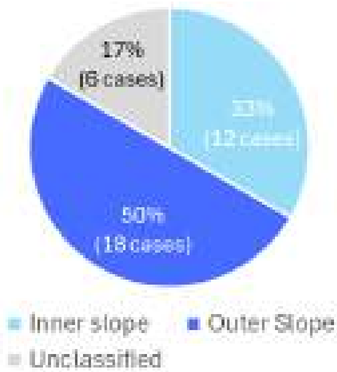

Figure 8. The sides on slopes of dikes where high-foundation houses placed

Figure 9. The sides on slopes of dikes where high-foundation shrines are placed

3. The location and the materials of the High foundation wall

Foundation walls are classified into five material types. The walls to prevent flooding for housing and shrines are constructed with mainly earth, but only on sides of roads on the dike crests, a higher percentage of the walls consist of piled stones which can be collected from surroundings near the rivers (Table 1-2).

Table 1. Materials of Foundation Walls on the Dike Road Side"

Foudation Wall Material		Outer Slope		Inner Slope	
Piled Stone	House, Piled Stone, Dike Road	15	58%	9	43%
Soil	House, Soil, Dike Road	2	8%	2	10%
Concrete	House, Concrete, Dike Road	2	8%	4	19%
Retaining Wall	House, Soil, Retaining Wall, Dike Road	6	23%	5	24%
Concrete & Various Materials	House, Soil, Concrete, Dike Road	1	4%	1	5%
Total		26		21	

Table 2. Materials of Foundation Walls on the Outer River and Inner Land Sides

Foudation Wall Material	Outer Slope (Facing River)			Inner Slope (Facing Inland)		
Piled Stone	House, Piled Stone, River	8	38%	House, Piled Stone	9	39%
Soil	House, Soil, River	6	29%	House, Soil	7	30%
Concrete	House, Concrete, River	1	5%	House, Concrete	2	9%
Retaining Wall	House, Soil, Retaining Wall, River	5	24%	House, Soil, Retaining Wall	5	22%
Concrete & Various Materials	House, Soil, Concrete, River	1	5%	House, Soil, Concrete	0	0%
Total		21			23	

4. Settlements on the old dike and bamboo planted on slopes

Study Area: Former Saya River Dike-top Settlements in the Tatsuta Waju Region.

Figure 10. Bamboo forest in Miyaji (1850) Data source: Aichi Prefectural Library (retrieved in 2024).

Figure 11. Bamboo Forest in Miyaji (2024) Data source: Modified from Google Maps (2024).

To the east of this dike, the Saya River once flowed. Even after the river was decommissioned, houses remained along the outer slope of the dike, with parts of the dike itself persisting as part of the topography. Today, bamboo forests are widely planted around settlements.

Table 3. Changes in Bamboo Forest Area Over Time

	1961(m²)	2009(m²)	2024(m²)
Akame	1013.2	174.7	222.5
Hayao	11630.3	1115.7	1502.3
Shimoishiki	6338.0	7632.6	1119.6
Morikawa	4299.2	3147.3	3043.9
Miyaji	11005.9	10848.2	10006.6
Yamaji	2094.3	0.0	122.5

This study focuses on six settlements where bamboo forests remain and twelve cases where bamboo forests surround houses. It aims to clarify that these bamboo forests are not simply windbreak forests for the seasonal winds from the northwest but rather serve distinctive roles in protecting houses from adjoining outer rivers. In the three settlements on the outer slope of the dike from the illustrations from the late Edo period - Akame, Hayao, and Miyaji - a series of bamboo forests is observed to be planted on the outer side (Aichi Prefectural Library, 2024). By 1961, bamboo forests exceeding 10,000m² existed in Hayao and Miyaji, though only Miyaji retains a similar size today (Table 3). Interviews and aerial analysis revealed that settlements like Shimoishiki, Miyaji, and Hayao retained bamboo forests. This persistence can be attributed to the forest owners being different from the adjacent house residents or due to mixed ownerships of the forests. On GIS, we computed the slope angles of the areas planted with bamboo forests. We define the most frequently observed angles in each area as the slope. In Miyaji Village, bamboo is planted on the steepest slope angles compared to the other villages. (Table 4).

Table 4. Slope of Bamboo Planting Locations

Name	Slope (°)	Name	Slope (°)
Akame1	9	Miyaji1	12
Hayao1	2	Miyaji2	13
Shimoishiki1	5	Miyaji3	2
Shimoishiki2	6	Miyaji4	13
Morikawa1	2	Miyaji5	13
Morikawa3	8	Yamaji1	7

4. Conclusion

These results indicate that dikes in flood-prone areas in Japan are not only flood control facilities but also facilities that support multiple and multifaceted uses, functioning as bases for flood countermeasures and as evacuation places during disasters. To realize such multifaceted and multi-faceted use of the narrow width at the crest of the dikes, various ingenuity was used in every detail. The crest of the dikes are not uniformly the same height, but are raised above the surrounding area to allow for the storage of goods, such as in warehouses, and are also raised above some areas of the shrines that serve as evacuation centers for the local community. In addition, the center of the crest of the dikes is covered with a road, which forms a traffic network between villages in “Waju”. Even when embankments are built, stone walls are placed between the road and the embankment to prevent landslides from affecting the road.

Moreover, the analysis of bamboo forests on the outer slopes of former Saya River dike-top settlements suggests potential spatial and functional roles beyond windbreaks. The observation of a series of bamboo forests in specific areas, such as Miyaji, and their growth on steep slopes with varying ownership provides insights into traditional land-use practices and their influence on the landscape. These findings contribute to understanding the interactions between settlements, topography, and vegetation.

Since current civil engineering standards do not allow land use on dikes, this study is conducted in the belief that it is possible to understand the integration of flood control facilities and land use. In Japan, where the population is decreasing rapidly and occurring frequent extreme weather events, it is time to rethink the role of disaster prevention facilities and land use.

Note

During the process of identifying the existing old dike, we applied the following criteria: (1) embankments that are one meter higher than the surrounding terrain, and (2) a dike road from the old map that remains unchanged in form on the embankment.

The *Konjaku Map* (Tani, K., 1891–1898) used for the analysis lacks detailed information regarding the spatial relationship between houses and dikes in certain areas. As a result, in Figure 8 (*The sides on slopes of dikes where high-foundation houses are placed*), some data points are classified as "unclassified" due to insufficient historical records.

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Reviving Traditional Village Regulations for Environmental Sustainability in Chinese Villages

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Abstract

This study examines the contribution of traditional village regulations to rural environmental governance in southern China, addressing a significant research gap in understanding how traditional ecological knowledge can be applied to contemporary environmental challenges. Through analysis of historical documents and contemporary case studies, this research investigates the evolution, ecological wisdom, and modern applications of village regulations in environmental protection. The findings reveal that these regulations are founded on sophisticated understanding of human-nature relationships, manifested through feng shui principles, forest management practices, and water conservation measures. The study demonstrates how village regulations effectively facilitate environmental governance through three mechanisms: providing a framework for sustainable development practices, enabling multi-stakeholder participation, and optimizing management while reducing administrative costs. Contemporary applications in southern China show that these traditional regulations can successfully adapt to modern environmental governance needs while preserving cultural heritage. The research contributes to both theoretical understanding of traditional ecological knowledge and practical approaches to rural environmental governance, suggesting that village regulations, when properly adapted, can serve as an effective tool for promoting environmental protection in rural areas.

Keywords: Traditional village regulations; rural environmental governance; traditional ecological knowledge; environmental protection; sustainable development

1. Introduction

As China's economy has developed rapidly, numerous ecological challenges persist in rural areas, including agricultural resource shortages and ecosystem degradation (Han et al., 2019). Traditional ecological knowledge, particularly in the form of village regulations (乡规民约), offers potential solutions to these environmental challenges. These regulations, which represent the heritage inherited from thousands of years of human-environment interaction, have historically played a crucial role in rural environmental governance (Knowledge & Centre (Canada), 1993; Liu, 2018).

A comprehensive review of academic literature reveals extensive scholarship on Chinese village regulations, focusing primarily on their historical origins, legal status, and role in rural governance. Researchers have traced these rules back to pre-Qin times, analyzing their evolution from informal customs to formal governance mechanisms (Dang, 2012). While existing studies acknowledge village regulations' contributions to shaping rural society, there remains a significant research gap regarding their specific application to environmental governance (Supriatna et al., 2018; Zhou & Zhang, 2017). This gap is particularly noteworthy given the increasing environmental pressures facing China's rural areas due to rapid development.

With nearly 700,000 administrative villages in China, no single environmental governance model can comprehensively address all challenges (Hao et al., 2023). The essence of environmental governance lies in managing farmers' daily practices and lifestyle changes (Han, 2021; Wang et al., 2023), which aligns closely with the fundamental aims of traditional village regulations. Southern China presents a particularly compelling case study due to its long-standing and diverse village regulations, combined with its environmental vulnerability to development pressures. The region's agriculture-centric economy, growing population, and industrialization challenges make it an ideal context for examining how traditional governance mechanisms adapt to contemporary environmental challenges.

This study aims to explore the contribution of traditional village regulations to rural environmental governance in southern China, focusing on three key objectives: (1) examining the historical evolution and cultural foundation of these regulations, (2) analyzing the traditional ecological wisdom embedded within them, and (3) investigating their contemporary applications in modern environmental governance. By analyzing these aspects, this research seeks to bridge the gap between traditional ecological knowledge and modern environmental management practices, offering insights for sustainable rural development.

2. Material and Method

This study employs a qualitative research approach combining historical document analysis and case studies to examine traditional village regulations in southern China. The research scope encompasses village regulations from multiple provinces in southern China, with a particular focus on documents dating from the Qing Dynasty (1644-1911) to the present day, allowing for a comprehensive analysis of both historical and contemporary practices.

The primary data sources consist of historical village regulation documents, including the 1786 village regulations of Xiyong Township, the 1824 regulations of Dijici Village, and contemporary village regulations from various communities in southern China (Li, 2005). Additional data were collected from stone tablet inscriptions, such as the "Stele Inscription on Sealing off Mountains and Protecting Forests" from 1799, which provide valuable historical records of environmental governance practices. Modern village regulations were obtained from multiple administrative villages, including Pudong Village, Liping County, and Dongfu Village, Jianhe County, offering insights into current implementation practices.

The document analysis followed a systematic approach focusing on three key aspects: (1) historical context and cultural foundations of village regulations, (2) specific environmental protection measures and ecological wisdom contained within the regulations, and (3) contemporary applications and governance mechanisms. This analytical framework allows for both diachronic examination of how village regulations have evolved over time and synchronic analysis of their current implementation in rural environmental governance.

Case studies were selected based on three criteria: (1) the presence of well-documented historical village regulations, (2) evidence of continuous implementation of traditional ecological knowledge, and (3) demonstration of contemporary environmental governance practices. This selection process ensures that the cases provide rich information for understanding both the historical continuity and modern adaptation of village regulations in environmental governance.

3. Findings and Discussion

3.1 Historical evolution and cultural foundation

The development of village regulations in southern China has been shaped by distinct geographical, cultural, and political factors that have collectively contributed to their effectiveness in environmental governance. The geographical context of southern China, characterized by remote mountainous regions, forested areas, and isolated valleys, historically created conditions where communities needed to develop self-governing mechanisms (Chen & Gu, 2004). These isolated environments, combined with limited agricultural productivity, fostered a deep dependence on and respect for natural resources, leading to the emergence of early environmental protection measures within village regulations.

Cultural beliefs, particularly the primitive religious concept of "everything has a spirit," played a fundamental role in shaping these regulations. This spiritual framework manifested in specific environmental protection measures, such as the designation of sacred forests and the prohibition of deforestation. For instance, among the Qiang people (羌民), the belief that "mountains, trees, and stones all have lives" led to the establishment of protected divine forests, which were passed down through generations (Meng & Zhou, 2003). These cultural beliefs effectively served as early conservation mechanisms, demonstrating how traditional ecological knowledge was embedded within local spiritual practices.

The political context further reinforced the development of village regulations through the implementation of "governing in accordance with local customs" (因俗而治) policies since the Qin Dynasty. This approach allowed southern ethnic minority areas to maintain relatively independent and autonomous social organizations (Su, 1997). Local governance was typically administered by respected village authorities, such as the Lao Min (老民) elders of the Qiang people and Degu (德古) elders of the Yi people (彝民), who not only presided over the formulation of village regulations but also ensured their implementation through mediation and adjudication (Li & Li, 2017).

The modern transformation of village regulations has been marked by both challenges and opportunities. While these traditional governance mechanisms faced significant pressure during the political movements of the 1950s and 1960s (Huang, 2009), they experienced a revival following China's reform and opening up in 1978. The formal legitimization of village regulations through the Village Committee Organization Law in 1988 and subsequent policy support has reinforced their role in contemporary rural governance (Tan et al., 2019). This evolution demonstrates the adaptability of traditional village regulations to modern governance requirements while maintaining their core function in environmental protection.

3.2 Traditional ecological wisdom in village regulations

Traditional village regulations in southern China embody rich ecological wisdom through various environmental protection mechanisms, particularly manifesting in four key aspects that demonstrate sophisticated understanding of human-nature relationships.

First, village regulations reflect a profound understanding of environmental protection through the lens of feng shui principles. Feng shui represents a value system and psychological behavioral orientation toward the environment, emphasizing the harmony between humans and nature (Long, 2002; Sun et al., 2014). For example, the 1786 village regulations of Xiyong Township explicitly stated that "good feng shui is cultivated by trees," while the 1824 regulations of Dijici Village established a direct connection between forest protection, feng shui, and community prosperity (Li, 2005). This cultural framework effectively promoted environmental conservation by integrating it into local belief systems.

Second, these regulations demonstrate an empirical understanding of the ecological function of forest vegetation, particularly regarding water conservation. Although lacking modern scientific terminology, historical village regulations showed remarkable insight into the relationship between forest coverage and water resources. The 1808 regulations of an Anan Yi ethnic minority village succinctly captured this understanding with the statement "although water is important, trees are the basis for keeping water" (Li, 2005). This knowledge was further elaborated in the 1781 regulations of Zixi Mountain Township, which explicitly linked deforestation to water scarcity and agricultural productivity decline.

Third, village regulations established comprehensive measures for farmland protection through vegetation management. By the Qing Dynasty, communities in southern China had recognized the connection between vegetation destruction, soil erosion, and agricultural productivity (Zhang, 1998). The "Stele Inscription on Sealing off Mountains and Protecting Forests" from 1799 provides evidence of this understanding, prohibiting deforestation and emphasizing the long-term benefits of forest conservation over short-term agricultural gains.

Fourth, these regulations incorporated ecological aesthetics into environmental governance. The Naxi people's regulations exemplify this approach, establishing comprehensive protection measures for water sources and forests while emphasizing the aesthetic value of natural harmony. Their regulations not only prohibited environmental damage but also promoted a holistic view of ecological preservation that connected environmental protection with cultural identity and aesthetic appreciation.

3.3 Contemporary Applications and Implications

The traditional village regulations have demonstrated significant adaptability and practical value in modern rural environmental governance, particularly in three key areas that address contemporary challenges.

First, village regulations provide a historical foundation and practical framework for implementing sustainable development principles. Through the reasonable and effective coordination of natural resource use with production, ecology, and daily life, these regulations promote harmonious development between humans and nature(Chen, 2012). The implementation of these regulations in modern contexts demonstrates how traditional ecological knowledge can be effectively applied to raise environmental awareness and promote sustainable practices. To illustrate the practical implementation of contemporary village regulations, Table 1 presents examples from various villages in southern China, demonstrating specific measures for environmental protection.

Table 1. Examples of Contemporary Village Regulations for Environmental Protection in Southern China

Category	Location	Regulation Content
Protection of Forest Resources	Zhanli Village, Congjiang County	Prohibition of fire use in public welfare forests
	Qingzhai Village, Liping County	Prohibition of felling feng shui trees, auspicious trees, road protection trees and water source trees
	Kengdong Village, Liping County	Returning farmland to forests and preserving ancient trees
Rational Use of Forest Resources	Pudong Village, Liping County	Those who have left their land deserted will have the land taken back by the village group
	Qingzhai Village, Liping County	The height of the upper edge of the field is 13.3 meters, the lower edge is 3.3 meters
	Bi-Wa Village, Liping County	Protection of collective and private forest management rights
Water Conservation	Dongfu Village, Jianhe County	Prohibiting the use of water pumps and machinery, violators penalized 1000 yuan
	Darui Village, Rongjiang County	Those who affect public hygiene near wells must remove all dirt on their own

Second, village regulations facilitate a multi-stakeholder governance model that enhances environmental protection effectiveness. These regulations serve as a unique public participation system in China's rural areas, significantly expanding villagers' involvement in environmental protection (Li, 2020; Liu & Chen, 2023). The process of formulating and implementing village regulations typically involves representatives from each household, environmental organizations, and researchers, creating a collaborative governance framework (Wang Y., 2020). This participatory approach has proven particularly effective in environmental supervision, enabling villagers to monitor both individual behaviors and local enterprise activities (Bi et al., 2017; Zhou & Cai, 2018).

Third, village regulations contribute to optimizing rural environmental management while reducing administrative costs. Given that village committees lack direct law enforcement powers, village regulations provide an effective alternative mechanism for environmental governance (Wang & Li, 2022). The regulations establish clear consequences for environmental violations while utilizing existing social networks for monitoring and enforcement. Furthermore, they incorporate innovative approaches such as environmental credit systems, where members receive positive or negative evaluations based on their environmental behaviors (Li et al., 2022). This system has successfully encouraged market entities to pay greater attention to environmental protection while reducing the need for costly administrative interventions.

These contemporary applications have demonstrated that village regulations can effectively bridge traditional ecological knowledge with modern environmental management needs. The success of these regulations in southern China suggests their potential applicability in other rural areas facing similar environmental challenges, particularly in regions with strong community ties and traditional governance structures. However, their implementation must be carefully adapted to local contexts and integrated with existing legal frameworks to maximize effectiveness.

4. Conclusion

This study has examined the contribution of traditional village regulations to rural environmental governance in southern China, revealing their continued relevance and potential in addressing contemporary environmental challenges. Our findings highlight three significant aspects of these regulations: their deep historical and cultural foundations, the sophisticated ecological wisdom they embody, and their practical applications in modern environmental governance.

The research demonstrates that village regulations represent more than just historical artifacts; they constitute a living tradition that has successfully adapted to modern environmental governance needs. The integration of traditional ecological knowledge with contemporary management practices, as evidenced in southern China, offers valuable insights for sustainable rural development. Particularly noteworthy is how these regulations facilitate multi-stakeholder participation while reducing administrative costs in environmental governance.

However, this study also acknowledges certain limitations. The successful implementation of village regulations largely depends on the strength of local community ties and traditional authority structures, which may not be equally present in all rural areas. Future research could explore how these traditional governance mechanisms might be adapted for regions with different social and cultural contexts, and how they might be more effectively integrated with formal environmental protection frameworks.

These findings contribute to both theoretical understanding of traditional ecological knowledge and practical approaches to rural environmental governance. The experience of southern China suggests that traditional village regulations, when properly adapted and implemented, can serve as an effective tool for promoting environmental protection while preserving cultural heritage.

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Grassroots Environmental Movement for Code Red: Ovacık Mining Landscape

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Abstract

Mining activities are humankind's domination of the landscape through extensive transformations. Affecting a thick section of the earth that embodies atmospheric, terrestrial, aquatic, and subterranean environments, extraction has devastating consequences on indigenous ecological systems. Considering the role of mining as a significant contributor to the environmental degradation that has led the Earth to a 'code red' crisis level, this study aims to explore the potential of grassroots movements in mitigating the profound and destructive impacts of extractive industries. This paper examines the dramatic spatial and sociocultural transformations of Ovacık, a village in Bergama, Türkiye*, which was once an agricultural settlement with fertile lands and orchards before the arrival of a transnational gold mining company in the late 1980s. Beyond the detrimental consequences of extraction, the paper also investigates the mitigating impact of the environmental movement led by local communities, who interpreted the landscape as the source of life for all living beings, and discusses the potential of such mobilization as a means of combating the 'code red' state of the Earth.*

Keywords: Mining landscape, grassroots environmental movement, environmental degradation

1. Introduction

Ovacık, a village in İzmir, lies along the intercity road between İzmir and Çanakkale near the west coast of Türkiye. The village is situated in the fertile Bakırçay basin, known for its agricultural lands, orchards, and forests, and bordered by the southern edge of the Kozak Plateau. This plateau, predominantly covered in stone pine forests (*Pinus pinea*), is home to endemic plant species and various aquatic systems, including groundwater reserves, creeks, and waterfalls (Eriz et al., 2022). The relevance of this region to gold dates back to the Lydians, an ancient civilization that ruled around 700 BC and minted the first gold coin in history (Ünal et al., 2016).

Upon the discovery of an orebody in Ovacık at the end of the 1980s, a transnational gold mining company named 'Eurogold' was established by leading mining companies from various countries in 1989 (Küçük, 2001). Shortly after the establishment, with the initiation of exploratory drilling, Ovacık underwent radical spatial and sociocultural transformations. Substantial landscape degradation, coupled with concerns about the potential risks of cyanide-leaching gold processing, resulted in opposition against the mining activities within the local communities. Although the opposition, which turned into a social movement in time, led to delays in extraction activities, the construction of mining facilities was completed in 1997 (Özen & Özen, 2009) and Eurogold achieved to gain permission for one-year trial production in 2001 (Uncu, 2012).

Meinig (1979) discusses that the concept of landscape is a subjective construction. Landscape, even experienced under identical circumstances, is attributed diverse interpretations and meanings based on the subjective backgrounds and stances of diverse individuals or groups. In Ovacık case, the landscape was acknowledged as an instrument to generate surplus value, an inanimate raw material for capital accumulation by the company. Likewise, for the Turkish government, Ovacık's landscape was a source of national economic growth and development. While radical transformation originated from the association of the landscape with the concept of interest, the grassroots perspective, which views the landscape as the habitat for all life forms, generated an organized action to halt this transformation.

This paper explores the relationship between extraction and environmental degradation, and the role of grassroots movements in mitigating the effects of this transformation. The impacts of gold mining and ore processing on Ovacık's landscape will first be examined to comprehend the role of extraction as one of the factors fostering the code red state that the earth is going through. Next, the local response to the existence of a gold mine, which manifested itself in the legal arena first and later turned into a long-running grassroots environmental movement, will be introduced. Finally, the outcomes of the movement will be evaluated to explore its potential to reduce devastating impacts on the Earth and mitigate the Code Red crisis.

2. Material and Method

This research is centered on a case study of Ovacık, integrating desk research and fieldwork. The desk research involves a comprehensive literature review, focusing on both the concept of mining landscapes and the specific case of Ovacık, through the analysis of academic articles and books. Additionally, to deepen understanding of the case, official documents from the mining company, reports from various state institutions, newspaper articles, and documentaries were examined. On the other hand, the fieldwork phase involved site visits and interviews with the villagers and other actors involved in the case, such as a journalist and the spokesperson of a local environmental organization. Also, archival research, conducted at the Bergama Municipality Directorate of Planning and Urbanization and a local newspaper, contributed significantly to the study.

3. Impacts of the Ovacık Gold Mine on Diverse Environments

The Ovacık gold mine had profound environmental and social consequences, driven by the self-serving perspectives of the mining company and the government, which viewed the landscape primarily as a source of economic gain. For instance, in Ovacık village, approximately fifty houses were demolished in the first half of the 2000s as their locations, which were next to the planned surface mining area, made them vulnerable to the impacts of extraction activities (Reinart, 2003). The vanished structures, which were examples of vernacular architecture, were replaced by reinforced concrete houses, built on the opposite side of Ovacık. However, these new houses lacked continuity with the local architectural context, differing significantly in architectural style, material composition, and the number of floors. Additionally, the village cemetery, originally situated within the designated surface mining area, was relocated in the early 1990s, with more than a hundred graves transferred to the new cemetery (Oygür, 2017). Both interventions served as strokes to the collective memory and the history of the settlement.

The fenced presence of the mining site was another factor in altering the built environment and land use in Ovacık. By inhiving "…*behind opaque layers of safety and environmental regulations*" (Rosier, 2022), mining sites form gated enclaves and restricted areas, a phenomenon also observed in the area discussed in this paper. The vast land, previously owned partly by public institutions, foundations, villages as public properties, and individuals, (Oygür, 2017) was consolidated into the possession of a single legal entity with rigid boundaries. This shift resulted in the reproduction and highlighting of the concept of private property within the settlement.

The transformation of forest and agricultural lands, along with their particular ecosystems, into mining territory further altered the landscape. In 1996, numerous pine and olive trees were cut down, (Reinart, 2003) one of the incidents which ignited the fire of resistance among local communities. The soil, along with the entire range of non-human populations it hosts, was stripped from the surface mining area. Landforms were reshaped with the formation of a great pit of surface mining and the generation of artificial hills of waste soil, whereas the subsurface ecologies were disturbed through the construction of tunnels.

The tailings dams, which store cyanide-containing pulp generated during gold processing, are also another bold mark disrupting habitats of diverse species and redefining surface morphology. The operation of the processing plant in Ovacık pushed the capacities of two tailings dams to their limits despite their substantial volumes, necessitating the construction of two additional dams. As the newly constructed tailings dams continue to fill, reclamation efforts for the older dams remain ongoing. Reclamation of dams does not correspond to a complete rehabilitation as the waste is not eliminated thoroughly, but it is encapsulated underground, layered with rock, gravel, clay, and a top layer of vegetal earth (Gökvardar, 1999). This process renders the chemical waste a permanent component of the landscape indefinitely. In addition to the anticipated environmental impacts of the tailings dam, two dam-related accidents occurred in Ovacık in 2011 and 2014. The first incident, triggered by heavy precipitation, resulted in the dam overflowing and discharging contaminated water onto agricultural lands (Ud, 2024). The second incident stemmed from a leakage in the pipelines transporting process waste from the plant to the tailings dam and led to contamination of Nardal Stream, the water body flowing next to the mining site (Akdemir, 2014).

Beginning from the earliest stages, aquatic systems in the region were exposed to the detrimental effects of mining activities. For instance, during drilling activities conducted to determine the precise location and characteristics of the orebody, chemical compounds used to protect drilling equipment infiltrated water source, resulting in the contamination of the drinking water (Arsel, 2016). Furthermore, groundwater exposed during excavation for underground mining operations was discharged into the Nardal Stream, disrupting the stream's ecological balance (Koç et al., 2005). Excavation activities and the use of explosives during these processes generated significant amounts of dust. This not only contributed to air pollution but also led to the desiccation of plants as the dust settled on their leaves, impairing their physiological functions (Reinart, 2003).

The presence of the transnational company also led to the fragmentation of social relationships within local communities, driven by intense polarization between proponents and opponents of the mine. This atmosphere of conflict prompted some villagers employed by the mine to relocate, often moving to the town center of Bergama and commuting to work (Reinart, 2003). Additionally, spatial divisions emerged in the use of public spaces among those who remained in the villages surrounding the mining site. A notable example of this division was observed in Narlıca, a village located approximately one kilometer north of the Ovacık gold mine. As in other Turkish villages, the village square was the centre of social life with coffeehouses, which were frequented exclusively by men. However, the lack of consensus on the mine strained relationships, leading to the exclusion of certain individuals from coffeehouses, which became largely segregated by opposing factions. During this period, Narlıca village had three coffeehouses: two were frequented separately by supporters and opponents of the mine, while the third served as a neutral space for those who remained unaffiliated with either side (Reinart, 2003).

4. Local Response

The interpretation of Ovacık's landscape as a habitat encompassing not only human life but also a diverse array of other life forms in a symbiotic relationship raised significant concerns regarding the potential risks associated with cyanide-leaching. These concerns served as the impulse for the local communities to take collective action against the mine. Following the issuance of an operational permit by the Ministry of Environment in 1994 (Arsel, 2016), the opposition to the mine resulted in lawsuits demanding the annulment of the permit, as the first tangible step in the resistance (Uncu, 2012). This initial legal action marked the beginning of an extended and complex judicial struggle, that involved numerous lawsuits with varying -and at times, contradictory- outcomes. While some rulings favored the transnational gold mining company, others mandated the closure of the mine. Even though mining activities halted occasionally as a result of these decisions, permanent closure of the mine was not realized.

The opposition transcended the legal domain, manifesting through widespread civil society actions fueled not only by intermittent legal setbacks but also by the profound and visible impacts of landscape degradation, which were directly experienced by the villagers. For instance, the mass felling of pine and olive trees within the borders of the planned mining site encouraged the villagers to organize and resist. As a response to this incident, the villagers blocked the traffic on the intercity road adjacent to Ovacık village for six hours, an event recorded as the first organized civil society action in the history of resistance against the mine (Reinart, 2003). This demonstration, as a breaking point, ignited a wave of civil society actions. Experiencing direct consequences of mining within daily life was the reason that sustained the movement for years and kept the participants' tension always high. These occurrences prompted the inhabitants to realize that preservation of the living space and the local lifestyles can merely be achieved through the preservation of the landscape. As a result of this epiphany, the mobility rooted in the villages of Bergama resulted in a long-running grassroots environmental movement, marking the country's first instance of civil disobedience (Reinart, 2003) and longest-lasting ecological resistance (Çoban, 2004).

Initially, the movement was predominantly driven by men. However, as it became increasingly clear that the environmental changes caused by mining threatened both human and non-human habitats, women began to take an active role. Their involvement soon became indispensable, playing a critical part in ensuring the movement's sustainability. Even in moments when men were on the verge of abandoning the cause, it was the women who sustained and revitalized the social movement.

The demonstrations spanning years were not only held in the region, but extended to quite symbolic spaces such as the Bosphorus Bridge in İstanbul, (Reinart, 2003) the crossroads near the Grand National Assembly of Türkiye in Ankara, and the public spaces around various ministry buildings. What made this resistance visible and attention-grabbing nationwide was not only the strategic selection of these critical locations but also the innovative tactics employed by the protestors. For instance, half-naked protests garnered extensive media coverage, amplifying the movement's reach and impact. Through these actions, the demonstrators were able to exert pressure on both the company and decision-makers, securing certain concessions and gains.

5. Favorable Consequences of the Grassroots Environmental Movement

Neither the court decisions nor the social movement could halt mining operations permanently, however, the organized action of the local communities produced favorable consequences for the landscape by compelling the gold mining company to make concessions and improvements. A primary concern repeatedly voiced by the villagers through various platforms was the cyanide-containing process waste that would be stored in the tailings dam situated directly above the village of Ovacık. In an attempt to address these concerns, the company initially announced plans to line the base and side walls of the dam with a layer of clay to ensure impermeability. However, this measure failed to convince the protesters, prompting the company to promise an increase in the clay layer's thickness. Despite these assurances, the debate over this issue did not subside. Finally, Eurogold agreed to enhance the dam's design by incorporating a polyethylene geomembrane layer sandwiched between two compressed clay layers (Apolitika, 1997). Moreover, to further allay the villagers' concerns, the INCO SO_2 air cyanide removal process, which alleviates cyanide concentration in the process waste, was incorporated into the operations in the Ovacık gold mine (Arsel, 2016).

Both the social movement and the legal process caused delays in the construction of mining facilities and the initiation of extraction activities. The landscape transformation decelerated and was even falted for a certain time. These delays and temporary halts provided time and opportunity for public discourse on gold mining which led to developments in favor of the landscape.

Furthermore, the movement increased the environmental sensitivities of the local people, helping them recognize the significance of being organized in resisting powerful entities and partnerships that pose a threat to the environment. Çevre Yürütme Kurulu (The Committee of Environmental Execution), which was established to oppose the gold mine, (Reinart, 2003) resulted in the formation of a permanent environmental organization in the region: Bergama Çevre Platformu. This civil society organization is still an active and influential force, continuing to engage in a range of actions such as organizing demonstrations, issuing press statements, and filing lawsuits to protect the habitats of both human and non-human populations in the area.

The benefits of the movement extended across a broad geography, reaching beyond the Ovacık gold mine and its immediate surroundings. It raised awareness across the country about environmental degradation, became the initiator of the grassroots-based environmental activism in Türkiye, and gave courage and inspiration to other communities facing similar threats (Uncu, 2012). Besides being a source of inspiration, the Bergama villagers actively supported various mobilizations against nuclear power, hydroelectric power plants, and other gold mining projects in different regions of the country.

Another positive outcome of the movement is its contribution to advancing gender equality within the local communities. The substantial transformation of landscape, impacting the lives of all living forms, especially triggered women populations. Evident changes that the landscape experienced convinced women to eliminate long-lasting gender roles, codes, and restrictions imposed on them and contribute to the resistance. Thus, women, who had previously been excluded from the public sphere, became important actors within the community. Public spaces, once reserved solely for men such as coffeehouses, began to accommodate women as well. The knowledge learned from this movement that women are influential actors who can profoundly influence the course of a grassroots environmental movement still designs environmental mobilizations in the region today.

6. Conclusion

Extraction is diverse anthropogenic activities that redefine atmospheric, terrestrial, aquatic, and subterranean environments. The operations of the Ovacık gold mine transformed the landscape, however, the trajectory of this transformation was shaped by the actions of diverse actors and groups, each interpreting the landscape in different ways. While the grassroots tended to act out of a protective instinct, those who viewed the landscape primarily as a source of economic interest exhibited a more indifferent attitude towards its transformation and degradation. The actions of the company and the government tended to prioritize economic rationality over anything, including the rights of human and non-human populations. In contrast, the bottom-up organization of local communities appeared to hold the potential to advocate for all living beings sharing the same landscape, challenging this self-interested approach. This paper states that the mobilization of grassroots, who can grasp that their existence is inextricably linked to the landscape and the coexistence of all beings, appears critical in addressing environmental crises. Herein, through the narration of the Ovacık case, it is advocated that the bottom-up organization of local communities, emerging as the result of meaning and value attributed to the landscape, is pivotal and offers a potential way out of the "code red" state that the Earth is currently in.

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Resilient Landscapes, Resilient Minds: Highlighting the Role of Perceived Oppressiveness

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Abstract

Landscape architecture significantly influences how people experience urban spaces, affecting their emotional and behavioral responses. One important but underexplored aspect is perceived oppression, a common issue in densely populated areas. This perception of oppression leads to psychological strain, negatively impacting mental health. Identifying the factors contributing to perceived oppression is critical for promoting mental well-being and societal stability. This paper aims to explore how landscape architecture can reduce perceived oppression and support mental restoration for a more sustainable society. Using qualitative research and content analysis, the study highlights the potential of landscape environments to alleviate oppression. The findings suggest that enhanced, sustainable landscape design can decrease feelings of oppression and improve mental health. The paper identifies four key elements that influence perceived oppression: biological, social and interactive, physical, and management/planning aspects. These elements interact in a hierarchical process, where addressing them can lead to mental healing and contribute to societal resilience. The study emphasizes the importance of integrating these elements into landscape architecture to create environments that foster psychological well-being. The research offers practical insights for urban managers, landscape designers, and policymakers, providing guidance on how to design spaces that promote sustainability, mental health, and social stability.

Keywords: Resiliency, perceived oppressiveness, sustainable landscape, mental restoration

1. Introduction

The World Health Organization (WHO) identifies stress as one of the most critical health challenges of the 21st century, responsible for exacerbating up to 80% of diseases (Fink, 2017). Recent research provides stronger evidence than before, indicating that symptoms of mental illnesses are more prevalent in urban areas than in rural regions. Infact, urbanization has significantly increased mental health challenges among city residents, with psychological stress emerging as one of the primary concerns of modern urban living (Bolouki, 2023; Liu et al., 2019; Zhu et al., 2020). In densely populated cities, urban spaces often fail to serve as areas of relief and instead become sources of heightened stress. Research indicates that crowded urban environments are linked to increased stress levels, higher rates of depression, and other psychological disorders (Adli, 2011; Heinz et al., 2013; Hosang, 2016). Additionally, environmental demands-whether physical, mental, social, or emotional-further intensify these pressures (McSweeney et al., 2021).

Amid these challenges, the concept of perceived oppressiveness emerges as a crucial yet often overlooked factor in urban psychology. This term refers to a subconscious feeling of psychological pressure that discourages individuals from fully engaging with certain urban spaces (Asgarzadeh et al., 2012; Chung et al., 2019; Luo & Jiang, 2022). These environments are not merely physically restrictive but also mentally exhausting, contributing to increased psychological fatigue and avoidance behaviors. At the same time, rapid urbanization and the shrinking availability of green spaces have significantly reduced opportunities for restorative interactions (Peschardt & Stigsdotter, 2013). Even small urban green spaces play a vital role in alleviating psychological stress and supporting mental well-being (Birch et al., 2020; Dzhambov et al., 2019; Pearson & Craig, 2014; Wang et al., 2019).

Given the pervasive exposure of individuals to urban environments, understanding and addressing the factors contributing to perceived oppressiveness is essential. Identifying these dimensions and integrating them into urban design strategies can not only alleviate psychological stress but also create spaces that actively foster mental restoration and enhance societal resilience.

Based on what has been discussed, the importance of examining the relationship between landscape architecture and the mental health of individuals in urban spaces is clearly evident. In particular, the feeling of perceived oppression and psychological pressure in crowded spaces can have significant negative effects on the well-being of individuals. Therefore, the main question of this research is, "How can urbanscape design reduce this feeling of perceived oppression and improve mental health?" In response to this question, the content analysis method has been used as a qualitative approach, through which data are extracted and analyzed from various scientific sources. This method is particularly effective in identifying and analyzing the various dimensions of complex and multifaceted issues, such as landscape architecture and its effects on mental health. In this study, after reviewing various scientific sources and theories in this field, data related to the different dimensions of landscape design and mental health were collected and analyzed from reliable databases in order to identify effective solutions for improving the quality of life of citizens and reducing the feeling of oppression.

2. Material and Method

The approach of this paper is qualitative, and content analysis has also been used. Content analysis, as a research method, is used to analyze communications in a purposeful, systematic, and quantitative manner to measure influential variables (Kerlinger, 1986). Also, Holsti (1968) emphasizes the importance of inference by identifying specific features of messages in a purposeful and systematic manner (Holsti, 1968). Content analysis seeks to extract and analyze the content from a message. In this study, four main databases, such as Google Scholar, Scopus, Science Direct, and SAGE, were used to collect data. In this process, filters such as articles in English and scientific and social fields related to social sciences, environment, arts, and humanities were applied to extract and analyze data. The data were evaluated for the period 2000-2024.

The literature review process in this paper included two main categories: perceived oppression and urbanscape indicators and components. In this regard, articles and sources related to these two topics were carefully reviewed and analyzed to identify and systematically code the findings and theories in these areas. This study aims to provide new insights into the role of landscape architecture in reducing perceived oppression and improving mental health, and analyzes and reviews related content.

3. Findings and Discussion

Based on what has been discussed, users in dense urban environments face a type of perception called "perceived oppression". Given that this type of perception can affect the mental health of citizens, therefore, identifying its dimensions can be important. Accordingly, the present study focuses on its factors and uses landscape elements as a mediator.

Humans are always interacting with their environment, including the landscape. Several factors can be considered effective in human perception of landscape. Kamičaitytė et al. (2020) proposed a theoretical model of landscape perception based on three features: the physical characteristics of the landscape, the psychological profile of the observer, and the interaction between the two. This interaction, they argue, is deeply shaped by socio-cultural contexts, including social and cultural features and functions (Kamičaitytė et al., 2020). Moreover, Khaledi et al. (2022) identified four key categories that influence human perception of landscapes: (1) Human factors, (2) Heritage, (3) Infrastructure, and (4) Landscape characteristics. These categories, are interconnected and form a hierarchical structure that shapes how individuals perceive their environment (Khaledi et al., 2022). The landscape is a composite whole formed by a range of components, and it connects people to places (Spirn, 1998). Furthermore, the landscape can be viewed as an objective-subjective phenomenon (Mahan & Mansouri, 2017), where humans are an inseparable part of the landscape's identity.

In discussions of human perception of the environment, a factor called 'perceived oppression' refers to a type of hidden stress experienced by users in dense urban environments. Perceived oppression refers to a psychological sense of pressure or distress experienced by users in dense urban environments, particularly in streetscapes dominated by tall buildings. Studies highlight that factors such as building height, width, configuration, and angle significantly influence this perception (Asgarzadeh et al., 2012; Zarghami et al., 2019). This phenomenon not only affects individuals' mental health but also poses challenges to achieving sustainable urban development (Asgarzadeh et al., 2009). Landscape architectural elements appear to prevent the emergence and intensification of this type of perception while also enhancing resilience by fostering a favorable psychological environment for citizens.

This study has classified landscape factors that affect resilience into four main categories: biological, social and interactional, physical, and management and planning dimensions. Each of these categories encompasses multiple dimensions, as listed in Table 1.

Table 1. Aspects and Dimensions of Landscape Architecture in Promoting Resiliency

Aspects	Dimensions	Source
Biological	Enhancing air quality and access to green spaces	(Peschardt & Stigsdotter, 2013)
	Reducing noise and environmental pollution	(Dzhambov et al., 2019)
	Improving physical health through walking and cycling paths	(Birch et al., 2020)
Social and Interactive	Enhancing social interactions and fostering social support	(S. L. Cutter et al., 2008)
	Promoting social justice in access to public spaces	(Ross et al., 2010)
	Strengthening collective identity and shared memory	(Adger, 2000)
	Increasing social and educational awareness	(Kuhlicke et al., 2011)
	Addressing vulnerable groups such as the elderly and children	(Buckle et al., 2001)

	Promoting social security	(Sanders et al., 2008)
	Strengthening social stability	(Aldrich & Meyer, 2015)
	Enhancing social cohesion	(Adger, 2000)
	Developing social participation	(Voss, 2008)
	Strengthening social trust	(Ross et al., 2010)
	Increasing emotional attachment to places	(Burton, 2012)
	Supporting cultural and creative activities	(Ross et al., 2010)
Physical	Designing public spaces with effective lighting	(McSweeney et al., 2021)
	Using natural and sustainable materials	(Wang et al., 2019)
	Creating safe pathways for pedestrians and cyclists	(Dzhambov et al., 2019)
Managment and Planning	Planning for balanced population density distribution	(Khazai et al., 2015)
	Managing urban population growth	(Normandin et al., 2009)
	Considering past experiences and applying lessons learned	(Norris et al., 2008)
	Enhancing flexibility to adapt to environmental changes	(Twigg, 2009)
	Implementing participatory policies in urban landscape design	(L. Cutter et al., 2008)
	Conducting social evaluation and monitoring	Abarquez & Murshed,) (2004
	The role of educational and religious institutions in social management	(Khalili et al., 2015)
	Utilizing local social organizations	(Burton, 2012)
	Using social networks for community participation	(Norris et al., 2008)

4. Conclusion

The findings of this study indicate that landscape architecture plays a very important role in reducing perceived oppression and, consequently, improving the mental health of individuals in urban spaces. Urbanscape design based on the stated approach is able to reduce the feeling of oppression and alleviate psychological stress for citizens by providing a relaxing space. The findings indicate that four basic dimensions affect perceived oppression: biological, social and interactive, physical, and management/planning aspects. These elements interact with each other in a hierarchical process, and attention to each of them is effective in improving the overall mental health and resilience of the community.

Among the most important findings of this research, the impact of biological aspects such as improving urban air quality and access to green spaces, social aspects that enhance social interactions and a sense of support, physical aspects such as designing public spaces with appropriate lighting and natural materials, as well as urban management and planning, which, when applied correctly, can provide healthier environments for urban life. These elements not only help reduce perceived oppression but also improve the mental health and social well-being of residents. The mutual interaction of these elements in a hierarchical structure, especially in the landscape design process, can effectively lead to the promotion of psychological and social well-being.

However, this research, like other studies, faces limitations that can be addressed in future research. One limitation is that the research data is mostly qualitative. Therefore, quantitative studies and the use of larger samples are necessary to confirm the findings. Another limitation is the measurement of the long-term effects of landscape designs on mental health. Future studies need to examine the effects of perceived oppression in urbanscape over extended periods. It is suggested that similar studies be conducted in different geographical areas with varying social, economic, and cultural characteristics in order to examine the effects of landscape design at more diverse levels. Additionally, conducting comparative studies between different regions can help identify more effective components in reducing perceived oppression.

The findings of this study can have broad operational applications in the field of urban space design. Based on the results of this study and in line with other research, creating more green spaces and providing easy access to them can help reduce stress and anxiety and improve the mental well-being of residents. Designing spaces that facilitate social interactions and foster a sense of support and belonging can help reduce perceived oppression and strengthen social resilience. In addition, the use of landscape design principles in urban planning processes can help promote the overall and psychological well-being of individuals, thereby creating more sustainable and healthier communities. Ultimately, the application of these principles can help urban managers, landscape designers, and policymakers design environments that, in addition to being functional, also improve the mental and social health of residents. These findings can be applied by urbanscape managers and planners. By adopting this approach, we can expect to have healthier cities for people facing mental health challenges.

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Designing Cities for Zoonotic Resilience - A Landscape Oriented Approach

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Abstract

Humans have coexisted with various species throughout history, but human-wildlife conflict is now becoming a growing concern. Beyond the loss of human life, animals are increasingly adapting to urban environments (synurbanisation), exhibiting traits termed urban wildlife syndrome. This, combined with microbial transfer, has contributed to notable plagues, epidemics, and pandemics. Around 60–80% of infections affecting humans are zoonotic, originating from animals, and this trend is becoming a major issue. While urbanization, habitat fragmentation, biodiversity loss, and agriculture are often cited as causes, few studies explore their connection to landscape architecture. Research in veterinary science and epidemiology has only occasionally cited distant linkages. This paper explores zoonoses through the lens of landscape architecture and examines how zoonotic resilience can be achieved via landscape design. It presents a prototype framework adaptable to urban ecosystems, emphasizing landscape architecture's potential to mitigate zoonoses. This knowledge is crucial for preventing future outbreaks in the post-pandemic era. The paper explores measures for fostering urban zoonotic resilience, emphasizing the need to reorient development norms amidst climate change. It highlights design interventions, expert consultation, and policy reforms as essential. Mimicking natural ecosystems and addressing ecological and conventional parameters individually are key strategies to mitigate zoonotic risks and enhance success rates.

Keywords: Biodiversity, healthy cities, landscape architecture, urbanization, zoonoses

1. Introduction

“The clash of human and animal interests may create friction when wild species from the peri-urban hinterland are attracted to feeding or nesting opportunities in the ever-expanding suburbs.” – An excerpt from Animal cities – Beastly urban histories by Peter Atkins

The above excerpt perfectly highlights a gist of the context that this research proposal strives to address. Over 3.5 billion years of evolution and adaptation on Earth has enabled microbial transfer through migration and civilization encounters, leading to infamous plagues and pandemics responsible for decimating our ancestral populations. And today zoonotic diseases or zoonoses are slowly turning into a predominant issue of concern discipline of public health sector. The rise or re-emergence as well as discovery of new disease causal pathogens such as Middle Eastern Respiratory Syndrome (MERS), Ebola virus, Nipah, Covid 19 etc. are a few to name, among the numerous virulent strains across the world. With the discovery of every novel zoonotic infection among the human population, it is being proven and confirmed that 60–80% of documented zoonoses are of animal origin (CDC Yellow Book 2024). Additionally, novel zoonotic diseases are known to manifest and escalate within short timespan as well. The spillover of human pathogens from animals to people is a serious concern for a globally connected community driven by social interaction and urbanization, seeking progress and a better tomorrow.

Improper land use and the conversion of wild habitats into agricultural areas to meet the growing food demands of a rapidly expanding population often contribute to zoonotic infections in humans. These challenges are deeply rooted in how we manage landscapes, the environment, and the planet. Landscape architecture plays a critical role in mitigating these issues by designing, preserving, and integrating nature within urban and global development. While studies link biodiversity loss and environmental destruction to zoonotic diseases, few address how landscape architecture can mitigate such risks. A deeper exploration of urban fringes—zones with high zoonotic pathogen transfer potential—is essential. Understanding the characteristics of these areas could help identify sites prone to disease transfer and guide strategies to protect biodiversity without compromising food security or development. The destruction of biodiverse habitats, analogous to removing a keystone in an arch, can destabilize ecosystems, prompting human-wildlife conflicts and resource competition in urban settings.

The current rate of species extinction is not only accelerating but is now estimated to be tens to hundreds of times higher than the average rate over the past 10 million years. Of the estimated 8 million plant and animal species, about 1 million are threatened with extinction, and over 10% of genetic diversity in flora and fauna may have been lost in the past 150 years (Richardson et.al. 2023). As cities transform into distinct urban ecosystems (Oke et.al. 2017), changes in environmental ecology can severely impact ecosystem dynamics and therefore zoonotic scenario; an issue likely to worsen with climate change. Studies show that nearly 80% (4.8 billion) of the global population in 2000 lived in areas where biodiversity threats exceeded 75% (Vörösmarty et.al. 2010). In a post-pandemic world with rising zoonoses, this knowledge is crucial for preventing future outbreaks.

The rising cases of zoonotic diseases highlight the need for a multidisciplinary approach in land use planning and development (One Health). Integrating health resilience into landscape design is still underexplored in landscape architecture. Collaboration among ecologists, landscape architects, planners, and veterinarians fosters a comprehensive understanding of ecosystems. Their engagement with local communities enables partnerships with planners and developers to create cost-effective solutions beyond pandemic response. This paper explores strategies for landscape architects and urbanists to mitigate synurbanisation[1] impacts and develop zoonotically resilient cities amid climate change.

2. Material and Method

This study aims to examine zoonoses through the perspective of landscape architecture and investigate how cities today can become resilient to zoonotic diseases using a landscape design-centered framework. This approach seeks to alleviate pressure on existing public health systems by integrating design solutions.

The primary objectives of this research are:

- To comprehend the fundamentals of zoonoses and analyze their relationship with landscape architecture through the One Health approach.
- To critically assess relevant theories and design strategies that can contribute to the development of zoonotic-resilient cities.
- To develop a comprehensive design framework and guidelines for creating health-resilient, habitable landscapes that are adaptable across diverse ecosystems without causing adverse effects on wildlife or human communities.

[1] Synurbisation is a wildlife response outcome of synanthropization under the context of urbanization; denoting the adjustment of a certain species populations to specific urbane conditions in connection with regular existence (often breeding) there in the wild status quo. Synanthropization refers to the adaptation of animal populations to anthropogenic conditions while urbanization refers to environmental changes as a result of urban development. Infact a global study comprising data from 379 cities on six continents has revealed such species to have adopted a collection of common characteristics nicknamed as "urban trait syndrome."

This research aspires to establish an inclusive and equitable landscape design that indirectly enhances zoonotic resilience. To achieve this, the study adopts a focused and practical research strategy. The methodology primarily utilizes an inductive approach, complemented by hybrid methods, as outlined by Swaffield (2006) in Landscape Architecture Research - Inquiry, Strategy, Design. The research integrates case study analysis and thematic content analysis to derive qualitative insights and construct a framework for zoonotic-resilient landscapes. The research strategy draws inspiration from Groat and Wang's Architectural Research Strategies (2002) and the work of Robert Johnson.

For clarity, critical terminologies used in this study are defined as follows:

Zoonoses: Diseases caused by pathogens that are endemic to human populations or enzootic in animal populations, with frequent cross-species transmission to humans. According to WHO, zoonoses are diseases or infections naturally transmissible from vertebrate animals to humans through direct contact, food, water, or the environment, encompassing both existing and emerging infectious diseases. Emerging infectious diseases are those that have either newly appeared in human populations or are rapidly increasing in spread (WHO, 2014). The term "zoonoses" was first introduced by Rudolf Virchow and derives from the Greek words zoon (animal) and noson (disease). Zoonoses are particularly significant at the human-animal interface, where the risk of disease transmission is highest. These infections are major contributors to infectious disease outbreaks, placing significant strain on public health systems and leading to consequences like mortality and food insecurity. Zoonotic diseases are categorized based on various parameters, with some of the most common classification criteria including etiological agent, mode of transmission and reservoir host.

Around 60% of human infections originate from pathogens hosted by wildlife or domesticated species, reflecting the complex interaction between humans and nature. Zoonoses, a longstanding phenomenon, arise from the ability of microbes to adapt to new hosts over time. Although natural processes can create niches for pathogens, human activities have the most significant impact. These activities, including land use change, resource extraction, animal farming, and global trade, disrupt the ecological processes that regulate pathogen survival. Practices such as wildlife hunting, exotic animal domestication, and overgrazing facilitate pathogen transmission. Recent research also highlights the emergence of unnoticed pathways, including antimicrobial resistance (AMR), stormwater runoff, non-point source pollution, open defecation by animals, and hospital- associated infections.

The research adopts a macroscopic perspective to create a flexible prototype suitable for various landscape design contexts, regardless of ecological differences. It will also explore the role of common zoonotic hosts in natural settings to assess their impact on urban landscapes. Understanding these dynamics will be essential for shaping the proposed design framework, with host selection guided by ecosystem diversity.

Due to the novel nature of this research topic, accessing comprehensive data may pose challenges. Time and geographical constraints will likely necessitate reliance on secondary data sources. Consequently, the study will primarily address zoonotic diseases holistically at a broader scale, focusing on vector classifications.

Google Scholar was extensively utilized for literature searches, employing keyword combinations like "zoonoses," "landscape architecture," "design interventions," "framework," and "design guidelines" within the fields of landscape architecture, ecology, and health. Alongside academic sources, the author's experience as a research associate at NIUA informed the study. The majority of the data consulted was from recent publications (5-10 years), though older relevant sources were also reviewed. References from selected studies were further examined for relevance.

The World Health Organization defines human health as complete physical, mental, and social well-being, not merely the absence of disease (WHO, 1946). The decline in human health is closely tied to environmental degradation, underscoring the importance of addressing the relationship between human health and the natural environment. While the link between ecosystem services and health is recognized, public health often remains sidelined, which leads to the neglect of vital conditions for sustaining life. This neglect contributes to the spread of zoonotic diseases, especially when public health considerations are excluded from landscape conservation and infrastructure planning. Green infrastructure, whether large or small, can provide health benefits, but its effectiveness depends on connectivity to maximize its life-supporting potential.

3. Findings and Discussion

Human habitat design has historically prioritized health, shaped by environmental factors such as landforms, water, climate, vegetation, wind patterns, and epidemics (Martensen, 2009). Public health evolved through two primary schools of thought: miasmists, who attributed diseases, particularly among the poor, to "bad air," and germ theorists, who identified pathogens spread through poor sanitation. The discovery of pathogens shifted public health focus toward immunization, reducing emphasis on environmental factors. However, the link between landscape and health remains significant. Green infrastructure emphasizes the health benefits of well- designed environments (Rouse & Bunster-Ossa, 2013). Ecological models of health underscore the importance of understanding human-environment interactions for promoting health, providing a foundation for landscape designers, architects, and planners to balance human well-being with environmental sustainability.

The relationship between health and disease ecology highlights the role of landscape modifications in human- zoonotic interactions and pathogen transmission. Human interaction with animals and ecosystems is a natural pathway for pathogen transmission. Green infrastructure promotes biodiversity, but human activities increase health risks by disrupting ecosystems. Research indicates that green space composition impacts zoonotic disease spread by influencing pathogen reservoirs and vectors, affecting both biodiversity and human health. A thorough understanding of human-environment relationships is essential for effective disease ecology.

Landscape changes, particularly in tropical regions, can enhance zoonotic disease risks. For example, the wild meat trade, a major source of protein and income, increases human contact with zoonotic pathogens during hunting and butchering (Nasi, Taber, & Van Vliet, 2011). Economic drivers like commercial logging have transformed subsistence hunting into a commercial activity, further facilitating pathogen transmission as roads and markets increase wildlife trade. Zoonotic diseases like Ebola and anthrax can result from a single animal- to-human transmission, with repeated spillovers, or "viral chatter," enabling viruses to adapt to human hosts (Wolfe et al., 2005; LeBreton et al., 2012).

Human-driven landscape changes, such as forest fragmentation, increase contact between humans, wildlife, and livestock, facilitating the spread of zoonotic diseases. For example, shared bacteria in the gut of primates, humans, and livestock near fragmented forests (Goldberg et al., 2008) underscore this risk. The Nipah virus outbreak in Bangladesh is another example, where bats contaminate date palm sap consumed by humans, heightened by fragmented forests and agricultural practices (Luby et al., 2006; Hahn et al., 2014).

Landscape alterations also impact vector-borne diseases, which account for nearly 30% of emerging infections. Deforestation and water projects create new breeding grounds for vectors, escalating disease transmission risks (Jones et al., 2008; Patz et al., 2008; Patz et al., 2000). While resilience in planning traditionally focuses on recovery from natural disasters, it is increasingly crucial to design zoonotic-resilient landscapes. The One Health Approach, integrating ecological and health disciplines, is essential for preventing zoonotic disease transmission (Ostfeld, Glass, & Keesing, 2005). Effective ecological interventions, such as restoring predator habitats, can reduce spillover risks more successfully than conventional methods like deforestation (Nasi, Taber, & Van Vliet, 2011).

This research highlights the critical parameters influencing zoonotic behavior in landscapes namely climate, ecosystem ecology, land use, deforestation, habitat fragmentation, agriculture, food insecurity, socio-economic factors, and landscape design interventions.

4. Design for Zoonotic Resiliency in Urban Landscapes

Ecological resilience underpins the capacity of landscapes to deliver health benefits despite environmental challenges, highlighting the vital connection between human health and ecosystem stability. Recognizing this link bolsters efforts to conserve natural blue-green infrastructure. The human ecosystem approach integrates social and ecological systems to emphasize reciprocity between environmental health and human well-being. This dynamic framework, adaptable across scales, underscores the role of ecological systems in human sustenance. However, rising human-wildlife interactions heighten zoonotic risks, necessitating multi- disciplinary collaboration to mitigate infections. Rather than disrupting habitats, landscape architects must champion nature-based, biomimetic solutions, ensuring sustainable coexistence among all species involved.

Based on the literature data reviewed on the concept and functionality of zoonoses, the entire inference towards the basics of landscape planning and design approach when it comes to designing zoonotic resilient landscapes can be categorized into the following categories:-

- Site selection criteria
- Design approach
- Policy level interventions
- Design guidelines and checklist

Together all these constitute a generic framework for designing a zoonotic resilient landscape that may be used an adapted according to the site context.

Site Selection Criteria

Selecting the right site is crucial for project success, as it can significantly influence outcomes. Every landscape supports specific anthropogenic activities and land uses, which must align with existing ecological processes. Unfortunately, interventions often disregard these ecological systems, leading to severe ecological issues such as zoonotic disease outbreaks, which can trigger a cascade of problems. To create zoonotic-resilient landscapes, it's essential to map socio-ecological spaces at both regional and micro-site levels. Socio-ecological systems (SES) recognize the interconnectedness of human and ecological systems (Berkes et al., 2003). In this framework, socio-ecological hotspots are areas of high perceived landscape value and favorable biophysical conditions, while low-value, high-bio-physical locales are SES warm spots that need conservation. Regional analysis identifies eco-sensitive areas requiring controlled or minimal development, while site-level mapping ensures preservation of crucial ecological regions. Understanding SES is key to identifying factors that enhance or compromise landscape resilience.

A micro level decision tree to assess the quality of the site before proposing a design on a landscape is illustrated below :-

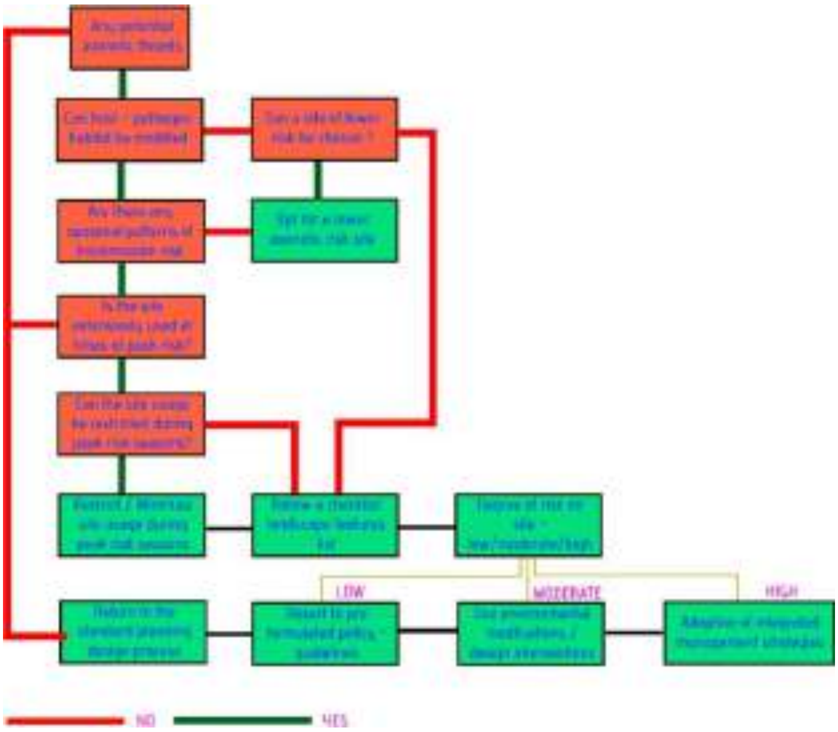

Figure 1. Site Selection Tree (Source-Author)

Another important factor during site selection is determining the intensity of risk the site holds with respect to designing of the landscape. Following are a set of checkers to determine the same.

A site is high risk if any one of the following is true

- The site includes an eco – sensitive and biodiverse region such as forest, wetland etc.
- The site extent is less than or equal to 0.5 acres.
- The site is a habitat for potential host vectors or was previously a home for them.
- There have been past cases of zoonotic cases in the site or in the near vicinity.

A site is moderate risk if any one of the following is true

- The site consists of a patchy habitat with high proportion of ecotones.
- The site includes artificially intervened landscape elements at a distance ≤1m from the ecotones.
- There have been occasional sightings of potential host vectors on site.
- There have been occasional cases of zoonotic cases in the site or in the near vicinity.

A site is low risk if any one of the following is true

- The site has already been designed once and includes ornamental plantings, lawn, grasslands, open spaces etc.

Design Approach

Designing zoonotic resilient landscapes requires a site-specific approach, starting with understanding how zoonoses spread within the area. This informs the design strategy for creating a landscape resilient to zoonotic diseases. The next step is analyzing the site's ecological complexity, divided into transmission complexity (current and future zoonotic transmission) and site-specific factors (attributes influencing transmission). Climate's impact on zoonotic activity must also be considered. Creating a relationship map of species interactions helps clarify these impacts. Once zoonotic activity is understood, a disease ecology perspective can guide design, balancing animal and human health equity. Finally, guidelines and policies can be developed

Policy level interventions

Before drafting the design guidelines, mandate policies to combat the effects of each parameter need to be drafted so that they can be adopted on generic terms, regardless of the type of landscape that is being dealt with.

Design interventions

Post the formulation of policies at a macroscopic level, design guidelines to be incorporated at the site level need to be formulated. The prime factor that sets ecological interventions apart from conventional interventions is that they are aimed towards managing the underlying transmission processes based on ecological understanding of the landscape in reference. transmission process. Most often conventional management strategies are more focused towards directly and perhaps temporarily altering the count of susceptible, infectious and recovered individuals. Ecological interventions are based on the idea that zoonotic spillover can be prevented or limited by reducing or debarring the pathogenic flow across on one or multiple potential barriers in several layers and systems such as culling population size, pathogen persistence in the environment, reservoir – spillover host contact etc.; inorder to prevent the pathogens and host from aligning in space and time.

Formulating site specific interventions is illogical due to the uniqueness associated with each site; however generic guidelines that need to be taken in to consideration for blue - green infrastructural design may be formulated. This includes:

Table 1. Design Guidelines for Achieving Zoonotic Resilience in Urban Landscapes

Design Guidelines for Achieving Zoonotic Resilience in Urban Landscapes		
S.No	**Landscape Type**	**Guidelines**
1.	Open Greenspaces like urban forests, parks etc.	• Avoid planting fruit trees around site boundary or near to domesticated animal zones as they act as a beacon for potential vector hosts like bat. • Understand the predator – prey relationship in a design project before intervention – manipulation of this relationship can tamper the species diversity and count. • Interaction with potential vectors such as rodents must be minimized as much possible. • Selective defaunation must be avoided as much possible. • Techniques like zooprophylaxis[2] and dilution effect need to be incorporated as design strategies as well for large scale projects. • Maintaining interconnectivity between the landscapes is extremely important to ensure unwanted spillover is prevented. • Suitable landscape habitats need to be developed for ensure that the potential vectors or hosts stay confined to those boundaries instead of invading into the human habited zones for food, water,etc • Potential routes for movement of these hosts into the human settlements (like through railways, waterways, sewage systems, etc.) need to be blocked through proactive site planning and technological interventions. Simultaneously alternate movement trails for the vectors through permissible landscape regions need to be developed as well. • Densely planted vegetation patches need to be reduced to avoid unexpected fostering of newly introduced pathogens into the urban landscapes. • The connectivity between resource rich landscape patches need to be minimized as much possible or if connected be placed with some buffer between them and the human settlements to prevent spillover. • Increased understanding of the complex life cycles of the pathogens and their vectors is essential for developing effective risk reducing ecosystem interventions.

2.	Waterbodies and Wetlands	• Artificial waterbodies need to be constructed depending on the need and site context of the site as larval populations densities are known to be higher when compared to natural environments. It is preferable to introduce waterbodies only if the functional requirement cannot be met by alternative means. • When constructing artificial waterbodies, efforts must be undertaken to prevent water stagnation (one of the potential factors that make a water habitat suitable for vectors like mosquitoes) via introduced movement using components like pond pumps, waterfalls, fountains, aerators etc. • A carefully curated palette of natural predators need to be introduced into these waterbodies – both artificial and natural to avoid unnecessary pathogenic host proliferation. • Increasing the holistic ecosystem complexity should also be encouraged in urban wetland and water planning as a means of reducing the threats of host vector proliferation. • Buffer strip (riparian edge) along the water bodies without anthropogenic interference need to be developed along the water edge with periodic pest management. • Increasing the incline of the sides of the constructed water body may also be done to eliminate shallow areas where sunlight reaches the bottom inorder to avoid creating suitable environment for excessive vegetation growth that can promote unwanted pathogenic growth.
		• Cautionary signages with protective detail measures need to be placed in all moderate to high risk sites. • Pathways need to be wide enough to avoid any potential contact with adjacent vegetation. • Pathways need to be constructed using xeric materials or treated with desiccant. • Dense bushes, ground covers and heavy leaf litter need to be kept at a distance of atleast 3m away from the pathway edge.

[2] Zooprophylaxis implies the use of non-reservoir host of a certain disease (wild or domesticated animals) inorder to divert the vectors of the concerned disease from human hosts.

5. Conclusion

Human health and survival have long been deeply connected to nature, but human activities have increasingly disrupted even remote wilderness areas. In the Anthropocene era, rapid technological advancements have fostered a misleading belief in human independence from nature, largely due to reduced interaction with natural environments and essential ecological processes. Although technology has prolonged human survival, it cannot substitute the Earth's natural life-support systems. Climate change significantly impacts entire ecosystems, potentially increasing disease risks. Addressing this requires better understanding of disease ecology, long-term monitoring, and adaptive strategies.

Humanity often relies on advanced technological solutions to tackle problems when proactive planning could address issues at their source. This paradox is explored in the study of how landscape architecture can help mitigate zoonoses. The research suggests that such mitigation is possible, but success relies on interdisciplinary collaboration and regional policy implementation. Understanding the causes of zoonoses is critical to developing effective public health strategies. The complexity of disease emergence, driven by human actions, requires extensive field studies. Ecological interventions, focusing on ecosystem processes, offer potential solutions by managing spillover risks, emphasizing the need for integrated approaches to tackle zoonotic threats.

Endnotes

Originally this research work was undertaken as part of dissertation towards partial fulfilment of the requirements for the award of the Master of Architecture (Landscape) in the Department of Architecture, School of Planning and Architecture, Vijayawada. A modified version of this research work was presented under the category of oral presentation titled " Designing Cities for Zoonotic Resilience - A Landscape Oriented Approach" presented at IFLA 2024. This paper is an extraction of the oral presentation.

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The Latent Layer of the Landscape: *Plant Bioacoustics*

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Abstract

Considering human history, the vital harmony between human and nature has continued uninterruptedly until recent times how people create their relationship with nature can be observed through the tribal societies that have survived to this day and their ongoing rituals. However, today, it can be seen that the results of many human-oriented destructive actions stem from the disconnection of the human-nature interactional network. The teachings of Shamanism, with their role as information transmitters that emphasize the unity between human and nature, mention the existence of an auditory layer. In Shamanic teachings, this auditory layer involves the integration of plants (especially beech and pine species) into social life. There's a similar acceptance of the same auditory layer in the contemporary scientific approach today: bioacoustic phenomenon. Bioacoustic phenomenon occurs when plant organisms perceive and emit certain sounds in their own audible frequency ranges. So, how this human-plant communication has transformed is a question worth asking. In this scope, the aim of the study is to examine the evolution of plant acoustics, which is poised to become a significant datum in human-nature communication, from shamanic teachings to the present day. In line with this goal, it is aimed to investigate the formal and functional role of the auditory layer present in Shamanic rituals and to determine chronologically for what purposes plant acoustics are used in today's technology. In this context, the literature data on bioacoustic rituals in Shamanism will be examined concurrently with current experimental studies aimed at obtaining plant acoustic frequencies. The potential of this auditory layer can be as a guide in repairing of human-nature interaction will be discussed.

Keywords: Plant bioacoustics, auditory landscape, nature-based rituals, human-nature relationship, Shamanism

1. Introduction

The teachings of Shamanism, with its role as a transmitter of knowledge emphasising the unity between human and nature, speak of the existence of an auditory layer. This auditory layer is incorporated into social life through plants in Shamanic teachings. The acceptance of the same auditory layer in the contemporary scientific approach is the phenomenon of bioacoustics, which consists of plant organisms perceiving and emitting certain sounds in their own audible frequency ranges (Bayat, 2023). So, how has this plant-human communication, which is nowadays called 'plant bioacoustics', but whose foundation dates back to much older times, been transformed?

Figure 1. Mother tree with nests on which shaman candidates are trained (Bayat, 2023)

The research is based on this problematic. In the most general terms, shamanism is defined by three main functions. These are; seeing, understanding and communicating (Bayat, 2023). In other words, Shamanism emphasises the unity between human and nature with an auditory layer.

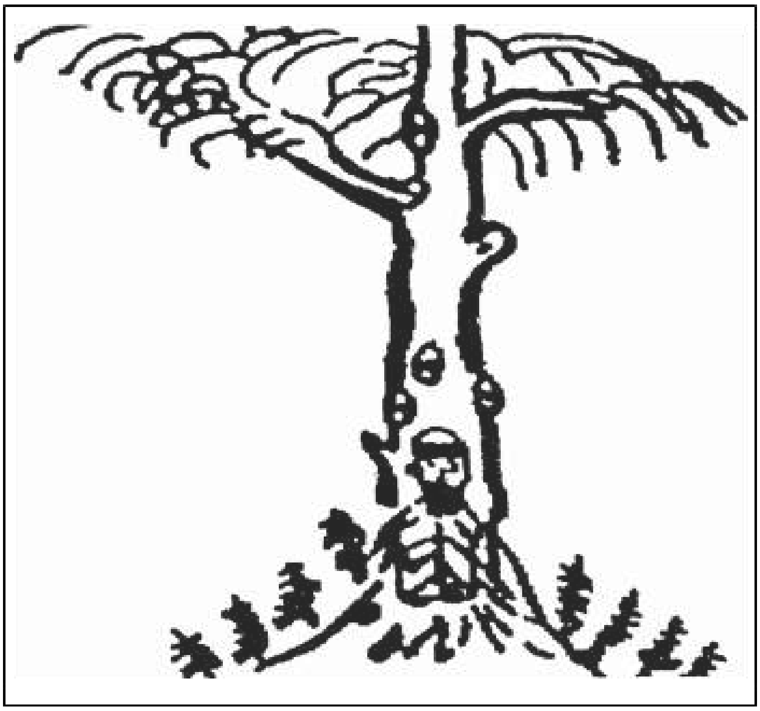

Figure 2. Mother tree where shamans grow in their nests (Bayat, 2023)

2. Material and Method

The study aims to examine the evolution of plant bioacoustics, which is a candidate to be an important data in human-nature communication today, from Shamanic teachings to the present day, and to question how these teachings can be utilised in order to repair or revitalise the relationship network between nature and human beings.

In line with this aim, three main objectives are set out, one after the other. The first main objective is to analyse the formal and functional role of the auditory layer in shamanic rituals. The second is a chronological evaluation of the uses of plant bioacoustics in today's technology. The last one is to question the contribution of plant bioacoustics to today.

Methodologically, literature data on acoustic rituals in shamanism and recent experimental studies on plant bioacoustic frequency acquisition were compared and evaluated. In addition, visuals and video sources of rituals were also analysed and included in the study.

3. Findings and Discussion

In shamanic teachings, especially in the periods before the industrial revolution, human beings and nature are regarded as equal values in an existential unity. The formal and functional role of the auditory layer in shamanic rituals is illustrated by three different examples.

The first of these examples is taken from an article belonging to the Udmurt tribe. This article is devoted to the Udmurt understanding of the world of sounds, the norms of behaviour towards sound in the acoustic community. The Udmurt's sonic worldview is formed under the influence of the landscape. The distinctive sound of the forest, which the Udmurts see and hear in their own unique way, results in a specific sound response and musical approach. According to this tribe, the natural environment is full of different kinds of noises and sounds, which are defined and charged with cultural concepts in the traditional consciousness. In particular, they see natural sounds as special signs or signals from the other world. In a 19th century study, it was observed that the Udmurt produced instantaneous reactions to ordinary natural phenomena (Nurieva, 2021).

This leads to the following extraction; the Udmurt tribe seeks to understand nature in order to achieve a better state of being and to access the essence of knowledge.

The second case study focuses on how the various formal meanings of trees in Shamanic rituals have acquired functional meanings. The use of trees in artefacts or as medicines for healing purposes, that is, the lifelong role they play from cradle to grave, has led people towards them (Tanyu, 1976: 129). For example, it is believed that the beech tree, one of the species considered sacred, was brought down from the sky in the teachings of Shamanism. The reason for this is supported by a legend that has been told for generations. In the legend, when the first man wanted to know where he was created from, he approached a beech tree and a voice coming from the hollow of the tree whispered that he was created as the father of the human race (Çoruhlu, 2002:130) (Sarıtaş, 2011).

This legend expresses the effort to make sense of and benefit from nature and its own existence by questioning its existence through trees, which are seen by people as a concrete symbolic element that connects the earth and the sky.

The last sample is shaped by the gifts of knowledge acquired by the Shamans who interacted with the Peruvian Forest. In this jungle, teachings on the diagnosis and treatment of diseases with different types of plants were obtained. For example, a shaman named Don M., in one of his solitary treatments in the middle of the jungle, stated that the plant spirits called him by name and gifted him with dreams, visions and precious medicine songs (icaros-healing songs).

It has been argued that these songs, far from being a metaphor, are tangible gestures of the plant's fondness to communicate and relate to man through kinship. It is also recognised as a blessing that gives man access to the enriching power of the plant, a priceless gift entrusted to the heart of the shaman as the guardian of knowledge. For thousands of years, shamans around the world have learnt their songs as a way of communicating with these non-human beings. So in the midst of the Peruvian Forest, plants have spoken through dreams, visions, telekinetic speech and songs. As they have done for thousands of years, they have taught their role in supporting the physical, psycho-emotional and spiritual development of humanity on an individual, societal and planetary level (Gagliano, 2018).

This study draws inferences about Shamanic teachings in terms of learning on the spot, gaining knowledge about being, healing and strengthening human development, that is, that nature is the center of knowledge and that human beings take this knowledge from it in various ways and incorporate it into their own being.

Looking at the present, it is noteworthy that the interaction and/or communication between human and nature has come back on the agenda and studies have tried to emphasize its importance.

The first of these studies was conducted by Brenner et al. (2006) in the context of plant neurobiology, investigating the signaling mechanisms between plants and their neighbors as well as whole plants. These studies focus on uncovering the function of long-distance electrical signals and fully understanding their role in regulating plant responses.

Another study attempts to make sense of nature by looking at the communication between plants. Going one step further, ‘Plant nanobionics’, which is considered as one of the methods of obtaining mechanical vibration from plants, has emerged due to nanotechnological methods. Studies show that plants exposed to osmotic or drought stress close their stomata and transmit this condition to the rest of the neighbouring plants that are not under stress (Falik, et al., 2012). Uses of nanotechnology include gene transfer to plants with the help of nanoparticles to develop insect-resistant varieties, food processing and storage, nano feed additives and increasing product shelf life. MIT engineers have created new sensors that can be placed on the leaves of plants (Sharma & Kar, 2019). These sensors will detect water scarcity and help recognise plants facing drought conditions (Saxena, Tomar, & Kumar, 2016). Thus, the intermediary role of plants in human-nature interaction will be concretized as a messenger of changing environmental conditions.

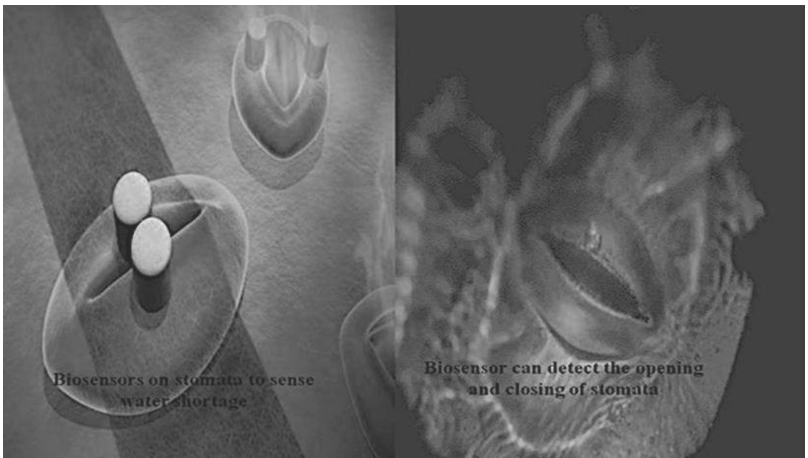

Figure 3. Nanobionic plants used as biosensors to detect drought (Saxena, Tomar, & Kumar, 2016)

In another study conducted in the similar years, corn plants were used. This study provides important information on whether, why and how plants perceive sound and vibration in their environment. The study of plant bioacoustics has revealed how the roots of the corn plant are oriented towards acoustic signals in water, the response of the roots tilted towards the source of the sound at different frequencies, and the time-dependent orientation velocities of the roots. It was concluded that plants are organisms that actively receive information from their environment, perceive, evaluate, interact and even facilitate each other's life (Gagliano, Mancuso and Robert, 2012).

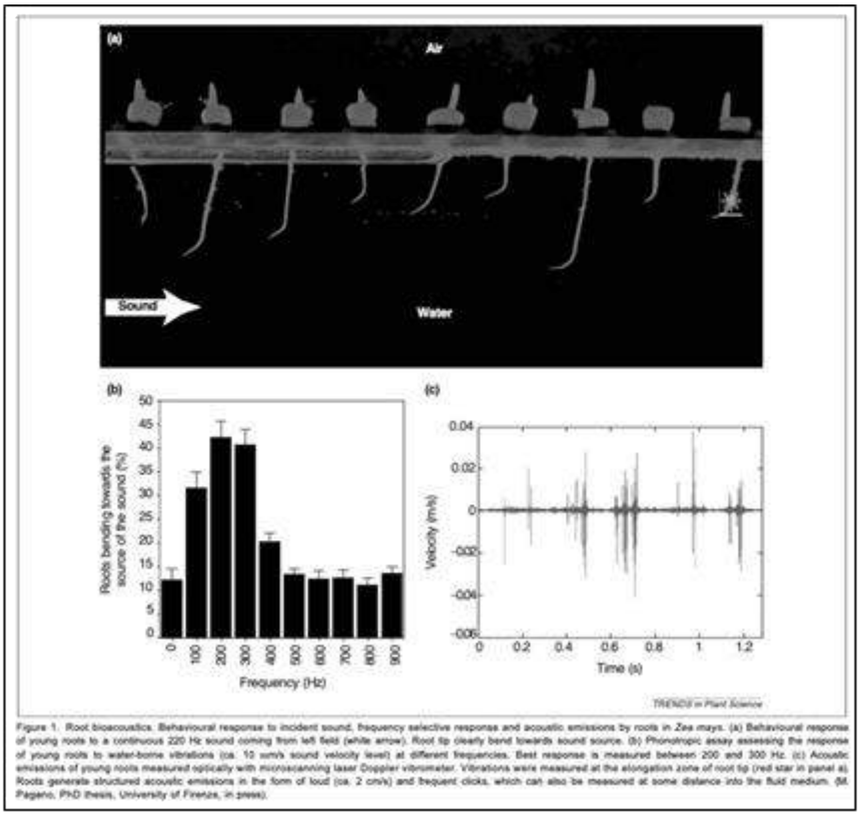

Figure 4. Reactive analysis of maize plant roots in response to acoustic signals (Gagliano, Mancuso and Robert, 2012)

In recent research, the focus has shifted to revealing the characteristics of plants and the distance traveled by the communication/interaction network between plants and their neighbors. For example, Appel and Cocroft (2023) propose an experimental approach that focuses on the experience of plant tissues using methods that precisely measure and reproduce the actual acoustic energy received by the plant. The aim of this study is to uncover the characteristics of sound-sensitive plants and explain how they develop the ability to make sound-based decisions in growth, defense and reproduction.

In a similar study, Demey et al. (2023) underline a holistic approach within an ecological and molecular perspective to make sense of plant behaviour. Problems such as the ecological place of sound in plant life, how sound is perceived by plants and transformed into a morphophysiological response constitute the main lines of the study. In addition, the responses of plants to different sound frequencies have been measured, and it has been concretised in this study that they hear and respond to humans.

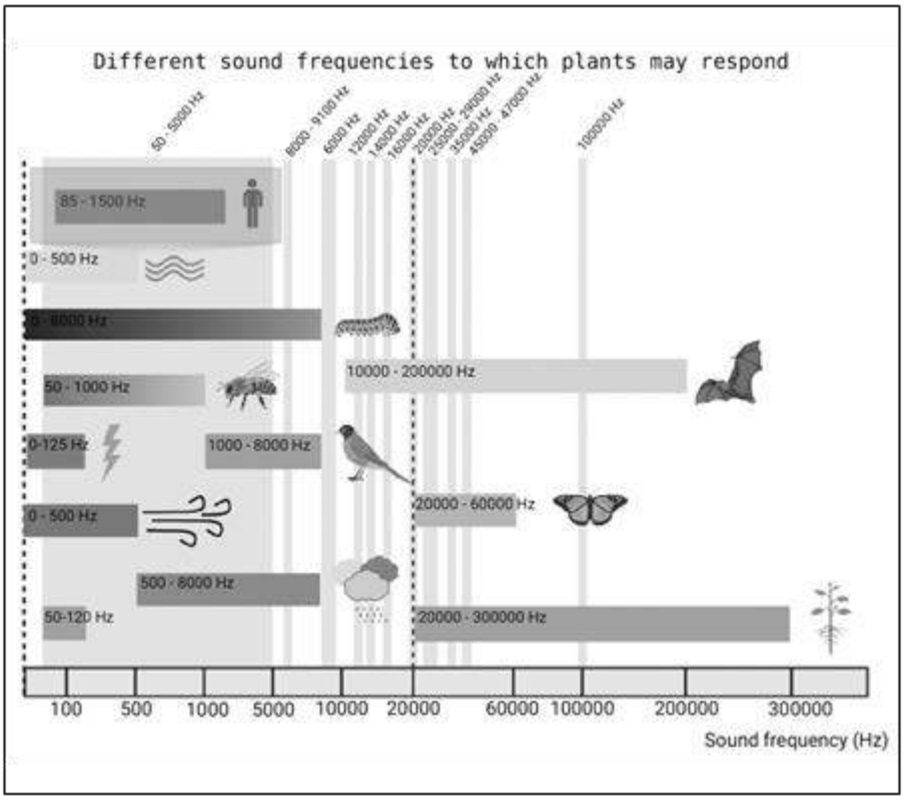

Figure 5. Plant responses to different sound frequencies (Demey et al., 2023)

Waqas et al. (2023) conducted a study showing that plants under stress seek help by acoustic signals. In this study, it was emphasised that plants emit informative ultrasonic sound signals when under stress, which can be classified according to their species, type and severity of stress.

The fact that sound acts as a physical signal between plants and their environment was clarified by using tomato and tobacco plants in the experiment. The subjects (tomato and tobacco plants) were placed in a controlled environmental chamber, subjected to drought and injury and their acoustic signal production was monitored.

Son et al. (2024) mention that plants utilise mechanical vibrations under biotic and abiotic stresses such as drought, but that these vibrations, although high-pitched, are of low intensity and propagate only a short distance.

Arguing that most studies demonstrating the sensitivity of plants to airborne sound are actually concerned with the perception of substrate vibrations from the soil or plant part, the study concludes that while low-frequency, high-intensity sounds emitted from a loudspeaker close to the plant seem to have tangible effects on various plant processes such as growth-finding with possible applications in agriculture, it is unlikely that plants can perceive the sounds they produce, at least over long distances.

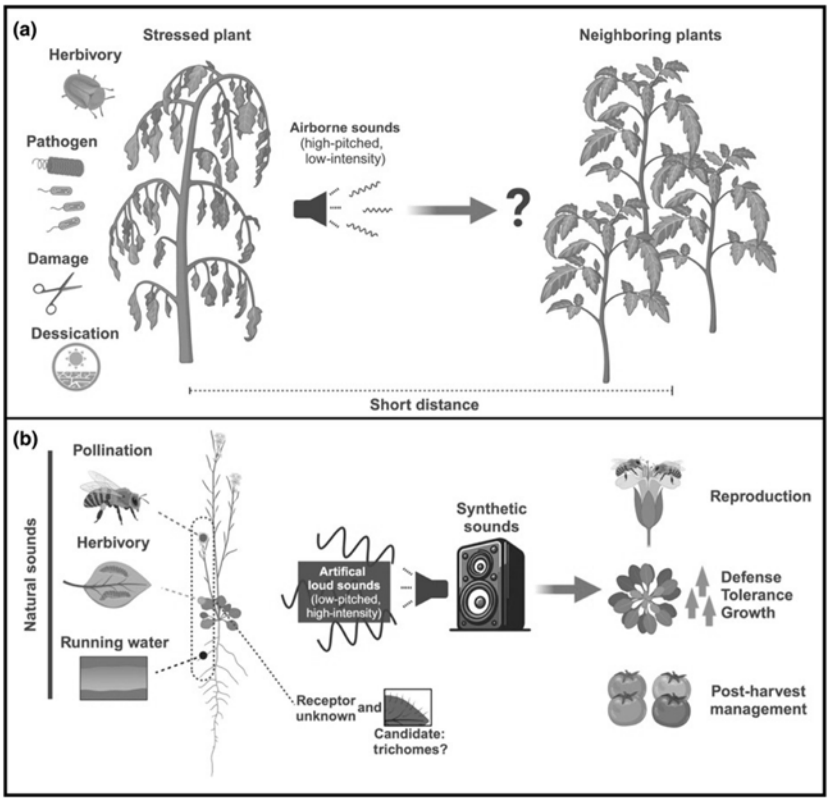

Figure 6. Propagation and reception of airborne sounds and substrate vibrations by plants (Son et al., 2024)

A contrary study was carried out by España Keller (2024). The work is a speculative investigation of plant bioacoustics, a sonic intra-active engagement by humans with non-human entities (plant life), activated by acoustic wave signals emitted by plants to create electronic patterns of sounds generated by humans and emitted by machines. Plants emit sound waves at relatively low frequencies of 50-120Hz and generate sonic data lines. By following these sonic data lines, the study conducts patching and modulation experiments and sheds light on sonic experiences that touch the musicology of the universe.

Figure 7. Sends biofeedback feeding midi data to an experimental hybrid synthesiser with Cereus sp. (Keller, 2024)

All these studies you've seen all say the same thing:

- ❖ We're trying to find out what's stressing them out.
- ❖ We're looking for ways to make them grow up healthy.
- ❖ We try to know what and to whom they resist.
- ❖ We question how we can reproduce them faster.
- ❖ And of course, we are looking for how we can reconnect with them!

4. Conclusion

In Shamanism and its teachings, the answer to how to become a higher being as a human being is sought. For example; to become physically or spiritually stronger - the search for healing. In other words, the basis of Shamanism teachings is the endeavour to obtain this essence from nature, knowing that nature contains more than learned knowledge. Shamans learn knowledge on the spot, seek healing in nature, try to make sense of existence with what they have obtained from nature and seek a way of co-existence. It is for this reason that they see nature and human as a whole in their ancient rituals.

However, when we look at today, it is seen that research is more oriented towards problem solving. With the transformation of concepts such as modernism, industrial revolution and rapid urbanisation into action, listening and understanding nature has been left at one point. This has caused problems by creating destruction in the communication between human and nature. Current studies are carried out in order to find answers to these environmental problems, to eliminate them and to search for ways to interact with nature again.

In this context, when Shaman teachings and current researches are evaluated together, two types of distinction stand out. The first of these is the spatial distinction and the second is the targeted distinction. Spatial distinction; Unlike the teachings of Shamanism, today it describes the attempt to repair/re-weave the communication network in a sterile laboratory environment and with the help of certain apparatus. On the other hand, the objective distinction is described as the search for solutions to the problems created instead of the search for healing in Shamanism, the effort to heal nature today instead of trying to understand the existence in the past, the need to support the existence of plants as a living being with numerical data instead of trying to understand nature by accepting it as a living being, that is, the need to concretise the disconnection in the existential integrity and the effort to understand nature for the continuation of humanity.

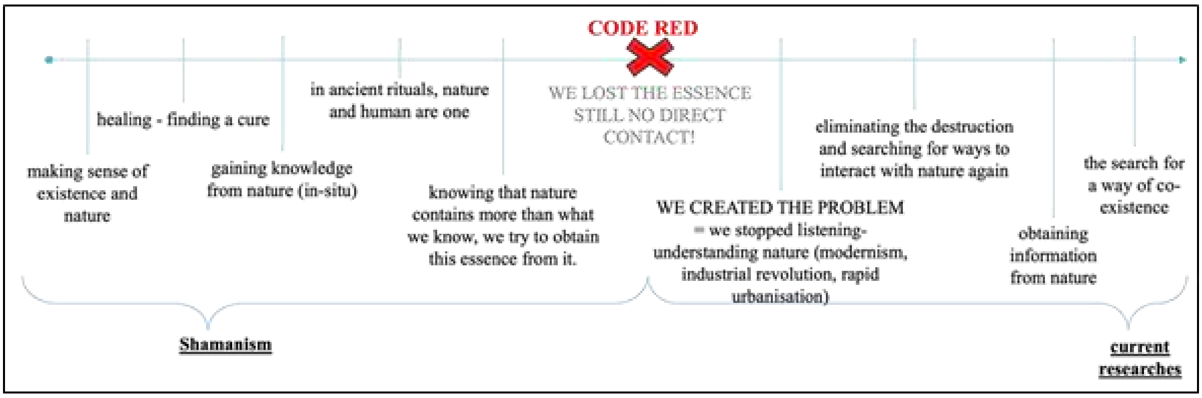

Figure 8. Temporal comparison of shamanic teachings and current researches

As a result, when spatial and targeted distinctions are taken into consideration, it is revealed that there is no direct interaction between human and nature and this situation causes disconnections in reading the existential integrity and makes it necessary to face environmental problems such as global climate change.

Note

Figure 8 is due to the fixed position of the plants and the lack of recognisable clarity of their response.

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The Great Willow Weave: Weaving a Communal Narrative

"The Great Willow Weave: Weaving a communal narrative" Community agency through spatial activation

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Abstract

Using willow as a medium, socially engaged environmental artist and landscape architecture tutor Sophie von Maltzan conducted several spatial and social activation projects with communities in Dublin's parks from 2017-2024. The resulting 7-15 willow installations vary in size from 1m x 1m to 30 m long and up to 7m height. They are designed and built in loose and spontaneous collaborations between various community groups and independent community members. Primary school children, Landscape Architecture and Art students as well as resident groups, neighbours and passers-by work together over a week. The installations then stay in place for months, sometimes turning into living sculptures. Building the willow structures is an effective and creative way to empower audiences to become agents of change and give civic space local and personal meanings beyond the often anonymous design and atmosphere of open green spaces in Dublin.

Keywords: Exploratory practice-based research, green city spaces, placemaking, normative aesthetics of civic space, co-creation and making, natural play spaces, an environmental call to action, socially engaged environmental art and landscape architecture

1. Introduction

My socially engaged environmental projects attempt to achieve a paradigm shift in the use of marginal open spaces in our cities. They explore how citizens can be involved in the shaping of public spaces, by creating platforms that encourage communities of place to develop around them and improve biodiversity.

My projects aim to provoke a shift of cultural values and aesthetic norms. Currently the "normal" for urban private and public open space is a tidy-looking and biodiversity-poor landscape that does not allow for vegetational natural processes. Such settings do little to expand understanding of climate change and our capacity to mitigate those changes. They even perpetuate alienation from nature. In my investigative projects, I set out to promote and democratise nature-filled green infrastructure in urban settings, thereby providing 'stepping stones' to more sustainable towns and cities.

I am an artist, academic, landscape architect and farmer. My predominant focus is on environmental, socially engaged and collaborative practice. My artistic and educational endeavours also serve as research projects: interrogating and working to change humanity's relationship with the environment. To this end, I have developed a variety of collaborative approaches that weave together ecology, participatory and site specific design. Place making and creating communal narratives are foundational to my practice. Through environmental socially engaged art practice I have delivered an extensive array of participatory design projects with communities.

I have 15 years of experience developing nature-based creative installations in the public realm with various communities and have worked with a broad variety of stakeholders as an artist as well as as a landscape architect on urban and rural projects at all stages from feasibility to construction.

For this, I have received awards, including Irish Landscape Institute Awards.

I am also part time tutor at the school of Landscape Architecture in UCD and has lectured at many other universities in Ireland and abroad over the last 16 years. She has been teaching on an ad-hoc basis at NCAD over the last 8 years. This year she taught a Landart and Environmental art module at DCU, Dublin. Her research and teaching is concerned with community collaborative design, green infrastructure in the urban and rural context and querying aesthetic norms in the landscape context. She is a member of the UCD Earth Institute.

Using willow as a medium, I have conducted several spatial and social activation projects with communities in Dublin’s parks from 2017- 2023. The resulting 7-15 willow installations vary in size from 1m x 1m to 30 m long and up to 7m height. They are designed and built in loose and spontaneous collaborations between various community groups and independent community members. Typically, primary school children, Landscape Architecture and Fine Art students as well as resident groups, neighbours and passers-by work together over a week. The installations then stay in place for months, sometimes turning into living sculptures.

Building the willow structures is an effective and creative way to empower audiences to become agents of change and give civic space local and personal meanings beyond the often anonymous design and atmosphere of open green spaces in Dublin.

Weaving site-specific installations into grounds, these projects offer a tool to negotiate the environmental, climate and ecological emergency as well the current socio- economic crisis at a micro-scale. They offer a way to explore how artistic and creative performative practices based on participative design can disrupt the normative aesthetics of civic spaces. As such, they are an environmental call to action, demonstrating how the immediate environment can be “renewed” and “re-explored” by the community itself and with a minimal carbon footprint.

The building process is open: no cordoning off of the site is required; no watchman; no warning signs are needed. Everyone is invited to participate via social media and posters pasted up in the community.

Von Maltzan arrives with a load of willow and they morph - with the actions of the community - into installations over a week. No prior knowledge is required to weave. Trial and error is the best way to learn.

The participants began weaving without a prior design, and they are encouraged to follow the directions of the willow they began to weave, engaging and to respond directly without bias to the “matter-flow” of the material and their surroundings.

The resulting project add recreational value to neighbourhood parks, encouraging people to relax and play close to home, as well as to work with a native plant as a creative material. The process of weaving and constructing with willow is playful and therapeutic. Participants and passersby talk and tell stories while they work or observe. Von Maltzan documents this symbiosis of weaving place-based structures and communal narratives through various subjective methods.

‘The Great Willow Weave’ can be regarded as an activist project as well as socially engaged art practice. It challenges the conventional coding of a public park. Temporarily changing the nature of the public realm, it questions the often prescribed ways city functions.

The projects act as inspiration for other communities to construct their own willow structures in their own neighbourhoods. The willow installations built in Summer 2023 on the grounds of the Irish Museum of Modern Art in Dublin have begun to root and the plan is to harvest l from them to expand the installation in summer 2024.

(Sophie Graefin Von Maltzan, 2024, LandscapeArchitecture Department, UCD Engineering & Architecture College, Dublin, Ireland).

The research problem

This applied qualitative research addresses the low design standards and usage of Dublin's Parks in general as well as those in this study specifically. It asks whether encouraging the community to take agency and build (within) their neighbourhood park, can improve the usage of the park and what it means to the community using it? As such, the study describes and critiques creative placemaking.

2. Material and Method

To date, Von Maltzan has undertaken 5 "spatial activation" studies that bear the title 'The Great Willow Weave': two "Great Willow Weaves" took place in Great Western Square in Dublin 8 in the summer of 2017 and 2018; another was mounted in Mount Bernard Park in the summer of 2019 and again on the grounds of the Irish Museum of Modern Art (IMMA) in the summer of 2022 and 2023. Each year approximately 10 students from UCD and /or NCAD (the National College of Art and Design in Dublin), 150 school children and 30 members of the community living around the parks have taken part. At IMMA, the event took part during the "Earth Rising" eco festival, and approximately 200 visitors joined in the weaving over the 4-day duration of the festival. The willow installations remained in place for 10 months at Great Western Square; for 3 months at Mount Bernard park and at IMMA they were permitted to stay up for 4 weeks in 2022 and 6 months in 2023. On Great Western Square, the residents committee decided it was up to the maintenance team of the parks (Dublin City Council/ Office of Public Works) to decide when the willow structures would be removed.

My method has been to combine action research as well as close observation. This permits me to analyse who and how people interacted and perceived the willow structures as well as the ways that attitudes have changed over the lifespan of the willow structures. The intrinsic focus on temporality was essential as it permits understanding of the willow installations changed the "sense of place" for the people who use the parks regularly.

(Sophie Graefin Von Maltzan, 2024, Landscape Architecture Department, UCD Engineering & Architecture College, Dublin, Ireland).

3. Findings and Discussion

No quantitative data on the usage of the park, before, during and after the "The Great Willow Weave" was gathered for this study.

Findings

I have documented and analysed the process through photography, film making, sketching, writing. I have also curated an exhibition about the project at the Royal institute of Architects, Dublin (September 2019). My findings indicate that:

- the number of people using the parks had increased;
- visitors stayed in the park for longer;
- people of all ages interacted with the willow installations;
- children engaged through imaginary play with the installations;
- deterioration of the structures occurred eventually, through children and also dogs interacting with the willow installations;
- the willow did not get a chance to root in the parks that were heavily used (Mount Bernard and Great Western Square). When it is dead, the soft wooded willow is very fragile and breakable;

- throughout the studies there was no vandalism (the residents often predicted that all the installations would be vandalised within days and only one sculpture in over 50 was ever vandalised. It was a round bench in Great Western Square, a park without a single bench, since the wrought iron benches were removed almost 20 years ago.
- visitors noted that the installations created a sense of community of place;
- visitors remarked that it is easier to strike up a conversation with strangers when the willow installations are in the park;
- the haptic process of weaving willow allows for a sensuous, affective proximity with natural material and natural surroundings.

Discussion

The research has shown that temporary, non-prescriptive improvised creations of willow structure with communities is a functional "placemaking" agent. Placemaking is a way to improve the quality of various places in a neighborhood, and by extension, the community and region in which those places are located. (DEFINITION OF PLACEMAKING: Four Different Types By Mark A. Wyckoff, FAICP, Professor, MSU Land Policy Institute)

The people observed and questioned have spent more time and engaged more with their public open green spaces during the duration of the project.

(Sophie Graefin Von Maltzan, 2024, LandscapeArchitecture Department, UCD Engineering & Architecture College, Dublin, Ireland).

4. Conclusion

It would be useful to repeat the study to gather more analytical data and disseminate a method statement on how communities and councils can implement this cost- efficient, low carbon footprint placemaking project without my involvement.

(Sophie Graefin Von Maltzan, 2024, LandscapeArchitecture Department, UCD Engineering & Architecture College, Dublin, Ireland).

Figure 1. Photo of the Great Willow Weave 2017 by Sophie von Maltzan
(Sophie Graefin Von Maltzan, 2024)

Figure 2. Photo of “Weaving a communal narrative” at IMMA 2022by Sophie von Maltzan (Sophie Graefin Von Maltzan, 2024)

Figure 3. Photo of “Weaving a communal narrative” at IMMA 2022by Sophie von Maltzan (Sophie Graefin Von Maltzan, 2024)

Figure 4. Sketches and Photos of the Great Willow Weave 2017 & 2018 by Sophie von Maltzan
(Sophie Graefin Von Maltzan, 2024)

Figure 5. Photo of "Weaving a communal narrative" at IMMA 2022by Sophie von Maltzan
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Figure 6. Sketches and Photos of the Great Willow Weave 2017 & 2018 by Sophie von Maltzan
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Figure 7. Photo of "Weaving a communal narrative" at IMMA 2023
(Sophie Graefin Von Maltzan, 2024)

Figure 8. Photo of "Weaving a communal narrative" at IMMA 2023
(Sophie Graefin Von Maltzan, 2024)

Figure 9. Photo of "Weaving a communal narrative" at IMMA 2023
(Sophie Graefin Von Maltzan, 2024)

Study on the Distribution of Environmental Factors in Urban Parks from the Perspective of Public Health

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Abstract

Urban parks are one of the main open spaces, and their internal environment is closely related to the health of residents. A better urban park environment can increase the frequency of residents' outdoor activities and enhance the vitality of urban. How do the characteristics of urban parks landscape affect the microclimate and public health? In this research, through the investigation of three urban parks cases in China, it was analyzed the correlation between parameters of urban parks landscape and the microclimate and the public health. The internal spaces of the three urban parks are classified into five types (open squares, lawns, semi-indoor spaces, forested spaces and waterfront spaces). The spatial and temporal distribution of environmental factors in urban parks and their relationship with residents' health were investigated through field surveys, monitoring environmental factors (wind speed, temperature, humidity, sky view factor (SVF), leaf area index (LAI)) and population distribution characteristics in different spaces. The results showed that the comfort levels of lawn, semi-indoor, forest and waterfront spaces were the best level, and the comfort levels of open squares were on the hot level. Comforts in urban parks were influenced by the overall environment of the city. During the daytime, humidity and wind speed affect the changes of population distrubution characteristics. However, SVF and LAI did not change population distribution characteristics. The results of the study provide a theoretical basis for future planning, design and management of urban parks aiming at public health.

1. Introduction

Nowadays, the rapid development of cities promotes the continuous improvement of economic level, but also brings various ecological and environmental problems, including the heat island effect and other climate problems (Domeisen et al., 2023; Lei et al., 2021).

In recent years, the frequent occurrence of extreme weather disasters in the world has attracted unprecedented attention from all mankind. Climate change has become an important issue of global development (Abbass et al., 2022; Howe et al., 2019).

Nowadays people have a higher understanding and requirements on the suitability of climate and the comfort level of the urban environment, and the traditional planning and design of the urban living environment can hardly meet people's needs.

Therefore, how to bring climate factors into the traditional design scope, to design a more refined and comfortable living environment, has become a hotspot of current multidisciplinary research.

The urban climate is one of the most important components of urban environment, and its most significant feature is the heat island effect, and it is found that urban climate also has "dry island effect", "wet island effect", "turbid island effect ", etc. (Luo et al., 2021; Shuzhen et al., 1991; Zhang et al., 2023). In addition, some factors from human activities can cause significant climate differences between local areas in the city, which is the urban microclimate. As an important part of the urban green space system, urban parks play a significant role in regulating urban microclimate, improving the urban ecological environment and enhancing the public health of the living environment of residents (Arzberger et al., 2024; Liu et al., 2020). Long-term studies have found that substrate conditions affect the formation of local urban micro-climates. Areas with different subsurface conditions have different changes and distribution patterns of air temperature, relative humidity, and wind speed (Hou et al., 2020). Moreover, the air and its microclimate characteristics are influenced by the subsurface the closer they are to the subsurface itself (Morabito et al., 2021).

Urban parks have rich types of substratum environments with complex topography, water, vegetation, etc. The diverse spaces composed of these elements have different microclimate characteristics (Alizadeh & Hitchmough, 2019). For example, the topography of urban parks affects the range of wind environment, and changes in topography also have an impact on the spatial and temporal dynamics and spatial distribution characteristics of particulate matter (PM_{10}, $PM_{2.5}$ etc.) (Barros Moreira de Carvalho & Bueno da Silva, 2023); water of different areas and shapes in urban green spaces have different cooling effects, and can also increase the humidity of the air around water, regulate wind speed, alleviate the urban dry island effect, and provide a comfortable and livable environment for residents (Lin et al., 2020; Tan et al., 2021); vegetation in parks has an obvious effect on the regulation of microclimate. The transpiration of plants can have a great impact on the air temperature and relative humidity of the surrounding environment, and the planting layout and the physiological structure of branches and leaves can produce the effect of sedimentation and filtration of atmospheric particulates in green space (Akhbarizadeh et al., 2021; Choi et al., 2020; X. Wang et al., 2021).

Different micro-climates can cause differences in human comfort. Human comfort is based on the principle of a heat balance between the human body and the surrounding atmospheric environment on a small scale. Since human comfort is greatly influenced by microclimate, the main important environmental factors that cause changes in human comfort are also air temperature, relative humidity, and wind speed (Haeri et al., 2023). In the past hundred years, with the deepening of the research on human comfort, the evaluation index of human comfort has also been developed (de Freitas & Grigorieva, 2017). The process can be divided into two stages: the initial stage represented by the empirical model index and the later stage represented by the mechanism model index. The empirical model index is a kind of evaluation index constructed by statistical analysis of the human body's feelings under different environmental conditions.

At present, the research on the microclimate of urban parks mainly focuses on the influence of different landscape elements on microclimate, while the relationship between microclimate environment of different space types and population features is less studied (Karimi et al., 2020; Xu et al., 2018). In addition, most of the studies only selected one research object, leading to results that were not representative enough and conclusions that were not sufficient and comprehensive (Karimi Afshar et al., 2018; Y. Wang et al., 2018).

With the aim of understanding how the characteristics of urban parks landscape influence the microclimate and public health, this research analyzes the correlation between parameters of urban parks landscape and the microclimate and the public health, through investigating three urban parks cases. Finally, this research proposes the suggestions and methodology for improving urban parks.

Taking Zhengzhou People's Park, Bishagang Park and Zijingshan Park as the research cases, this study selected 15, 17 and 17 sample areas respectively, and divided these sample areas into five types. The environmental factors and population distributions characteristics in these sample areas were statistically analyzed to reduce the insufficiency of analysis results caused by the single research object. Based on the measured data, the spatial distribution and temporal variation of microclimate and population features of different types of spaces in urban parks were tallied up to analyze the influence of space types on microclimate and human comfort. In addition, the correlation analysis and significance test between each environmental factor and the relation between the population features and environmental factors were also carried out. Our specific objectives are to: (1) To explore the relationship among space types, environmental factors and population features. (2) To seek the best time and space for human health activities in urban parks. (3) To provide a theoretical basis and methods for the construction of reasonable and elaborate urban parks with high comfort level in the future.

2. Material and Method

In the open square, lawn, semi-indoor space, forest space, and waterfront space, landscape features and population features were monitored by setting up sample areas and sample points, the meteorological factors.

2.1 Study area

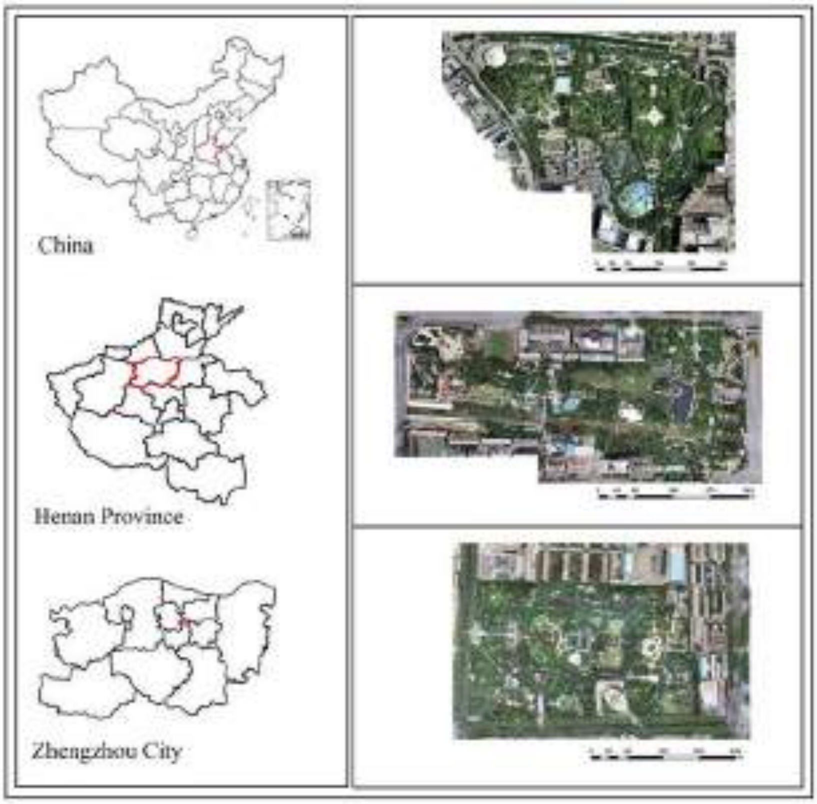

Figure 1. Location of three parks. (The right hand side of the figure shows the three parks (top to bottom), Zhengzhou People's Park, Zijingshan Park and Bishagang park)

Zhengzhou is the capital of Henan province. It is located in the central part of Henan province (East longitude 112°42'～114°14', North latitude 34°16'～34°58') (Figure 1), with an average elevation of 108m and 7446km^2 of land and population of 9.881 million. It faces the Yellow River to the north, Song Mountain to the west, and the vast Huanghuai Plain to the southeast. It has a temperate continental monsoon climate with an average annual temperature of 15.6℃, an average annual rainfall of 542.15 mm, a frost-free period of 209 days and an annual sunshine duration of about 1869.7 hours.

Sample areas for the experiment were selected from three large integrated parks in Zhengzhou City (Zhengzhou People's Park, Bishagang Park, Zijingshan Park). Zhengzhou People's Park, located in Jinshui District, is opened in 1952 and its area is 30.14 hm^2 (Figure 2(a)). Fifteen sample areas were selected in this park. Zijingshan Park is located in Jinshui District and was built in 1958 with an area of 19.2hm^2(Figure 2(b)). In this park, seventeen sample areas were selected. Bishagang Park is located in Zhongyuan District with an area of 22.4hm^2(Figure 2(c)). It was converted into a park from the Martyrs Cemetery in 1956 and officially opened in 1957. Seventeen sample areas were selected in this last park.

In order to make the study framework scalable and adaptable, this study selected 3-4 sample areas from the 5 types of spaces in 3 parks through field inspections and drone images and selected 2-4 sample points from each sample area.

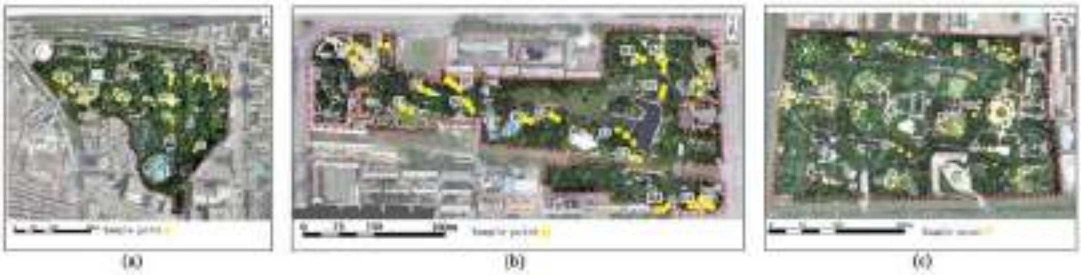

Figure 2. (a) Distribution of Zhengzhou People's Park sample area and sample points; (b) Distribution of Zijingshan Park sample area and sample point; (c) Distribution of Bishagang sample area and sample points (The yellow dots on the three drone image refer to each sample point).

2.2 Microclimate indexes and landscape features

The survey was conducted on good weather days in October and November 2019 (Table 1). The Kestrel NK5000 portable weather meter was used to measure the air temperature, relative humidity and wind speed on each sample point, and the sampling height was 1.5 m from the ground. Due to a large number of sample points and the heavy population in the park, to avoid disturbing residents' activities and affecting the results of the experiment, the survey adopted a dynamic collection method to measure data. The measurement was from 8:00 a.m. to 6:00 p.m. with a round trip at a constant speed according to the designed route every two hours. In order to analyze the relationship between environmental factors and population features, environmental factor data from 11:00 a.m. to 1:00 p.m. were also measured. The monitoring time of each sample point was 60 s, and finally the round-trip average value of each sample point is calculated. During the dates of the research, the CI-110 canopy analyzer was used to measure the leaf area index (LAI) and sky viewer factor (SVF) of each sample point. The instruments were calibrated before the measurement.

Table 1. Historical meteorological data of Zhengzhou in experimental dates

Date	**10.13**	**10.19**	**11.03**	**11.05**
Weather condition	Sunny	Sunny	Sunny	Sunny
AQI index	63	65	97	106
Air quality level	Good	Good	Good	Mild pollution
$PM_{2.5}$ index	33	32	71	79
PM_{10} index	76	72	106	122
Average daily wind speed /（m/s）	0.9	2.2	2.3	0.3
Daily average temperature /℃	18	17.3	15.9	12.5
Daily maximum / low temperature /℃	23.5/14.4	24.3/9.7	18.8/14.4	20.4/7.7
Daily average humidity /%	75	65	60	82

2.3 Population distribution features

In the morning, noon and dusk (8:00 a.m.—10:00 a.m., 11:00 a.m.—1:00 p.m., 4:00 p.m.—4:00 p.m.) on each monitoring date, the number of residents in sample areas were recorded by taking pictures with a panoramic camera and the crowd density and area per person were calculated along with the residents' activities.

2.4 Human comfort index

Human comfort is based on the principle of the heat balance between the human body and the surrounding environment and is a bio-meteorological index that evaluates the degree of human comfort in different environments. Among them, air temperature, relative humidity, and wind speed are important factors that affect human comfort. There are many prediction formulas for human comfort. In this study, the human discomfort index (DI) is selected, and its classification is in accordance with the unified standard set by the China Meteorological Administration (Table2). This study uses the classification standard for autumn and winter.

Using the human body comfort index formula adopted by the Henan Meteorological Bureau:

$$DI = 1.8 \times T + 0.55 \times (1 - RH) + 32 - 3.2 \times V^{0.5}$$

DI is the human body comfort index; T is the temperature (°C); RH is the relative humidity (%); V is the wind speed (m/s).

2.5 Data analysis

In this study, Microsoft Excel 2016 was used to manage data and give descriptive results. SPSS 22 and R-Studio were used for all statistical analysis. The meteorological factors (air temperature, relative humidity and wind speed), crowd density, area per people, SVF, and LAI between the five types of spaces were analyzed by one-way ANOVA and multiple comparisons to obtain the differences between different spaces. The scale function in R-studio was used for data standardization processing. First of all, correlation analyses and significance test were carried out on the microclimate factors (temperature, relative humidity, wind speed), SVF and LAI in the same space to analyze the relationship between different factors; secondly, correlation analysis and significance test were conducted to analyze the relationship between environmental factors and population features in different time periods. In this process, six packages named nlme, readxl, vegan, lme4, ggppubr and ggplot2 were used for analysis and generate charts by calculating the DI in different spaces based on meteorological indexes.

3. Findings and Discussion

The experiment was conducted to correlate microclimate indexes (air temperature, relative humidity and wind speed) and landscape characteristics (SVF, LAI), and the results are shown in Figure 3. In all space types, the temperature was significantly negatively correlated with humidity, wind speed, LAI, and positively correlated with SVF. Humidity is negatively correlated with temperature and wind speed. Wind speed was significantly negatively correlated with temperature, humidity, LAI, and positively correlated with SVF. It can be observed that in the square, air temperature and humidity have a significant negative correlation, but the correlation is weak. This is likely because the square lacks vegetation, resulting in relatively low humidity and minimal variation in humidity throughout the day. Relative humidity is found to have a negative correlation with SVF in the square, but a positive correlation in the lawn and semi-indoor spaces. These differences may be attributed to variations in spatial layout and vegetation configuration in different spaces. This further highlights the importance of spatial classification.

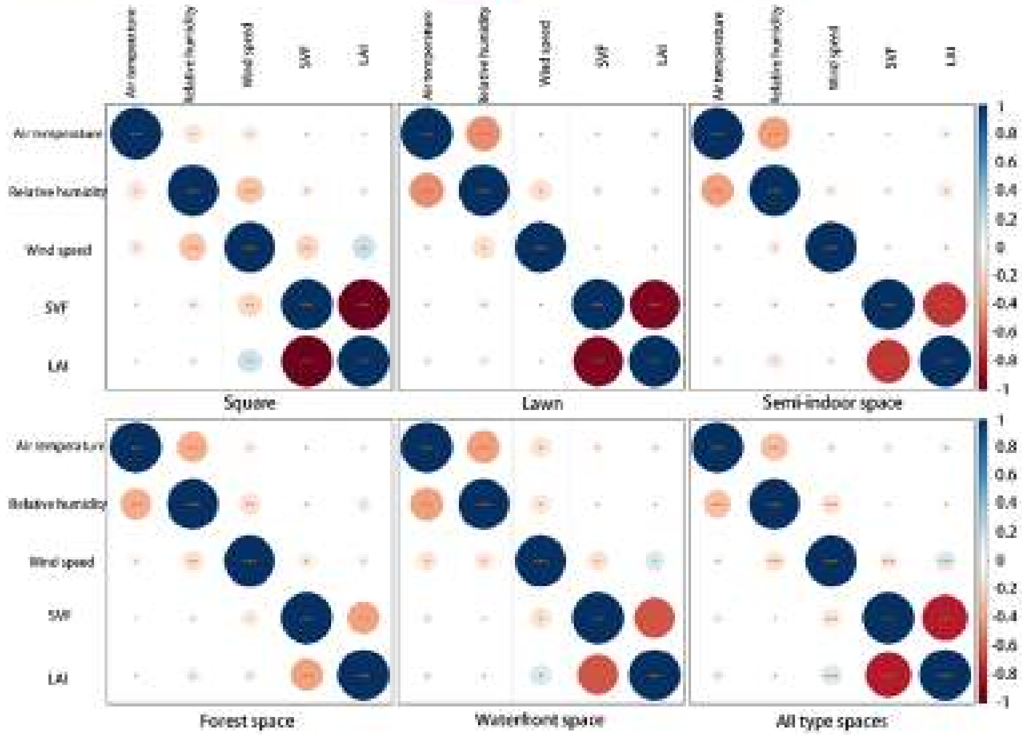

Figure 3. Correlation analysis of microclimate factors with sky visibility factor (SVF) and leaf area index (LAI). (* refers to 90% confidence interval, p<0.1. * * refers to 95% confidence interval, p<0.05. * * * refers to 99% confidence interval, p<0.01.).

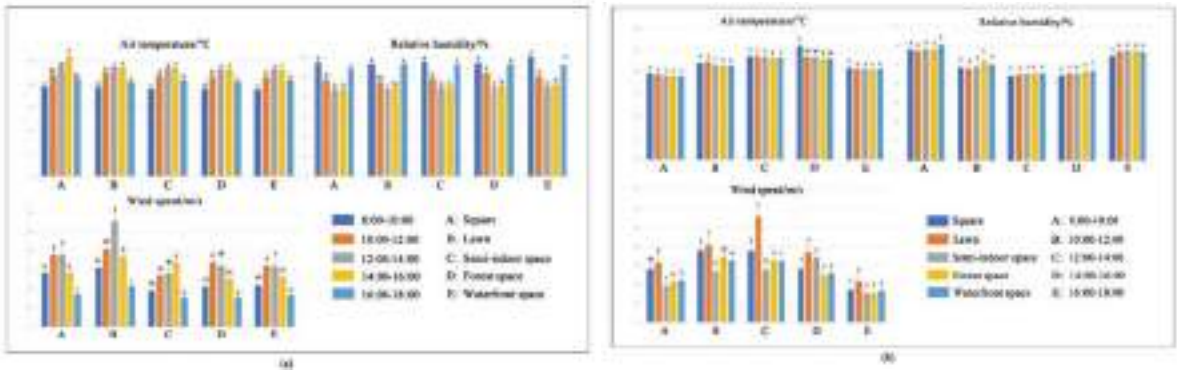

Figure 4. (a) Variance analysis of time distribution of microclimate factors (A-E refer to five different types of space, and five colors refer to five different time periods); (b) Variance analysis of spatial distribution of microclimate factors (A-E refer to five different time periods, and five colors refer to five different types of space).

The experiment compared multiple microclimate indexes at different times in the same space and the results were shown in Figure 4(a)The tempreatures of 12:00a.m.-2:00p.m. are significantly different to other times in the same space The relative humidities at 8:00a.m.-10:00a.m. and 4:00p.m.- 6:00p.m. are significantly higher than other times in the same spaces except the forest spaces. For wind speeds， only in square, the wind speed of 4:00p.m.-6:00p.m. is significantly lower than other times. In addition, the experiment compared multiple microclimate indexes in different spaces at the same time, and the results were shown in Figure 4(b). Except 2:00p.m.-4:00p.m., there is no significant difference between different spaces at the same timeAt the same time, there is no significant diffirenc between diffirent spaces. However, the wind speeds of different spaces are significantly diffirent at the same time.

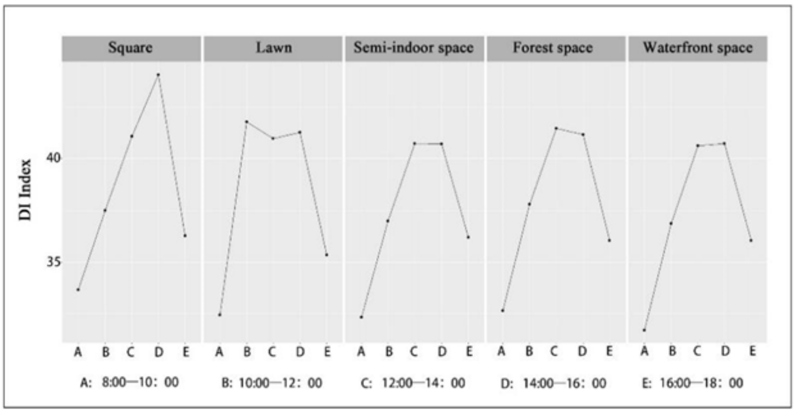

Figure 5. Time variation pattern diagram of human comfort in five kinds of space (A-E refer to five different time periods)

The variation trend of human comfort in the five types of spaces in a day is shown in Figure 5. The diurnal variation trend of human comfort in the four types of spaces, including square, semi-indoor space, forest and waterfront space, was a single peak inverted "U" shape. The lawn showed a double peak inverted "U" shaped trend. The variation in area per person across the five different types of spaces throughout the day is shown in Table 3. By analyzing the correlation between crowd density, microclimate factors, and DI, we obtain Figure 6. Throughout the day, crowd density shows a negative correlation with SVF. Conversely, crowd density has a positive correlation with LAI. This indicates the spatial needs of residents during park activities. SVF is related to the canopy of the space. A smaller SVF can block more sunlight, helping to lower temperatures, which in turn encourages more people to stay in the space.

Table 3. Average area per persion / m^2

	Square	Lawn	Semi-indoor space	Forest space	Waterfront space
Morning	64.86	668.85	30.63	32.95	52.41
Noon	213.64	239.34	24.54	43.02	32.09
Dusk	31.90	113.82	24.32	22.40	24.06

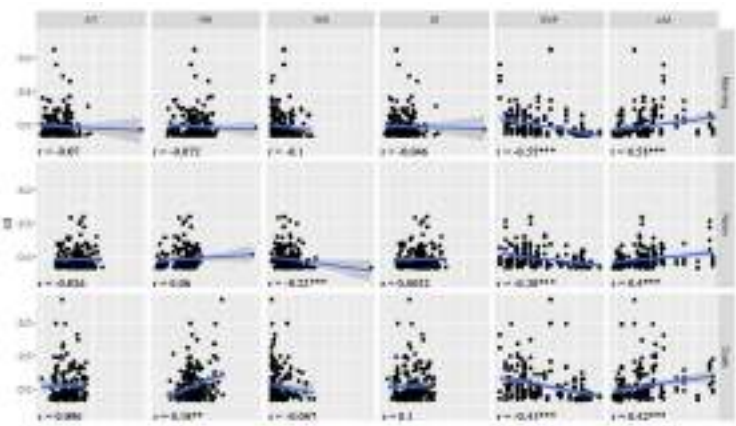

Figure 6. Correlation analysis of environmental factors with crowd density (r represents correlation coefficient; * * * is significantly correlated at 0.005 level (bilateral), * * is significantly correlated at 0.01 level (bilateral), * is significantly correlated at 0.05 level (bilateral); shadows represent 95% confidence interval range).

4. Conclusion

Through the field measurement of microclimate factors and population distribution features, the spatial and temporal distribution of these data were statistically analyzed. The aim was to show the correlation between space features and microclimate factors and between the environmental factors and people distribution features.

From the research results, it can be seen that different space features affect both the microclimate environment and the comfort level. In the diurnal variation trend of the five types of space, the change of square and lawn is more dramatic than the other spaces. In the design and remold of the square, it is suggested to improve the vegetation coverage of the square and re-select the material of the pavement. While increasing the vegetation coverage rate, the material with a larger specific heat capacity could make the microclimate environment and human comfort more stable in the open square. For the lawn, the surrounding plants can be increased, or it can be designed or transformed into scarce forest and grassland to improve the stability of the microclimate.

From the results of population distribution features, people's activities are affected by microclimate factors. Among them, the wind speed has the most significant effect on people flow. At the same time, the space with rich plants and low openness attracts more residents. Therefore, in order to improve the efficiency of using lawns with higher openness, the park management department could conduct activities on lawns regularly and guide residents choices in terms of spaces and time schedule. However, the semi-indoor space with low openness and low wind speed, which is suitable for crowd activities has a large flow of people, and cannot meet the needs of residents for private activities. In the future, it could be provided for residence more private areas by adding semi-indoor space.

In this study, a total of 49 sample areas in three parks are selected for observation and measurement on four different dates to reduce the inadequacy of the results, but there are still limitations, such as the impossibility to monitor microclimate change constantly during the investigation.

Nowadays, technologies such as internet of things information perception, internet of things information resources and GIS data fusion, and GIS-based data visualization are becoming more and more mature AI etc . In the future, it is possible to use these technologies to monitor microclimate factors and population features in real-time, in order to get more detailed and reliable results and conclusions. Furthermore, more micro-climate indexes related to health will be collected and analyzed. Taking this as a reference, we can make further contributions to the improvement of microclimate, as well as the improvement of human settlement environment quality, and put forward more specific suggestions for human activities.

Note: This article is derived from the poster presentation titled "*Health-based Landscapes: A study of Microclimate Factors in Parks*" presented at IFLA 2024. The original poster can be found in Figure 7.

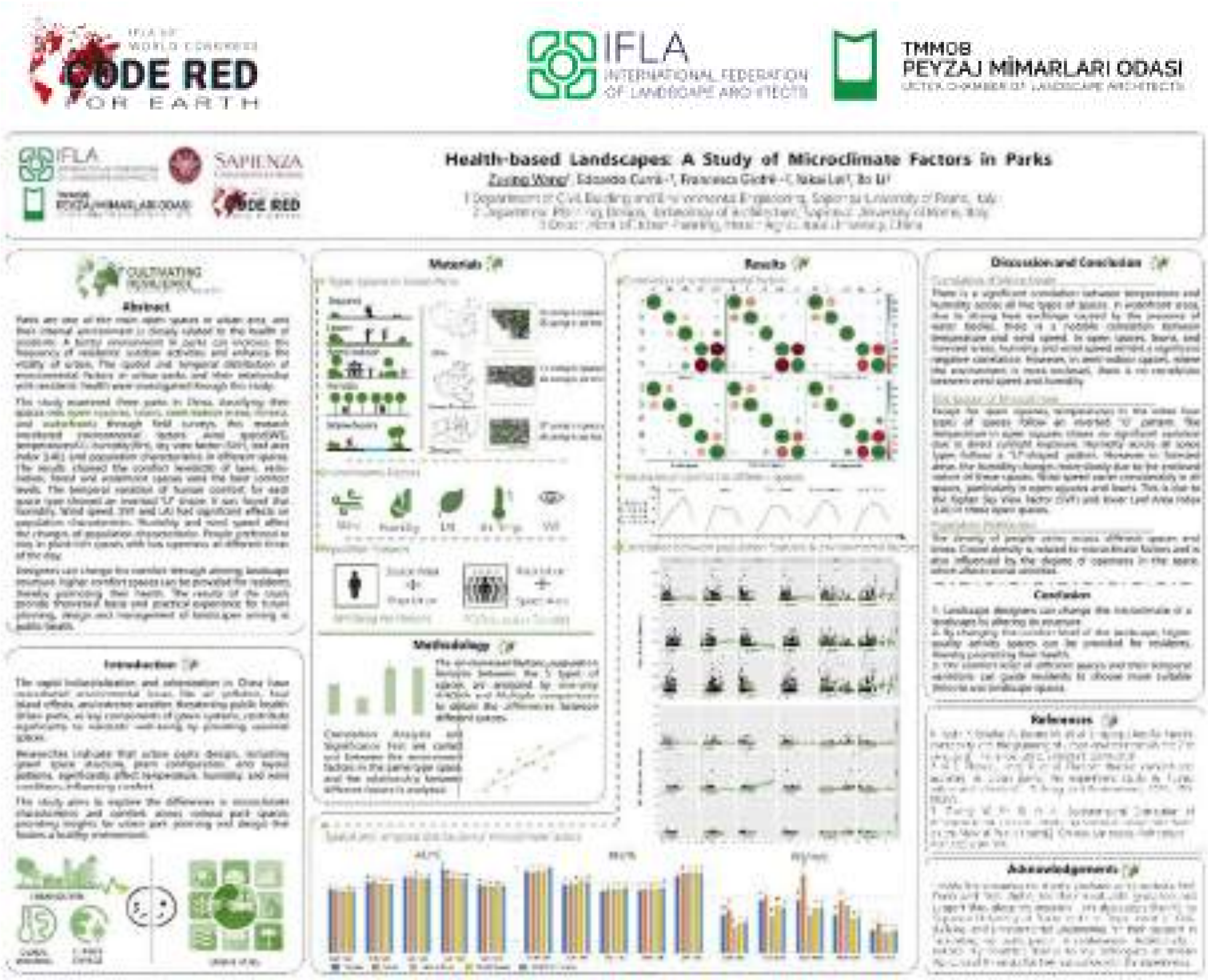

Figure 7. Poster Presentation for IFLA 2024

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Echoing Radical Traditions: Rural E-commerce Revolutions in Yellow River Floodplain

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Abstract

This paper focuses on rural e-commerce (Taobao villages) that are situated far from urban centers, positing that they represent an exception to the agglomeration externalities typically associated with large urban areas. Utilizing longue durée theory, we offer an explanation of this phenomenon from the perspective of social-historical heritage. We argue that the historical fluctuations of the Yellow River have shaped unique local rural social forms and have left specific legacies in contemporary times, which are related to the emergence mechanisms of peripheral Taobao villages. Quantitative analysis based on Geodetector supports this explanation. Finally, through a comparative conceptualization of historical and contemporary social realities, we reveal three aspects of rural social heritage in the floodplain areas that may influence the emergence of remote Taobao villages: labor flexibility, inter-regional mobility, and community dynamism.

Keywords: E-commerce, Yellow River floodplain, Taobao villages, social heritage.

1. Introduction: The Rural E-commerce Revolution

Since the 21st century, e-commerce has flourished in China, spurring grassroots entrepreneurship in manufacturing and online retail. Over the past decade, Alibaba, China's leading e-commerce group, launched the “Rural Taobao” initiative. Aligning with the government’s rural revitalization and poverty alleviation goals, this program leverages Alibaba’s digital platforms and logistics networks to integrate household and community-based production in rural areas. Villages actively participating in this initiative are recognized as Taobao Villages (TBVs). Studies indicate that this program has reversed rural population decline, economic stagnation, and weak entrepreneurial capacity (Li & Qin, 2022; Zhou et al., 2021). The rapid growth of TBVs—from 3 in 2009 to 7023 in 2021, representing 1% of all administrative villages nationwide—illustrates the successful collaboration between government policies and Alibaba’s strategy (Ali Research Institute, 2014).

TBVs exhibit diverse characteristics, with a key differentiator being their proximity to urban areas. Many TBVs are situated near medium and large urban agglomerations, such as the Yangtze River Delta, Pearl River Delta, and Beijing-Tianjin-Hebei region (Cao et al., 2019; Diao et al., 2017). These suburban TBVs leverage urban infrastructure and economic vitality, benefiting from urban agglomeration externalities or network externalities (Capello, 2000). They capitalize on the advantages of urban-rural networks while avoiding high costs like expensive rents and labor.

Conversely, significant clusters of remote TBVs are found far from urban centers. Their emergence is attributed to factors such as natural resource endowments, industrial foundations, infrastructure, government actions, and low production costs (Liu et al., 2020; Wang et al., 2022). This paper explores the formation mechanisms of remote TBVs through the lens of social-historical heritage, supported by quantitative analysis using Geodetector. By comparing historical and contemporary rural realities, it highlights three aspects of social heritage from the Yellow River floodplain that shape the rise of remote TBVs.

2. Research Hypothesis: Remote TBVs and Historical Disasters of the Yellow River

An analysis of TBVs across the country reveals that those remote TBVs are primarily distributed in the North China Plain, and their geographical distribution exhibits a correlation with a significant historical phenomenon—the Yellow River's disturbance and its flood disasters (Figure 1). We hypothesize that the historical fluctuations of the Yellow River have shaped the unique rural social structure in this locality and have left specific legacies in contemporary times, which are related to the emergence mechanisms of the remote TBVs.

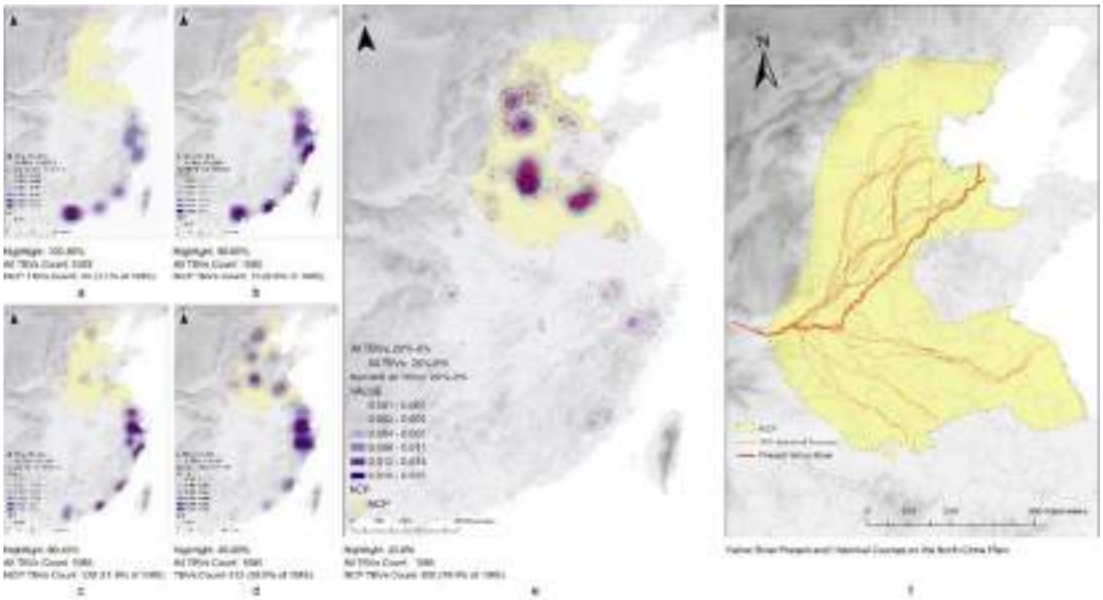

Figure 1. From the most suburban TBVs (a) to the most remote TBVs (e) all over the country. The remote TBVs are primarily distributed in the North China Plain (e), and their geographical distribution exhibits a correlation with the Yellow River fluctuations landscape (f). The graphs were drawn by Ruyang Sun.

This hypothesis is grounded in the concept of longue durée (Braudel, 1972), which emphasizes the continuity of social, economic, and cultural structures shaped by geography and environment over several centuries, and how these structures exert profound influences on contemporary short-term events. The historical prevalence of disasters serves as a quintessential example of longue durée, as disasters can shape a region's distinctive social relational structures, daily life, and cultural constructs (Bankoff, 2003; Oliver-Smith, 1996), and are preserved in history through collective memory and collective behavior (Pfister, 2011). Historically, the North China Plain has been a region prone to natural disasters, particularly those caused by the Yellow River. Some studies have revealed the impact of Yellow River disasters on local societies, suggesting that these societies exhibit characteristics such as collective organization, aggressiveness, difficulty in control, and frequent migration (Mostern & Horne, 2021; Perry, 1980).

3. Methodology

To validate this hypothesis, our study encompasses both quantitative analysis and qualitative discussion. The quantitative analysis based on Geodetector involves a consistency analysis between the distribution map of TBVs and the fluctuation pattern of the Yellow River. The objective is to examine whether the distribution of remote TBVs on the North China Plain exhibits a firmer consistency with the disturbance patterns of the Yellow River. The response variable is the distribution map of TBVs at different levels of urbanization, including those in remote areas. The explanatory variables encompass seven influencing factors from both historical and contemporary perspectives. Among these, the historical explanatory variables primarily consist of four factors used to characterize the disturbance map of the Yellow River.

Method: Geodetector

Geodetector is a set of statistical methods designed to detect spatial heterogeneity and reveal the underlying driving forces (J.-F. Wang et al., 2016). This method can be employed to assess the degree of consistency between the geographical differentiation characteristics of various explanatory variables (Xn) and a response variable (Y). The factor detection tool compares the geographical differentiation of a target research object (Y) with a single factor (Xn) to ascertain whether there is a significant consistency, thereby indicating the decisive significance of the single factor (Xn) on the geographical distribution of the target research object (Y).

Response Variable (Y): Distribution of TBVs at Different Levels of Urbanization

To extract the remote TBVs, we first filter all TBVs (2020) based on the urbanization level of their locations, determining a set of gradient distribution images of TBVs. Remote sensing nighttime light images have been utilized to estimate urbanization levels, which this study employs as the basis for selecting TBVs. We overlay the nighttime light raster images (2020) with the geographical locations of all TBVs, considering the total nighttime light intensity within a 2 km radius of the village committee locations as the urbanization level of the TBVs. A higher value indicates a higher urbanization level corresponding to the TBVs, categorizing it as a suburban TBV; conversely, a lower value classifies it as a remote TBV. Subsequently, we rank the TBVs based on this indicator and divide them into five groups to derive a distribution map of TBVs at different urbanization levels in the North China Plain (Figure 2).

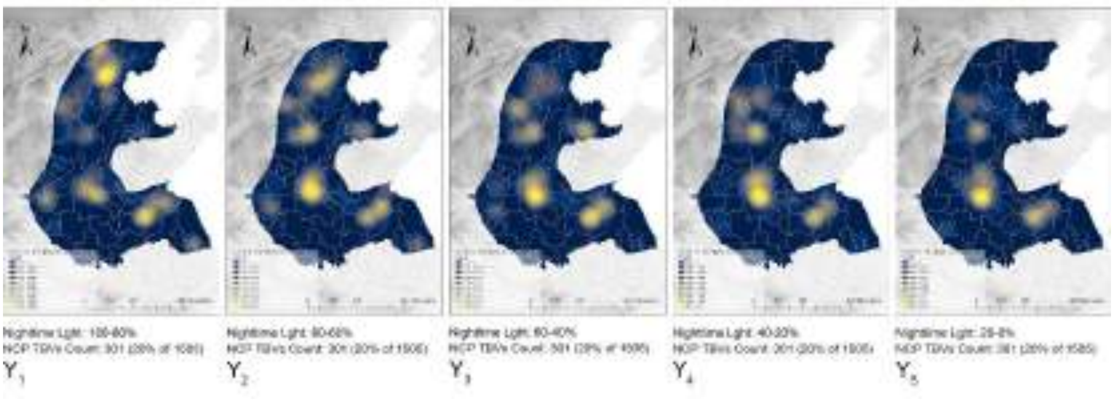

Figure 2. We rank the TBVs based on nighttime light and divide them into five groups to derive a distribution map of TBVs at different urbanization levels in the North China Plain (from Y1: most suburban TBVs to Y5: most remote TBVs). The graphs were drawn by Ruyang Sun.

Explanatory Variables (X): Ancient Yellow River Disturbance and Contemporary Conditions

Cities with water-adaptive landscapes (X2: CWAL) and villages with water-adaptive landscapes (X1: VWAL) have developed unique strategies to cope with frequent flooding in the Yellow River floodplain (Yu et al., 2008). These strategies shape distinct urban forms characterized by the integration of water and settlements. Villages are identified by names containing “gu (堌)” or “gudui (堌堆),” indicating proximity to ancient flood-resistant mounds. The kernel density of CWAL or VWAL serves as an indicator of human adaptation to water disasters, with higher densities reflecting stronger interactions between habitation and flooding impacts.

Hundred years cities (X3: HYC) refer to cities with over a century of administrative continuity, reflecting their resilience to Yellow River disturbances (Wang et al., 2021). Moderate HYC densities combined with high CWAL or VWAL densities indicate significant interactions between human settlements and water disasters. Conversely, high HYC densities with low CWAL and VWAL densities suggest limited flood-related influences on habitation.

The Grand Canal (X4: GC) has historically been a vital economic artery connecting northern and southern China. Its construction and maintenance often disrupted surrounding water systems, causing localized floods and droughts (Mostern & Horne, 2021). Buffer zones extending 30 to 120 km from the canal’s path are used to measure the canal’s indirect impact on Yellow River disturbances.

Contemporary Explanatory Variables (X5-7) reflect modern social factors influencing TBVs. These include urbanization rate (X5), road density (X6), and internet penetration rate (X7), sourced from 2020 government statistical data. The urbanization rate is calculated as the ratio of urban to total population in prefecture-level cities, road density as highway length per unit area, and internet penetration as internet users per hundred residents. This study examines whether historical disturbances of the Yellow River amplify the influence of these contemporary factors on remote TBV distribution.

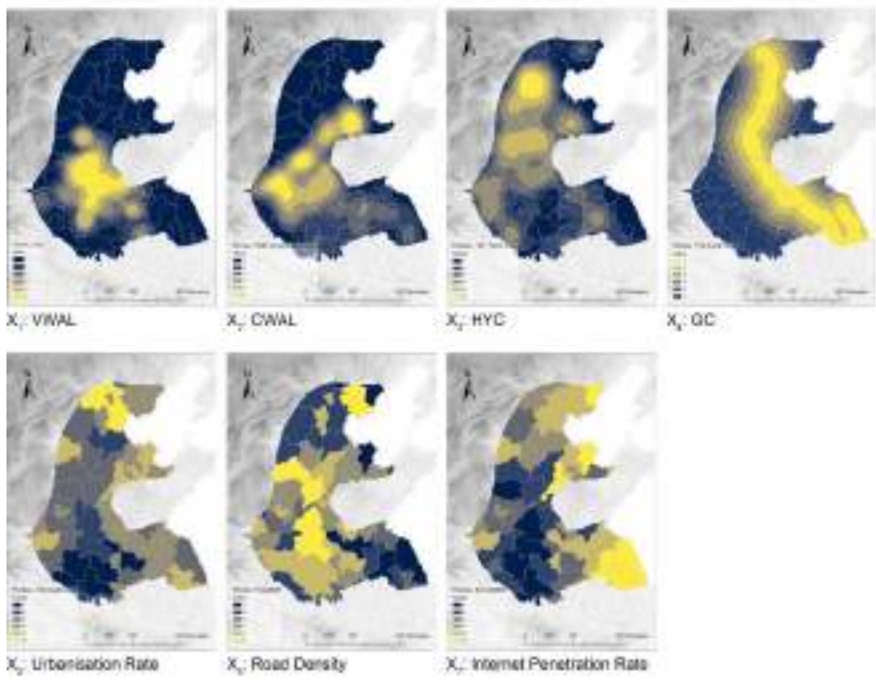

Figure 3. The explanatory variables encompass seven influencing factors from both historical and contemporary perspectives. The graphs were drawn by Ruyang Sun.

4. Results: The Remote TBVs exhibit a better consistency with the disturbances map of the Yellow River.

The findings from factor detection (Figure 4) indicate that the q-values of VWAL (X1) and CWAL (X2) steadily increase with the remoteness of the TBVs. For the most remote TBVs (Y5), the q-values of VWAL (X1) and CWAL (X2) are significantly higher than those of other historical factors. This suggests that the kernel density differentiation of water-adaptive landscapes aligns most closely with the distribution of remote TBVs. Observations reveal that the more remote the TBVs, the more significant the overlap with areas of high density of water-adaptive landscapes.

The q-value of HYC (X3) initially increases and then decreases, reaching a peak for the suburban TBVs (Y2), indicating a better consistency between the historically stable aggregation of human populations and the distribution of ordinary suburban TBVs. After reaching the peak, the q-value of HYC (X3) continues to decline, suggesting that the more remote TBVs exhibit a poorer consistency with the historically stable aggregation of human populations. By observing and correlating with the first result, we conclude that the distribution of the southern remote TBV clusters has a higher overlap with areas of moderate HYC density and regions with dense water-adaptive landscapes, indicating a significant correlation with areas historically impacted by flooding. Conversely, the remote TBV clusters show a higher overlap with regions of high HYC density but a lower overlap with areas of dense water-adaptive landscapes, leading us to deduce that human aggregation in this area historically has not necessitated significant consideration of flooding.

The q-value of GC (X4) fluctuates considerably, peaking for the most suburban TBVs (Y1), which suggests a better consistency between the historical distribution of the Grand Canal and the most suburban TBVs.

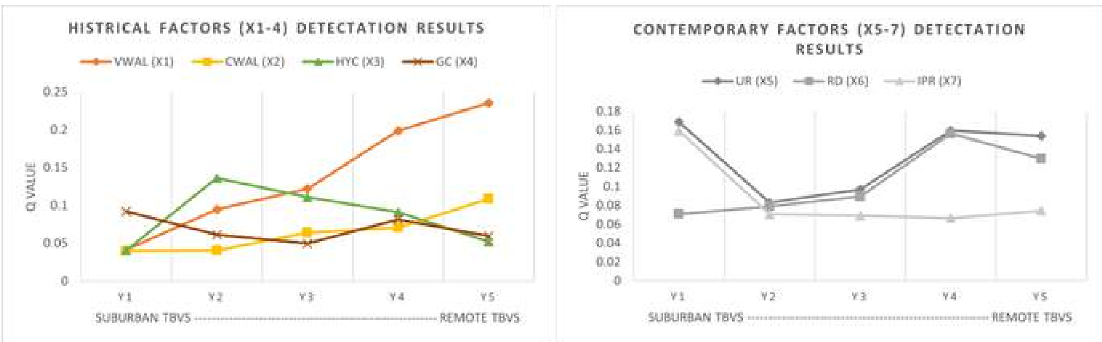

Figure 4. Factor detection results. The chart was drawn by Ruyang Sun.

The q-value of the contemporary urbanization rate (X5) initially decreases and then increases. This indicator demonstrates strong explanatory power for the distribution of most suburban TBVs (Y1) due to a more substantial consistency between the distribution map of suburban TBVs and high urbanization rate prefecture-level cities/municipalities. For instance, cities such as Beijing, Tianjin, Zhengzhou, and Shijiazhuang, which have high urbanization rates, contain half of the clusters of suburban TBVs. On the other hand, the explanatory power of this indicator for the distribution of remote TBVs (Y2-4) is also gradually increasing. Observations reveal that the distribution map of remote TBVs aligns well with prefecture-level cities of moderate urbanization rates, such as Suqian, Xuzhou, and Xingtai, where most clusters of remote TBVs are located. Heze is an exception, as it has a lower urbanization rate but hosts the largest cluster of remote TBVs in the North China Plain. The influence of road density (X5) shows an upward fluctuation, indicating a good consistency between the completeness of road infrastructure and the distribution map of remote TBVs. The influence of internet penetration rate (X6) was initially high but has remained at a low level, suggesting a good consistency between this indicator and the distribution map of suburban TBVs.

5. Discussion: The Resilient Heritage of the Yellow River Disturbance

Based on a qualitative analysis of the literature, this study compares research on the rural social history of the Yellow River floodplain with studies of TBVs within the target area, identifying similarities between the historical and contemporary rural characteristics of the region. These characteristics encompass three aspects: labor flexibility, cross-regional mobility, and community dynamism. We regard these as the resilient heritage of the Yellow River disturbance. This section elucidates how these characteristics manifested in the past and how they are expressed as heritage in remote TBVs.

The Resilient Heritage of the Yellow River Disturbance

Labor flexibility refers to the adaptability of smallholders' labor processes, shaped by the Yellow River's disturbances, including flexibility in tasks, timing, and locations. The river's frequent flooding and rerouting have constantly altered agricultural conditions. While sediment deposition sometimes improves soil quality for cultivation (Perry, 1980), these fluctuations often damage infrastructure like irrigation systems. Such instability forces residents to alternate between farming and supplementary activities such as handicrafts, fishing, and foraging (Mostern & Horne, 2021). In extreme cases, violent measures to secure necessities have been reported. Thus, the Yellow River's disturbances historically fostered labor flexibility among local smallholders.

Cross-regional mobility denotes the migration of individuals for survival. Poor living conditions in the Yellow River floodplain drive many to seek seasonal work elsewhere, often in southern Jiangsu or Shanghai. Disasters frequently necessitate village evacuations, though some return later to rebuild homes and farmland (Perry, 1980). These cycles of migration have deeply ingrained cross-regional mobility into the lives of local smallholders.

Community dynamism involves the constant restructuring of community systems to adapt to survival challenges, despite conflicts. The Yellow River's instability undermines property accumulation, creating persistent disparities between the rich and poor and amplifying survival anxieties. Assets like farmland and homes are easily destroyed by floods, potentially ruining affluent families overnight (Perry, 1980). Communities often unite in collective actions—such as looting, defense, or militarized production—to secure resources, requiring members to organize into armed groups.

Expressions of Resilient Heritage in the Remote TBVs of the Yellow River Floodplain

Labor Flexibility: Remote TBVs demonstrate labor flexibility through weak path dependency, enabling new industries to emerge from scratch (Liu Y., 2020, p. 119). Dongfeng Village in Shaji Town, Jiangsu, and Cao County in Shandong are prominent examples (Guanxin, 2021). This flexibility manifests in three forms: products, space, and skills. Flexibility in products involves frequent adjustments to meet shifting platform market preferences (Liu Y., 2020; Lüthje, 2019). Spatial flexibility refers to repurposing production or living spaces to accommodate e-commerce needs (Yuan & Luo, 2023; Zang et al., 2023). Skill flexibility highlights workers' capacity to acquire and adapt skills to evolving demands (Liu Y., 2020; Qiao & Qiu, 2024).

Cross-regional Mobility: Since the reform era, the Yellow River floodplain, hindered by slow urbanization, has been a major source of migrant workers. In the 21st century, state policies and investments have strengthened urban-rural networks, encouraging rural residents to return home and establish businesses. This has activated the legacy of cross-regional mobility in three key areas. Livelihood mobility involves frequent regional movements for survival, supporting entrepreneurship in TBVs (Wang et al., 2021; Zang et al., 2023; Zhou et al., 2021). Knowledge mobility facilitates exchanges and skill acquisition, ensuring industrial renewal (Liu Y., 2020; Zhang, 2023). Social relationship mobility maintains rural identity and cohesion among dispersed community members (Lin, 2019).

Community Dynamism: Traditional rural communities in the Yellow River floodplain, structured around individual-family-community tiers, display strong adaptive capabilities. As e-commerce penetrates rural areas, these communities dynamically reconfigure in three areas: production, culture, and power relations. Production dynamics involve adjusting organizational scale and models to meet platform demands (Guan & Zhang, 2020). Culturally, communities shift from collectivist values to embracing private wealth and economic interests (Zhang, 2023). Power structures fluctuate based on entrepreneurial success, linked to knowledge, learning, and creativity (Du et al., 2024).

6. Conclusion

This paper focuses on the remote Taobao villages (TBVs), positing that they represent an exception to the agglomeration externalities of large cities (or city clusters) or the network externalities of the urban-rural continuum. Drawing upon long-term theoretical frameworks, the paper elucidates the geographical distribution of remote TBVs from the perspective of social-historical heritage. Quantitative analyses reveal that the clustering of remote TBVs, particularly in the southern cluster on the NCP, exhibits a high correlation with areas historically affected by significant flooding. Furthermore, even when contemporary factors are taken into account, the historical disturbances of the Yellow River further enhance the explanatory power regarding the distribution of remote TBVs. These analyses support the initial hypothesis that historical fluctuations of the Yellow River have shaped a unique rural social structure locally, leaving specific legacies that are pertinent to the mechanisms underlying the emergence of remote TBVs. Finally, through a conceptualization that compares historical and contemporary conditions, three types of rural social resilience legacies from the Yellow River floodplain are revealed, which may influence the emergence of remote TBVs.

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Cultural Landscape Of Italian Inner Areas To Experiment Sustainable Development

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Abstract (150-200 words)

Inner rural and mountain areas, often perceived as marginal, represent valuable reserves of ecological, environmental, and cultural heritage shaped by long-term human-nature interactions. In the face of contemporary environmental crises, these territories offer an opportunity to rethink sustainable development models that integrate cultural landscapes, local economies, and social inclusion. The REACT research project, conducted through an interdisciplinary collaboration involving Architecture, Economics, Education, and Engineering, focuses on Casentino—a historical inner area in Tuscany— as a laboratory for innovation in participatory and community-based landscape regeneration. The study aims to develop strategies and policies that foster ecological resilience, economic sustainability, and social well-being through the active involvement of local communities. By promoting place-based governance models, participatory decision-making, and sustainable resource management, REACT seeks to redefine the role of inner areas as dynamic hubs for sustainable territorial development. This paper presents the intermediate results of REACT, emphasizing a holistic and transdisciplinary approach that considers tangible heritage, local economic systems, and human and social resources. Through collaborative practices and policy recommendations, REACT contributes to an alternative vision for inner areas, turning challenges into sustainable and inclusive regeneration opportunities.

Keywords: Cultural Landscape, Marginal Areas, Inclusive practices, Participatory Research, Heritage Regeneration

1. Introduction

In recent years, the debate on the role of cultural landscapes as a driving force for the development of inner areas has gained renewed relevance.

The well-established disciplinary discussion confirms the importance of an integrated landscape protection and enhancement approach based on a reinterpretation of the ever-evolving system of relationships between natural and human components. The idea of strictly separating these components is now widely recognized as artificial and inadequate, instead finding its synthesis in the definition of "cultural landscape" introduced by UNESCO in 1992 (The World Heritage Committee, 1992). This concept was later reinforced by the definition of "landscape" in the 2000 European Landscape Convention (Council of Europe, 2000). It seeks to integrate its various dimensions within a complex and ecosystemic vision.

The concept of cultural landscape is strongly connected to the holistic perspective advocated by the European Landscape Convention. It is adopted as an inclusive notion capable of overcoming the uncertain boundary between tangible and intangible heritage.

1.1 Cultural Landscape: from the UNESCO definition to the European Landscape Convention

The concept of cultural landscape has evolved over time through international research and various theoretical and practical approaches. Although early studies date back to the early 20th century with contributions from human geography (Schlüter, 1906; Sauer, 1925)[1], it was not until the 1960s that two major institutions, UNESCO and ICOMOS, driven by the urgent need to protect sites of exceptional value and designate them as World Heritage (UNESCO, 1972), began addressing both cultural and natural heritage as interconnected entities.

In 1992, UNESCO included cultural landscapes in the World Heritage List, defining them as: "[…] cultural properties and represent the "combined works of nature and of man" designated in Article 1 of the Convention. They are illustrative of the evolution of human society and settlement over time, under the influence of the physical constraints and/or opportunities presented by their natural environment and of successive social, economic, and cultural forces, both external and internal. […] The term "cultural landscape" embraces a diversity of manifestations of the interaction between humankind and the natural environment. Cultural landscapes often reflect specific techniques of sustainable land use, considering the characteristics and limits of the natural environment they are established in, and may reflect a specific spiritual relationship to nature" (UNESCO, 2021).

This definition goes beyond the traditional distinction between natural and cultural heritage, introducing a new integrated approach. In the expression "cultural landscape," the adjective "cultural" is used as a synonym for "human-made," the result of a human effort (Fribourg Declaration, 2007). This perspective highlights that the cultural landscape is not merely the counterpart of the natural landscape but rather an evolution of it (Fowler, 2001).

However, numerous interpretations and perspectives contribute to different dimensions of the cultural landscape, demonstrating its semantic richness and the broad range of disciplines involved (Fowler, 2001). This diversity of viewpoints generates a plurality of conceptual frameworks, each of which, though not exhaustive, establishes essential connections between the tangible and intangible components within the complex mosaic of cultural landscapes.

"The term' cultural landscape' defies any neat description, as meanings and their nuances shift shape. Cultural landscape questions of identity, definitions, and terminology may legitimately vary across varied places, cultures, and continents." (Jacques & O'Donnell, 2021).

At the end of the last century, the European Landscape Convention, also known as the Florence Convention (2000), marked a true cultural revolution. This international treaty, promoted by the Council of Europe, aims to foster the protection, management, and planning of landscapes and international cooperation in landscape policies.

It is thanks to the European Landscape Convention that landscape has been brought to new and greater attention by policymakers, scholars, and professionals, shedding light on its crucial cultural, scientific, ecological, social, and economic functions in an entirely new way (Calcagno Maniglio, 2015). The Convention introduces the concept of landscape in terms of a landscape dimension, understood as a transversal, holistic, and diachronic interpretative filter for systematically and syntactically reading social, historical, and ecological phenomena (Lambertini & Matteini, 2020).

The European Landscape Convention (2000) defines landscape as: "Landscape means an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors" (European Landscape Convention, 2000, Article 1.a)

Furthermore, The Convention includes the landscape dimension: "the entire territory […] natural, rural, urban and peri-urban areas. It includes land, inland, water, and the marine regions. It concerns landscapes that might be considered outstanding and everyday or degraded landscapes" (European Landscape Convention, 2000, Article 2).

By recognizing landscape as a fundamental component of the environment in which people live and including all types of landscapes, the European Landscape Convention deliberately omits the term "cultural" in the treaty text and the accompanying glossary. This omission reflects a conscious decision to reject any distinction between cultural and natural landscapes, reinforcing that landscapes result from community-driven transformative processes.

As a result, the Convention eliminates the traditional division between extraordinary and ordinary landscapes, encompassing all types of landscapes, including degraded ones. This overcomes dichotomies and disparities that have historically stemmed from different cultural approaches. Moreover, the Convention promotes the protection, management, and planning of landscapes, encourages international cooperation in landscape policies, and embraces a dynamic, process-oriented vision of landscapes, which had previously been regarded primarily as assets to be safeguarded through rigid constraints.

The concept of cultural landscapes, as defined by UNESCO in 1992 and the European Landscape Convention in 2000, has become a well-established and widely accepted notion. It has emerged as a central theme in the 2030 Agenda for Sustainable Development, particularly highlighted in Target 11.4, which calls upon all countries to make cities and human settlements inclusive, safe, resilient, and sustainable and to "strengthen efforts to protect and safeguard the world's cultural and natural heritage" (UN, 2015). Over the past twenty-five years, the landscape has evolved into a new lens through which to observe the world and the ongoing social and environmental changes. As Charles Waldheim (2002) notes, "across a range of disciplines, landscape is the lens through which the contemporary city is represented and the material from which it is constructed."

1.2 Inner Areas

In the current national debate, increasing attention is being paid to policies for protecting and enhancing the cultural heritage of the so-called inner areas. In this context, it has been rightly observed that cultural landscapes can serve as a driver for development, and their enhancement is considered one of the main strategies to counteract depopulation trends and contribute to the local development of these territories (Coordinamento Rete Nazionale Giovani Ricercatori per le Aree Interne, 2021).

A significant portion of the Italian landscape is characterized by a territorial organization based on small settlements, often offering residents only limited access to essential services. These landscapes form a dispersed settlement system integrated into the rural environment, shaped by agricultural patterns, land use, forest resources, and a dense network of roads, paths, and trails. Even when they lack strong tourist attractions, these areas possess various resources and are distinguished by historical continuity, strong social ties, biodiversity, and a widespread architectural heritage. Additionally, their rich gastronomic traditions can potentially enhance local cultures, a concept that links biodiversity to cultural heritage and traditional knowledge. The term inner areas summarizes the specific characteristics of these areas.

The term "area interna" - inner area, first used in 1958 by the Italian economist and agrarian expert Manlio Rossi-Doria, referred initially to rural territories in Southern Italy with low productivity, considered marginal compared to more developed areas. At the end of the 20th century, the issue of demographic decline became a key topic in urban and territorial studies, particularly affecting these inner areas, which often include small historic villages and highland territories. These areas frequently experience housing and agricultural abandonment, depopulation, and the consequent degradation of cultural and environmental assets.

The issue of demographic contraction is of great social and scientific relevance, spanning economics, urban planning, and public policy, and is a highly topical subject. According to recent estimates, population decline will pose a significant challenge in many developed countries in the coming years, with Italy being one of the most affected (UN, 2024).

In 2014, the National Strategy for Inner Areas (Strategia Nazionale per le Aree Interne, SNAI) was approved within the framework of European Union cohesion policies (Coordinamento Rete Nazionale Giovani Ricercatori per le Aree Interne, 2021) to address these issues. The strategy aimed to redefine inner areas' geographical and socio-economic identity and enhance local resources through targeted development policies. The SNAI classified over 60% of Italy's territory as an inner area. The criterion chosen to define the remoteness of a location was the distance from essential services such as healthcare, education, and mobility infrastructure. Therefore, according to SNAI, an inner area is not necessarily synonymous with a "fragile area" or a "poor and weak area" (Dipartimento per le Politiche di Coesione, 2014). These territories often safeguard essential resources, including environmental assets (forests, pastures, protected areas), productive activities (specialized agriculture, food processing, artisanal and traditional manufacturing), and cultural heritage (archaeological sites, museums, historical buildings, and conventional craftsmanship centers). However, the lack of services has contributed to the depopulation of these areas over time, in some cases leading to abandonment. Among the consequences of this phenomenon is the disruption of intergenerational knowledge transmission, which weakens the area's cultural identity and reduces essential stewardship of the land, making it increasingly vulnerable.

Figure 1. Italian municipalities are classified into poles and areas with varying degrees of remoteness from reference centers, highlighting the condition of Inner Areas. (Dipartimento per le Politiche di Coesione, 2014)

The SNAI initiative, implemented in 72 pilot areas, was initially conceived as an experimental policy but is now regarded as a fully-fledged long-term structural policy (Figure 1). The strategy introduces territorial policies based on a place-based approach, with the primary goal of revitalizing the development of marginalized areas by leveraging their opportunities and resources. The SNAI is supported by European funds (ERDF - European Regional Development Fund, ESF+ - European Social Fund Plus, and EAFRD - European Agricultural Fund for Rural Development) for co-financing local development projects and national resources.

With the 2021-2027 programming cycle, the strategy has been renewed and expanded, reinforcing its role within Italy's territorial cohesion policy and confirming a specific focus on these areas' economic and social sustainability (Agenzia per la Coesione Territoriale, 2021). This expansion aligns with broader European policies that emphasize resilience, green transition, and digital innovation as key factors for the sustainable development of rural and marginal territories.

2. Material and Method

The REACT research project (Regenerating the cultural landscapes of inner areas from a people-centered perspective. Historic villages and rural territories of Casentino as a laboratory for creativity and innovation) is an interdisciplinary initiative launched in December 2022 at the University of Florence, funded through the Competitive Research Projects Call under the PNR 2021-2027, with resources from the European Union – NextGenerationEU.

The project uses Casentino as a case study to develop replicable strategies, methods, and initiatives for the material, productive, and community regeneration of Italy's inner cultural landscapes. Its distinctive features include interdisciplinarity, strong community engagement, and a methodology designed for broader application beyond the initial study area. The research team integrates expertise from four university departments—Architecture, Industrial Engineering, Economics and Business Sciences, and Education, Languages, Intercultural Studies, Literature, and Psychology—creating a dynamic scientific community of over 40 researchers.

By adopting a people-centered approach, REACT fosters dialogue between academia and local communities, ensuring that the needs and aspirations of residents shape the regeneration process.

One of its key outcomes is the development of Guidelines for the regeneration of Casentino's cultural landscape, which will be expanded into a Strategic Guide for sustainable development in Italy's inner areas. Through its collaborative and applied research model, REACT generates scientific knowledge and practical tools to support future policies for inner regions.

Figure 2. The REACT research

2.1 Cultural Landscape in the REACT Research

In recent years, the debate on the role of cultural landscapes as drivers of development for inner areas has gained new relevance. The REACT research project addresses this theme in all its complexity. It explores tangible and intangible aspects of cultural landscapes and highlights how their transformation processes can foster virtuous practices for territorial growth, particularly in disadvantaged contexts like inner areas.

Within REACT, the concept of cultural landscape is closely linked to the holistic perspective outlined in the European Landscape Convention. It is adopted as an inclusive framework that transcends the often uncertain boundary between tangible and intangible heritage. The research methodology is based on an interdisciplinary approach, integrating different dimensions of the topic: settlements and architectural heritage, cultivated landscapes and ecosystems, as well as community practices and experiences. The analysis focuses on challenges, development prospects, and available resources, aligning with the project's strategic framework to provide a thorough and contextualized understanding of the opportunities and criticalities of these territories.

REACT mobilizes its multidisciplinary team to tackle the depopulation of inner areas by promoting virtuous processes, concrete actions, and targeted strategies for cultural landscape enhancement. The research seeks to reposition inner and marginal areas as experimental grounds for landscape valorization rather than territories marked solely by abandonment. It acknowledges that the regeneration of villages and rural landscapes cannot rely exclusively on public investment, which, though essential, must be complemented by participatory governance models that actively engage local communities. The ultimate goal is to revitalize local economies by leveraging the widespread landscape resources of these disadvantaged areas.

2.2 The research context

To achieve its objectives, REACT has focused on Casentino, an inner sub-region of Tuscany located in the northwest and the first valley of the Arno River. This study area was selected for its potential as a pilot project site where creativity and innovation could be tested in practice. Casentino represents a marginal territory with a significant cultural landscape shaped by a long-lasting co-evolution between environmental features and human activity. It is a region where abandonment and repopulation coexist, offering multiple opportunities for revitalization. Its strengths are well-established territorial animation initiatives and a dense and active network of local associations.

The landscape of Casentino is characterized by vast forested areas and a valley floor with a traditional agricultural matrix, though parts of it have undergone residential and industrial development. Historically marked by autonomy and marginality, these factors have shaped its settlement system, which consists of a homogeneous network of compact villages. With a low population density of 48.05 inhabitants/km² (ARS, 2023), Casentino faces mountain and hilltop depopulation, the abandonment of less accessible historical centers, and increasing hydraulic risks in the valley (Regione Toscana, 2015). These dynamics make it a relevant testing ground for strategies to balance landscape conservation, community participation, and sustainable territorial development.

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Figure 3. The Inner Areas of Tuscany in the SNAI 2021-2027 Programming (Regione Toscana, 2021)

3. Findings and Discussion

In light of these premises, it becomes evident that the concept of cultural landscape serves as a unifying framework, integrating its multiple dimensions into a complex and ecosystemic vision. The four key thematic areas identified in the REACT research provide a structured lens for assessing the current state of cultural landscapes, analyzing their challenges, development potential, and available resources within inner areas, and reinterpreting them through the strategic framework developed in the study.

1. Agro-food heritage, forestry, and local craftsmanship
2. Traditions and social practices
3. Landscape and territorial networks
4. Settlements, public spaces, and buildings.

Figure 4. Results of the participatory debate on 'Cultural Landscapes' during the III Seminar of the REACT research.

By exploring and understanding cultural landscapes in inner areas through the problem areas of the REACT research—agro-food and forestry heritage and local craftsmanship, traditions and social practices, landscape and territorial networks, settlements, public space, and buildings—the study highlights the interconnected nature of territorial dynamics. The thematic framework provides a comprehensive synthesis of the distinctive features of Italy's hilly and mountainous inner areas, supporting the identification of weaknesses, opportunities, and enabling resources (human, environmental, community-based, regulatory, and financial) for sustainable regeneration.

Each thematic area is illustrated with best practices from the Italian context, showcasing concrete landscape enhancement and territorial revitalization examples. This structured approach enables a deeper understanding of the criticalities and potentialities of Casentino, the chosen pilot case for the project.

Thematic Area 1: Agro-food heritage, forestry, and local craftsmanship

In the Italian territorial context, inner areas require enhancing agro-food and forestry resources. The abandonment of agricultural and pastoral activities has led to degradation and instability, negatively impacting local economies and territorial resilience. Though forests are historically crucial for hydrogeological protection and economic development, they are increasingly underutilized despite their strategic potential.

A notable example of best practice is the "Forest Condominium" in Alta Carnia (Friuli-Venezia Giulia region), which promotes land consolidation and sustainable forest resource management. The SNAI 2021-2027 framework emphasizes the importance of forest management and local wood supply chains, encouraging the development of new products and the recognition of ecosystem services.

Thematic Area 2: Traditions and Social Practices

Rural communities in hilly and mountainous areas have historically developed self-governance and cooperation strategies to adapt to environmental and socio-economic challenges. New social innovation processes are emerging across inner territories, often driven by a renewed interest in the primary sector among long-term residents and newcomers.

Post-pandemic trends indicate a growing desire among young people to remain in inner areas, valuing the "territorial capital" and the opportunities tied to local resources (Fenu, 2020; Membretti, Leone & Lucatelli, 2023). Participatory processes should engage current residents, emigrants, and newcomers as they contribute fresh ideas, skills, and knowledge, fostering sustainable reinhabiting.

A concrete example is the social housing project in Riccia (Molise region), which involves a collaborative network of municipalities to support elderly-friendly housing solutions in the historic center, addressing the demographic challenges of an aging population.

Thematic Area 3: Landscape and territorial networks

Understanding the ongoing transformations within landscapes is essential for assessing tinner areas' decline and future potential. Historically neglected in favor of urban-centered policies, these territories require rethinking demographic, economic, social, and cultural equilibriums to ensure long-term resilience.

A landscape-based approach necessitates a strong connection between ecological knowledge and community engagement while promoting sustainable land management practices. In response to hydrogeological risks, new river basin maintenance models have been developed, shifting away from localized engineering solutions to improve hydraulic efficiency toward approaches that restore natural water dynamics.

A noteworthy case is the "Territory Custodians" network in Garfagnana-Lunigiana (Tuscany region), where local actors maintain minor waterways and drainage networks, preventing landslides and floods. When understood as an ongoing and structured practice, landscape maintenance becomes a fundamental tool for balancing natural dynamics and human activities.

Thematic Area 4: Settlements, public spaces and buildings

A key focus of the SNAI framework is the preservation and adaptive reuse of traditional built heritage, often abandoned due to economic decline or environmental risks (such as earthquakes). Many innovative projects aim not only at the physical restoration of buildings but also at preserving local construction traditions and cultural knowledge, ensuring their continued relevance.

A striking example is Wonder Grottole (Basilicata region), where a collaborative initiative between residents and international visitors has transformed the town into a living laboratory of sustainable tourism and community revitalization. Unlike conventional heritage-driven tourism, projects like Grottole emphasize community engagement and knowledge-sharing, fostering place-based regeneration rather than mere economic exploitation.

Inner areas are a national priority for their development potential and because of the social and environmental costs associated with their decline. Issues such as hydrogeological instability, biodiversity loss, landscape degradation, ecosystem imbalances, cultural erosion, and limited access to digital and public services are critical challenges that directly affect the functioning of the entire country.

The REACT research highlights the crucial role of inner areas in building a sustainable future for Italy, recognizing cultural landscapes as a strategic resource for national economic and environmental stability and advocating for long-term territorial regeneration, community empowerment, and place-based innovation.

4. Conclusion

The REACT research highlights the cultural landscape as dynamic, evolving entities shaped by continuous human-environment interactions. Over time, the concept of landscape has moved beyond a perception-based and aesthetic-driven vision, embracing broader dimensions connected to the communities that actively shape and transform their surroundings.

It is particularly significant to note the semantic connection between the words "culture" and "landscape," both rooted in care and land shaping. Today, there is widespread recognition that all European and global landscapes are, to some extent, anthropogenic, shaped by human intervention over time. In this sense, all landscapes are cultural landscapes, with "cultural" as a synonym for "human-made."

The notion that cultural landscapes result from human effort is particularly fitting. They do not simply happen but emerge through intentional human activity. As noted by Fowler (2001), this perspective underscores that cultural landscapes are not the opposite of natural landscapes but rather an evolution of them. This aligns with the definition of "landscape" established by the European Landscape Convention, a perspective fully embraced by REACT.

By adopting an interdisciplinary and participatory approach, REACT demonstrates that cultural landscapes are not static heritage sites but active spaces for sustainable development. The research underscores the importance of community involvement in shaping and maintaining these landscapes, aligning with the principles of the European Landscape Convention and the Faro Convention.

For REACT, cultural landscapes are not limited to UNESCO-designated heritage sites; instead, they include all landscapes as they are perceived and shaped by communities over time. In accordance with the Faro Convention, the research places human and community dimensions at the center of landscape creation and stewardship, challenging the traditional tangible/intangible heritage dichotomy.

A key takeaway from the study is that the preservation and regeneration of cultural landscapes cannot rely solely on public policies or financial investments. Instead, active community participation and governance models are essential for fostering long-term sustainability. Inner areas, often perceived as marginal or in decline, should instead be seen as experimental grounds for innovative strategies that integrate heritage conservation, ecological sustainability, and social inclusion.

Ultimately, REACT reaffirms the centrality of cultural landscapes in shaping a sustainable future, advocating for policies and governance models that prioritize territorial resilience, community-driven innovation, and environmental stewardship.

Acknowledgments

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Addressing Urban Uncertainties: Reconnecting Heritage and Nature in Historical Cores

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Abstract

Considering the urgency of adapting urban environments to Climate Change, the role of Urban Green Infrastructures and Nature Based Solutions has been strongly recognised as crucial and an increasing number of research and practical experiences as involved cities in the past decades. However, this effort for adapting cities is not involving all urban areas in the same way. In particular, historical urban centers are almost excluded from the experimentation of NBS because of the additional difficulties they pose. At the same time, historic areas are even more vulnerable to the impact of Climate Change and cultural heritage is recognised as a key element for building improve urban resilience. So, there is a potential synergy with respect to the main goal of urban adaptation, but not exploited up to now. This contribution presents an improved methodology to extend the UGI planning process in historic urban areas, by reconnecting Culture and Nature as pillars of urban resilience and sustainable development. The paper includes a reconstruction of the State of the Art in research and practice, the explanation of a four-steps analysis to reconnect "green history" and "green planning" and the proposal for an improved methodology for planning UGI in historic urban landscapes.

Keywords: Urban Green Infrastructures, historic urban landscapes, urban adaptation, heritage resilience

1. Introduction

In the face of escalating global uncertainties and crises, driven by anthropogenic impacts on environmental conditions and rapid urbanization, urban research and strategic planning have assumed a pivotal role in preparing human society for adaptation and resilience. Cities, as focal points of population concentration and activities (United Nations, 2018), are at the heart of these efforts. The intense anthropogenic transformation has led to a profound disconnect from the biosphere, reducing the capacity of cities to face risks and provide flexible responses (Andersson et al., 2014). Additionally, urban areas are characterized by a high concentration of vulnerabilities, including human capital and material assets exposed to risk. However, cities also serve as hubs of critical resources and opportunities, which can be leveraged to initiate transformative processes toward sustainable futures. Cultural heritage, the historical stratification of the urban fabric, and the transmission of intangible assets such as knowledge, traditions, and cultures that permeate urban spaces can play a pivotal role in building resilient cities (Sesana et al., 2021). Historic urban areas in particular are repositories of knowledge, resulting through incremental transformations over centuries in response to changing pressures on the role of the city (Nadin et al., 2015).

Nowadays, strategies for urban adaptation and resilience increasingly emphasize the reintegration of nature into the urban environment as green infrastructures (GI) and the adoption of Nature-Based Solutions (NBS). Indeed, there is broad recognition of the the potential of NBS to provide flexible, effective responses to complex challenges (EEA, 2015; Pauleit et al., 2017). The GI approach perfectly fits the current historical moment, when scientific research has been transversally involved in the study of possible mitigation strategies and adaptation pathways to make urban contexts less vulnerable and more resilient in the short to medium term (Steiner et al., 2013). In this regard, the concept of an infrastructural green network plays a role of primary importance, supporting a holistic approach taking into account the capacity of natural systems to ensure a broad spectrum of benefits (Frantzeskaki, 2019). Building on the outcomes of the Natura 2000 project, the definition commonly adopted at the European level describes the GI as «a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services» (European Commission, 2013). The main purpose of this approach is to create a multifunctional network of green spaces in order to enhance the systemic behaviour of natural components and to provide multiple environmental, social and economic benefits. This approach also refers to the related concept of Ecosystem Services (ES) (Geneletti et al., 2020; Haase et al., 2014). The GI is considered as an effective approach to face major urban environmental and social challenges, including adaption to climate change (Klemm et al., 2017; Pauleit et al., 2017; Ramyar & Zarghami, 2017), and it is fully supported and promoted by EU policy for both rural and urban areas (Bouwma et al., 2018).

Despite its promising potential, the GI approach faces practical implementation challenges and the physical constraints imposed by urban morphology. The application of GI in historical urban contexts has very limited theoretical and practical references. This gap poses a critical challenge for the adaptation of historic urban areas, while also representing a missed opportunity to harness the synergy between nature and culture as foundational pillars for building resilient cities. This article briefly presents the approach developed during the first author’s doctoral research, under the guidance of her supervisor, Prof. Tzortzi. The research aims to integrate GI planning with the strategic directions inherent in the historical urban fabric. It aims to bridge this gap by proposing a framework to reconnect heritage and nature as essential components for enhancing resilience in historical urban areas, working at the intersection between different thematic fields (Figure 1). The final proposal is a culture-based approach for the strategic planning of GI in historic urban landscapes, adapting to the urban, morphological, and cultural specificities of historic contexts.

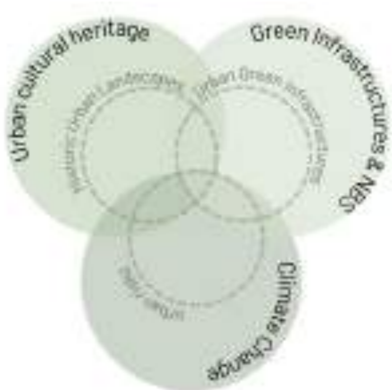

Figure 1. Conceptual framework of the research (Lux, 2024)

2. Objectives and Method

Cities are complex and dynamic systems shaped by economic, social, cultural, political, technological, and environmental dimensions. Cultural heritage —encompassing both tangible and intangible elements valued by a social group (Taylor, 2015) —is a fundamental component of cities, requiring for careful consideration in strategic planning and the assessment of urban resilience. At the same time, addressing the challenges posed by CC requires urban transformation processes to include historic centres, which are often excluded from such efforts. These areas remain in a fragile and crystallized condition. Restoring a balance between natural and built environments is critical for equipping cities to navigate uncertainty. In historical areas, however, renaturing processes require highly site-specific approaches, which are often resource-intensive in terms of effort, time, and costs. The compact, dense structure of historic urban cores, combined with the constraints of heritage preservation, generally limits the feasibility of conventional green solutions—such as green corridors and extensive parks—due to the scarcity of adaptable public space (Grădinaru & Hersperger, 2019). Despite European and international institutions issuing various guidelines for Green Infrastructure (GI) and Nature-Based Solutions (NBS) (European Commission, 2012, 2013), and despite some pioneering cities adopting resilience-focused approaches in their strategic planning, renaturing interventions remain rare in the historic cores of large urban settlements. This lack of implementation is highlighted by a comprehensive review of case studies across Europe, revealing an evident gap between theory and practice.

To address this gap, it is necessary to move beyond conventional top-down planning approaches, which are typically designed for large-scale transformations of public spaces. While effective in contemporary or peripheral urban areas, these strategies often prove inadequate for historic cores. This research aims to develop a complementary strategy tailored to these unique contexts. By designing a framework for incorporating Green Infrastructure into historical districts, this research seeks to bridge the gap between cultural preservation and environmental resilience, enabling these areas to confront future challenges more effectively. Replacing the “green history” of the city as the basis for the “green planning” of the future provides an opportunity for culture and nature to find a positive synergy (Tzortzi & Lux, 2021, 2022b). The study covers three main steps, starting from the analysis of the State of the Art, which emphasised the knowledge gap, moving to the proposal for a culture-based approach and resulting in an improved methodology for GI in Historic Urban Landscapes (Figure 2).

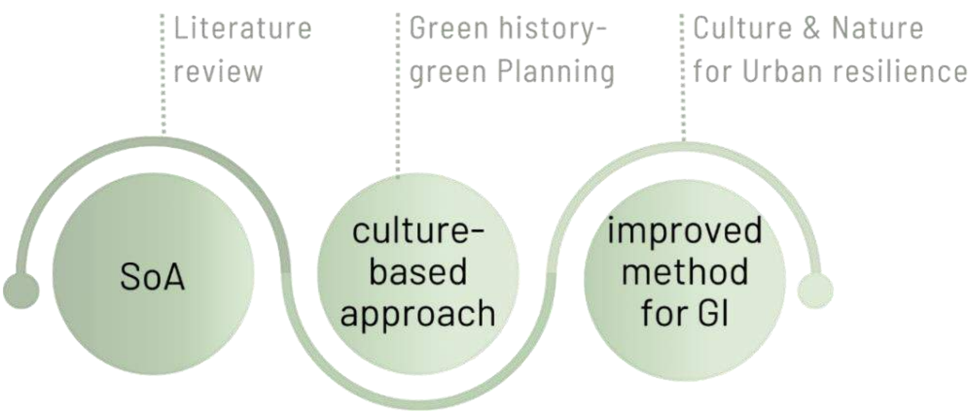

Figure 2. Methodological steps of the research (Lux, 2024)

3. Findings and Discussion

The reconstruction of the State of Art (SoA) conducted since 2021 and periodically updated clearly shows the imbalance in the research effort between the three research topics (climate Change, Green Infrastructures, Urban Cultural Heritage) and their intersections. Indeed, while the research effort on Climate Change, related mitigation and adaptation strategies and, in parallel, the role of GI and NBS to improve urban resilience has been constantly growing over the past decades, the studies on cultural heritage remained almost disconnected from this main strand and limited in terms of number. The role of urban cultural heritage has been investigated, both as a victim of climatic and environmental transformations on a global scale and as a non-renewable resource that is fundamental for building a more resilient society (Holtorf, 2018; Nocca, 2017). However, heritage has never been really included in a proactive way in the studies for strategic planning and improved resilience and it has never been combined with other strategies (such as the GI approach) to provide more effective solutions to urban challenges. The SoA in theoretical and practical experimentation about GI and urban cultural heritage has been investigated by mean of a systematic literature review in Web of Science and also by reviewing the practical NBS projects recorded in the European Platform od NBS 'Oppla'. The results are summarised in Figure 3.

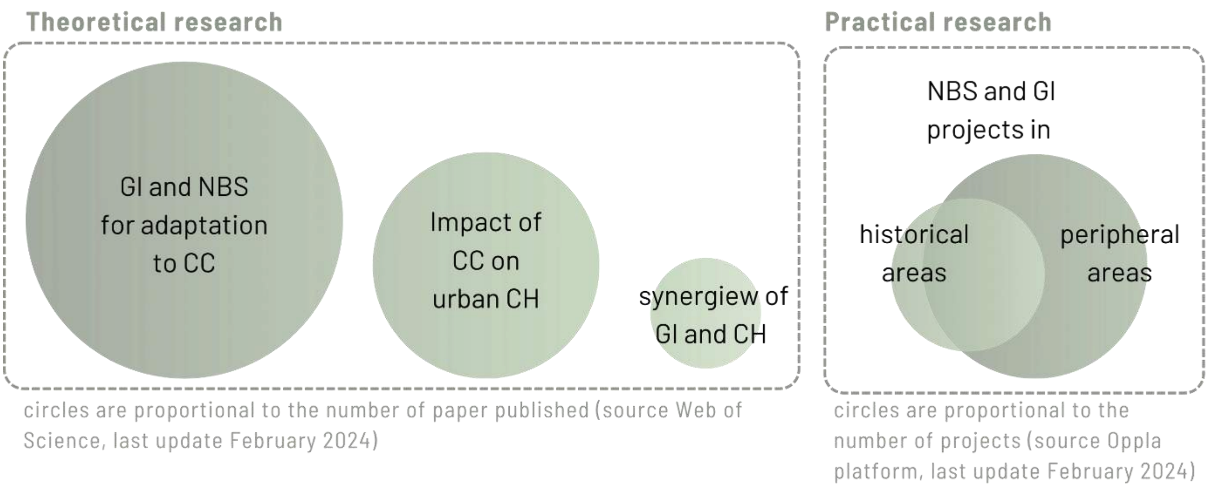

Figure 3. SoA in theoretical and practical research (Lux, 2024)

To fill the gap, we proposed to complement the current planning process of GI in historic urban areas with additional analyses to support a more informed and comprehensive planning procedure. The methodological integration is applied through four sequential analysis steps to be applied to the historical urban landscape under examination: historical, spatial, policy, and social (Figure 4). These are four consecutive steps. The historical analysis is aimed at reconstructing the "green history" of the city, i.e. the historical relationship between city and nature, and to identify the physical places and the scale of integration of natural components in a specific historical context. This step results in a spatial focus, namely the identification of suitable spatial units for implementing GI in that specific context. The spatial analysis focuses on the identified spatial focus with the aim of quantifying the extent and consistency of the spaces under analysis and their relevance in terms to contribution for the overall urban adaptation process. The policy analysis assesses the tools for the protection of existing green spaces and policies supporting the extension of GI in the historic urban context. Finally, the social investigation has the dual objective of investigating the attitude toward the proposed elaboration by both a technical audience (researchers, administrators) and non-technical individuals (citizens).

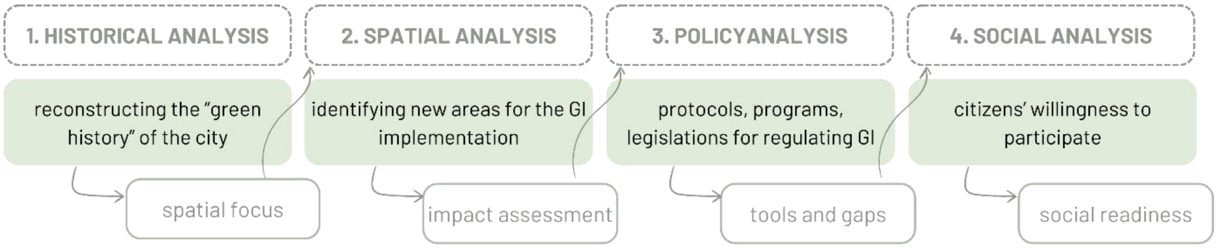

Figure 4. Analysis to support the integrative methodology (Lux, 2024)

The proposed approach was initially developed with reference to the case study of Milan, Italy (Tzortzi & Lux, 2022a), and subsequently applied to other urban environments that are geographically distant and culturally diverse, such as Bogotá, Colombia (Tzortzi et al., 2024), and Mardin, Turkey (Ucer et al., 2024). The experimental applications underscored the importance of small- and medium-sized spaces for both conserving existing greenery in historic urban areas and strategically expanding it. This outcome made it necessary to integrate the concept of "green network" with that of "green fragments", i.e. small-sized green spaces, whose contribution to the UGI and ability to provide Ecosystem Services depends on the creation of a dense and widespread system (Lux, 2024). The synthesis of all observations and experiments conducted on the integration of GI in historic urban landscapes has led to the development of an improved methodology. This method incorporates the four analyses described above into the processes of studying, designing, implementing, and monitoring GI (Figure 5). The result is a refined approach in which the goal of reintegrating natural elements into urban areas is closely aligned with the historical specificities of the context, leveraging these unique characteristics to enhance outcomes.

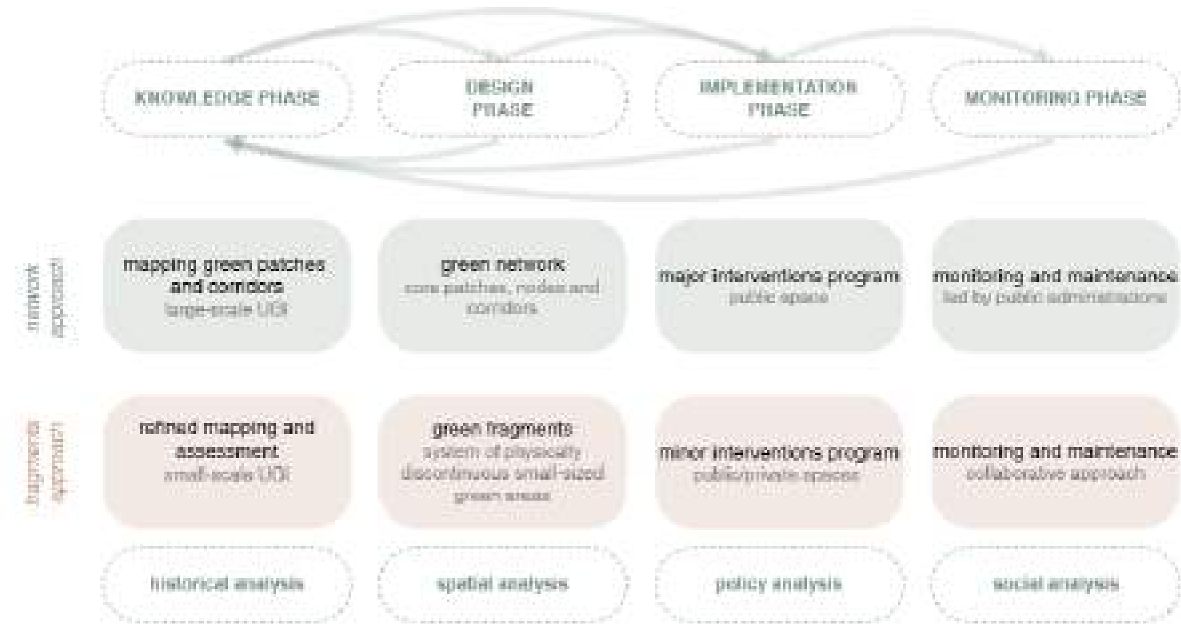

Figure 5. Improved methodology for planning GI in Historic Urban Landscapes (Lux, 2024)

4. Conclusion

In conclusion, this contribution aims to highlight the essential and potential synergy between nature and culture as a foundation for resilient cities and to support the adaptation of historic urban contexts. The studies conducted by the authors have underscored a significant research gap that currently excludes cultural heritage from strategies aimed at reintegrating nature into urban areas. This gap has further isolated and excluded historic centres from experiments with GI and NBS, leaving them more vulnerable to escalating risks. The approach proposed in this article seeks to address these challenges by providing a framework that bridges this divide, fostering greater resilience in historic urban environments.

The proposed methodology guides the planning process of GI in historic urban areas by accounting for the specific characteristics of the context and the established relationship between city and nature. Based on the authors' experiences, this often leads to a downscaling of interventions and a preference for small- to medium-scale NBS, which are more adaptable to the compact urban morphology of historic areas. Consequently, it becomes necessary to revise and update the concept of a green network, introducing the possibility of a discontinuous system of green fragments that can still significantly contribute to urban adaptation processes.

The approach presented aims to transcend sectoral divisions, fostering interdisciplinary synergies and proposing innovative strategies. Ultimately, this may be the study’s most important outcome: recognizing the need to break disciplinary boundaries and integrate diverse knowledge systems, as demonstrated by the combination of GI planning with the study of urban cultural heritage. Specifically, the history of places and the cultural layers of the city must necessarily serve as the foundation for any adaptation and resilience-building process.

Note

The improved methodology for Green Infrastructure in historic contexts presented in this article was previously published and extensively discussed in Lux, M. S. (2024). Networks and Fragments: An Integrative Approach for Planning Urban Green Infrastructures in Dense Urban Areas. *Land*, *13*(11), 1859. https://doi.org/10.3390/land13111859. All other sources and prior studies conducted by the authors are cited as references.

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ACTING FOR ALL

Suitable Dwelling Growth of Geelong

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Abstract

This study addresses the urgent need for strategic planning in Geelong to accommodate its rapidly growing population while ensuring sustainable urban development. By integrating Geographic Information Systems (GIS), weighted overlay analysis, and advanced UAV remote sensing, the research evaluates Geelong's current infrastructure, land use patterns, and environmental constraints. It identifies housing demand in specific areas through demographic analysis and assesses potential residential locations based on accessibility, ecological sustainability, and risk mitigation, particularly concerning bushfires and flooding. Additionally, community engagement through surveys and participatory mapping ensures that residents' preferences are incorporated into the planning process. The study pinpoints eight optimal Urban Growth Areas (UGAs) totaling approximately 2,049 hectares, strategically located to enhance connectivity and public service access while minimizing environmental impact. The outcome is a comprehensive residential development plan that supports Geelong's long-term growth projections and provides valuable insights for urban planners and policymakers.

Keywords: Immigrant cities, future residential areas planning, participatory planning, urban development, sustainable development

1. Introduction

In 1980, the World Conservation Union introduced the concept of sustainable development, emphasizing the need to balance ecological health with human progress. This concept has gradually been integrated into the planning and design of human settlements, contributing to more resilient urban environments. The practice of land suitability assessment has become increasingly important, enabling urban planners and policymakers to make informed decisions regarding urban spatial planning and the realization of sustainable urban development.

Looking ahead, the Australian government is poised to enhance its support for "remote areas" through increased investments in capital, technology, and policies, fostering the growth of diverse industries in these regions (Graymore et al., 2022). This strategic focus is expected to encourage a gradual increase in the population of remote cities, which will create new employment opportunities and effectively drive the economic, technological, and infrastructural advancement of these urban centers.

As a nation with a rich history of immigration, Australia also benefits from a steady influx of people, further bolstering the development of inland towns (Chen, 2021). According to the Australian Bureau of Statistics' 2022 report on population by country of birth, 29.1% of Australia’s permanent population consists of overseas immigrants, amounting to approximately 7.5 million individuals (Australian Bureau of Statistics, 2022). This demographic trend highlights the significant role that immigration plays in shaping urban growth and development across the nation.

The city of great Geelong

Geelong, located approximately 75 kilometers southwest of Melbourne, is a significant regional city in Victoria. It is the second-largest city in the state and is comprised of several distinct suburbs and districts. Geelong's economy has diversified over the years, evolving from its historical roots in the wool industry and manufacturing to incorporate sectors such as education, health care, and technology.

The population of Geelong has been steadily increasing, currently exceeding 260,000 residents, making it one of the fastest-growing regions in Victoria (Geelong City Council, 2023). This population growth is largely driven by both natural increases and immigration, creating an enormous demand for new housing. Forecasts indicate that Geelong will require approximately 1,500 new homes annually from 2024 to 2031 to accommodate its expanding population.

In response to this growth, the Victorian Government and Geelong City Council have established a vision for the sustainable development of the region, aiming for a population of around 400,000 by 2041. They are implementing strategic planning measures to enhance integrated transportation and land use, focusing on creating more walkable neighborhoods and developing infrastructure to support public transport systems.

Community feedback emphasizes a desire for improved planning outcomes, which includes prioritizing health and wellbeing in urban planning, as well as promoting infill development and responsible use of available land (Department of Transport and Planning, 2024). The strategic plan for Geelong outlines several key initiatives, including the development of new housing stock to accommodate the projected growth, integration of public transport and land use, and enhancement of commercial areas to sustain economic vitality. The council anticipates that this comprehensive approach will facilitate approximately 85% of future housing growth within the Urban Growth Boundary (UGB) and 15% in surrounding small towns (City of Greater Geelong, 2023).

Literature Review

Land suitability assessment is essential for identifying the most critical factors that influence the suitability of land for various uses (Graymore et al., 2022). The multi-criteria evaluation (MCE) method, utilizing Geographic Information Systems (GIS), effectively converts geographic data into visual representations and determines the significance of various criteria in the selection of appropriate land through weighted overlay analysis. The land use/land cover change model serves as a valuable tool for understanding and elucidating the causes and effects of land use and land cover dynamics (Geelong City Council, 2023).

Scenario-based analyses using these models can provide vital support for land management and enhance decision-making processes in environmental impact assessments (EIAs), which aim to protect the environment while improving residents' quality of life (Malczewski, 2021). Identifying potential sites for future urban development is a crucial aspect of promoting sustainable growth and development (Angelis-Dimakis et al., 2022; Ramachandra & Shruthi, 2022).

2. Project Objects and Planning Goals

2.1 Project objects

The project's main objective is to identify suitable land for future residential development in Geelong. By 2041, the population of Geelong is projected to increase significantly, reaching a target of approximately 400,000 residents and continue climbing as high as 500,000 by 2050. To ensure that the residents of Geelong have access to comfortable living spaces, the city will need to develop around 2000 hectares of residential areas over the next 20 years and provide approximately 20,000 new homes within these zones.

In the Geelong Residential Strategy, four key factors are critical in determining whether future residents can enjoy a high quality of life: the community's engagement, the availability of social resources, the ecological systems, and the safety of the city. Additionally, the city's compactness and connectivity will be considered to enhance the efficiency of utilizing existing public services and infrastructure (City of Greater Geelong, 2023).

To determine the most suitable areas for residential growth in Geelong, the report will employ a weighted overlay analysis based on Geographic Information Systems (GIS). The advantage of this method is its ability to enable planners to make informed decisions by incorporating various practical factors. This approach allows planners to assign weight to each criterion according to their relative importance, adapting the strategy to fit the unique needs and characteristics of different regions within Geelong. Such flexibility ensures that the planning process aptly reflects subjective views while addressing the practical needs of the community (Geelong City Council, 2023).

Planning Goals

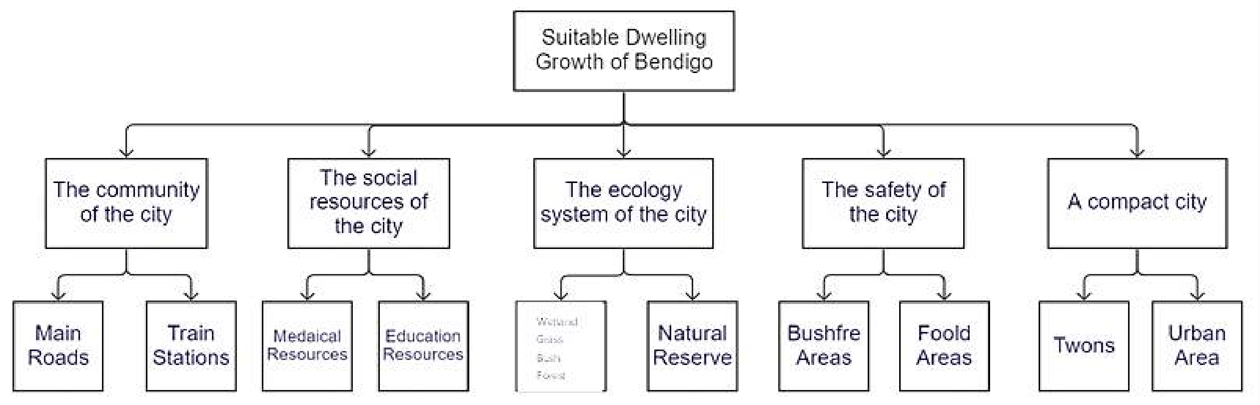

Figure 1. The Planning Goals of Bendigo (Zhang, 2024)

1）The community of the city:

Transportation is a critical factor in Geelong's development. Effective transportation systems promote interaction between areas, enhancing population mobility and facilitating economic exchanges. The existing transportation infrastructure will be a primary consideration in the analysis of the development potential of various areas. In this report, regions along key transportation corridors and near transport hubs will be identified as potential sites for development (Neal, 2012).

2）The social resources of the city:

Education and healthcare are significant factors affecting residents' daily lives in Geelong. To ensure that every resident can conveniently access these essential services, the proximity of potential development areas to educational institutions and healthcare facilities will be evaluated (Chen, 2016).

3）The ecology system of the city:

The harmony between human existence and nature is vital for the sustainable development of Geelong. Therefore, when analyzing potential areas for residential growth, it is essential to avoid harming natural reserves and to protect the habitats of local flora and fauna (City of Greater Geelong, 2023).

4）The safety of the city:

Natural disasters pose serious threats that can lead to casualties and property damage. Consequently, when selecting suitable areas for residential development in Geelong, it is important that these sites are situated at a safe distance from regions prone to frequent natural disasters. In Geelong, common risks include flooding and coastal erosion. Potential development areas should be assessed considering these risks (Bronstert et al., 2002; McCuen, 2003; Carlson, 2004).

5）A compact city:

This factor emphasizes the importance of proximity between distinct areas within the city. If newly developed regions are adjacent to established central areas, they will have better access to existing public services, facilities, and infrastructure. This proximity can significantly reduce construction and operational costs (Chen, 2015).

3. Findings and Discussion

1) The community of the city – utilizing existing public transport to develop.

Geelong features a robust transportation system, including well-developed railways and major road networks spanning the city. This structured transportation network effectively accommodates traffic demand and is conducive to housing growth. Euclidean distance analysis indicates that areas located near road infrastructure and railway stations are more likely to be targeted for development. The existing transportation infrastructure can significantly reduce development costs (DPTLI, 2015). Reliable public transport also attracts more residents, leading to enhanced cultural and economic opportunities. Through reclassification, transport corridors in Geelong can be identified as potential growth areas, supported by efficient road networks and public transport services (Chen, 2016).

2) The social resources of the city - Accessibility to education and health services and jobs

Education and healthcare are vital sectors in Geelong, playing a crucial role in attracting new residents and immigrants. With the government's commitment to ensuring broad access to education and healthcare, areas near educational and health facilities will be prioritized for development. Key institutions, such as Geelong Hospital, Deakin University, and various local schools, are essential infrastructures that draw investment and contribute to the area's growth. Euclidean distance analysis and reclassification reveal the areas surrounding these facilities, indicating that future development will concentrate around these core locations (Chen,2016) (City of Greater Geelong, 2023).

3) The ecology system and landuse of the city -built-up area, grass, bush, forests and natural resources

The urban ecological environment in Geelong supports economic and social development through benefits such as water resource management, pollution reduction, and climate regulation. Green spaces are essential for residents' leisure and recreation, contributing significantly to their physical and mental health. Protecting and conserving local ecosystems and natural resources is fundamental to Geelong's development strategy. Future development areas must not only avoid existing forests and protected natural areas but also consider the need to steer clear of built-up areas, grasslands, wetlands, and dense shrublands. These ecosystems are crucial for biodiversity and provide valuable ecological functions. Euclidean distance and reclassification analyses can help identify potential development regions while ensuring ecological preservation and the sustainable management of these critical natural resources (City of Greater Geelong, 2023).

4) The safety of the city – avoiding Flooding Areas and bushfire areas.

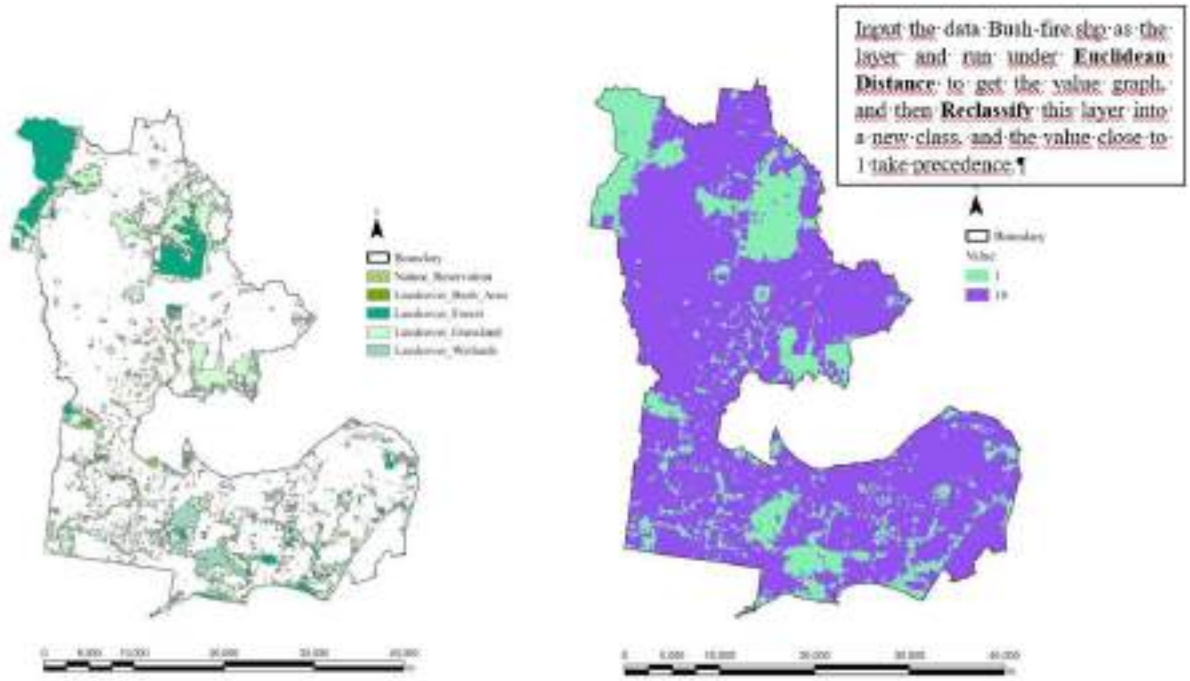

Figure 2. The Maps of Conservation areas and Reclassification of the Euclidean Distance to Conservation areas（Zhang, 2024）

Bushfires and floods are prominent natural hazards in Australia. The devastating 2019-2020 bushfire season saw enormous areas burned, resulting in significant property damage and health risks due to smoke exposure. Flooding is another frequent challenge that incurs substantial costs, averaging around $8.8 billion annually, and poses threats to lives and infrastructure. In Geelong, it is crucial to ensure that potential development areas are located a safe distance from flood-prone zones and high-risk bushfire areas. GIS analysis using Euclidean distance and reclassification can assist in identifying suitable regions for development (City of Greater Geelong, 2023).

5）A compact city – Proximity to established neighborhoods

A compact urban form in Geelong is effective in curbing urban sprawl while preserving open spaces in suburban areas. A mixed-use layout combining residential, commercial, recreational, and public service facilities enables greater job opportunities within shorter commuting distances. This planning approach not only reduces traffic demand and energy consumption but also fosters community connections and enhances social interactions. In the GIS program, Euclidean distance and reclassification analyses reveal potential development areas based on their proximity to existing neighborhoods and urban zones (Chen, 2016).

Table 1. Contribution (%) of different input layers in the weighted overlay analysis. (Zhang, 2024)

CRİTERİA	SUB-CRİTERİA	INPUT DATA/LAYERS	INFLUENCE (%) IN OVERLAY
THE COMMUNICATION OF THE CITY	Proximity Main Roads	Main Roads	10
	Proximity Rail Stations	Rail Stations	10
THE SOCIAL RESOURCES OF THE CİTY	Proximity Hospital	Hospital & Medical	6
	Proximity Education Proximity Urban	Education industry	12
THE ECOLOGY SYSTEM AND LAND-USE OF THE CITY	Avoid Forest, Bush, Grassland, Wetland	Forest, Bush, Grassland, Wetland	5
	Avoid Natural Reserves	Natural Reserves	5
	Avoid Built-up Area	Built-up Area	10
THE SAFETY OF THE CITY	Avoid Bushfire Areas	Bush-fire Area	10
	Avoid flood Areas	Water Area and Rivers	10
		Water Buffer Area	
		Sea level rise inundation zone	
A COMPACT CITY	Proximity Urban Areas	Urban Areas	12
	Proximity Towns	Towns	10

4. Weighted Overlay

A weighted overlay analysis was conducted in ArcGIS Pro 3.0, utilizing a reclassified input layer alongside a comprehensive literature review on multi-criteria analysis. Table 2 presents the weighting of each criterion and sub-criterion, reflecting their importance, priority, and impact as derived from the Geelong Regional Strategy (GBRS) and Geelong Biodiversity and Habitat Strategy (GBHS).

Avoiding hazardous areas is essential for the future development residential regions, as safety has become a significant concern for residents. Living in safe areas away from natural disasters can effectively reduce property damage and mitigate social issues, such as illness or fatalities caused by floods and bushfires.

The highest-ranked criteria include urban conformity, urban ecosystem, and urban compactness, which collectively account for 22% of the analysis. Transportation plays a vital role in facilitating regional interactions, such as population movement and economic exchange. Additionally, social resources are critical in attracting new immigrants, thereby promoting urban development.

In relation to the urban ecosystem, the ecological environment serves as a fundamental condition for human survival, production, and quality of life. Safeguarding the ecological environment is essential for the sustainable survival and development of humankind. Urban compactness holds a weight of 20% in this analysis. Notably, most of the criteria sources are concentrated on compactness and are predominantly located in urban areas. The standards for urban compactness primarily emphasize the locations designated for future urban developments (Bcc, 2016, 2017).

5. Dwelling Growth of Geelong

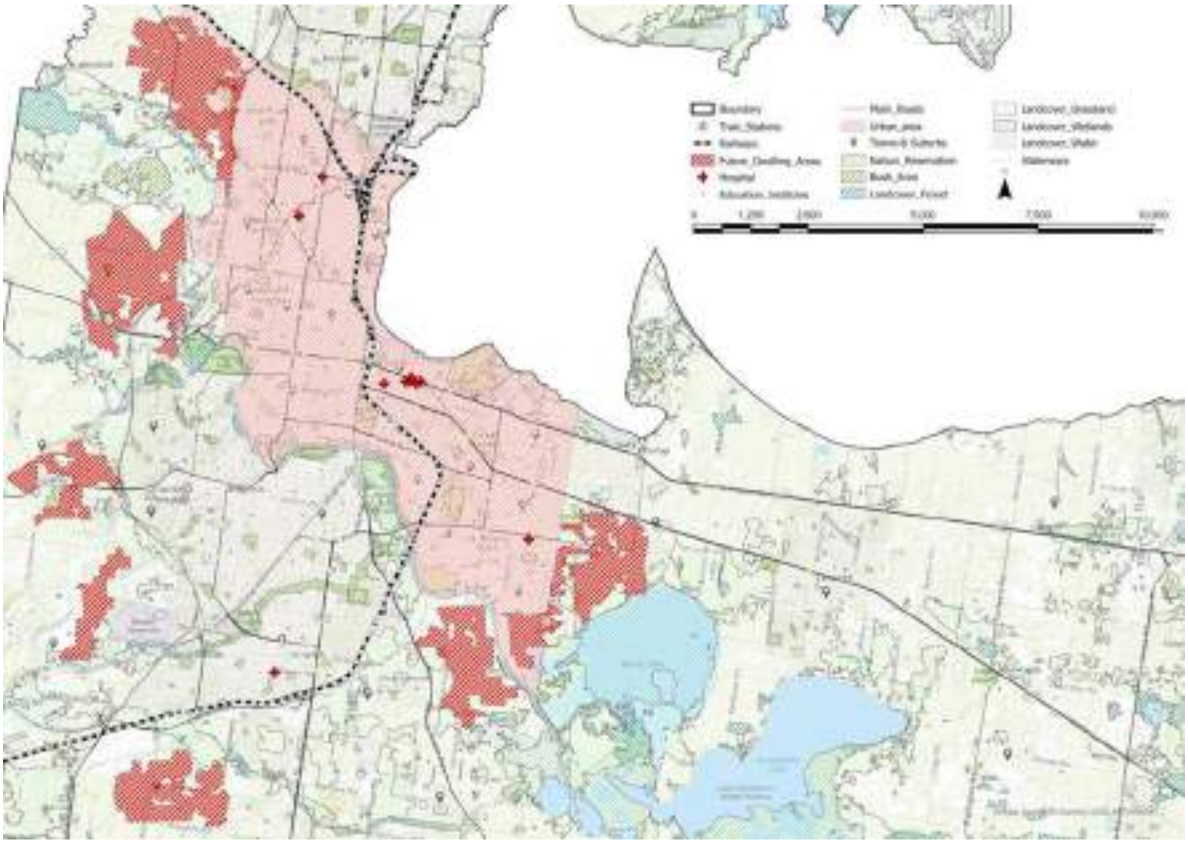

Figure 3. The identified suitable Urban Growth Areas (UGAs) for Geelong (Zhang, 2024)

By avoiding the urban area, drilling units may be established in new suburbs of Geelong, where there is more room for development, and lower prices are likely to attract additional investment. The remaining regions are analyzed to identify the eight most prominent areas for accommodating 20,000 drilling units. These eight areas are all located around the city center of Geelong or the bustling outskirts (Figure 17). The combined area of these eight Urban Growth Areas (UGAs) totals about 2049 hectares, with the excess above 20,00 hectares reserved to accommodate potential population growth and other unforeseen factors.

The selection of these eight UGAs is based on two key reasons. First, These areas have convenient transportation, are close to transportation hubs, and are also close to built-up areas of Geelong, enabling residents to access the public resources developed in the urban core.

Secondly, these eight UGAs are relatively large potential residential areas in the Geelong region, closer to built-up areas, which supports cooperative development and construction work and helps attract more investment. Large scale communities sharing new public facilities or nearby existing public facilities will also reduce overall investment costs, making these areas more feasible for future economic growth (Darjeeling City, 2023).

6. Conclusion

In this Geelong case study, GIS-based land-use suitability analysis presents several advantages:

1) Enhanced Urban Planning: Suitability analysis serves as a valuable evaluation tool that improves urban planning decisions. It facilitates the creation of informative maps and effectively conveys results, ensuring that the outcomes of urban planning are easily communicated, understood, and accepted by the public. GIS also allows for flexible and efficient adjustment of data to yield the best possible results.

2) Comprehensive Data Sources: The analysis incorporates data from various sources and aspects, including geography, social factors, and economic indicators, enabling a multi-criteria evaluation grounded in spatial references and attributes.

3) Euclidean Distance Analysis: This metric aids in calculating the influence value of source points and their radiation ranges. By categorizing different degrees of impact, it provides decision-makers with essential standards to consider in their assessments.

4) Weighted Overlay Flexibility: The weighted overlay method allows for the determination of the influence and proportional significance of each criterion by assigning different weights, thereby making the evaluation process more dynamic and efficient.

The selection of criteria is the most critical step in land suitability analysis, as it can significantly influence results. In this study, the Geelong Regional Growth Plan was selected as the primary guiding document, complemented by the Geelong Housing Strategy for additional insights. This project aligns with the objectives set forth in these documents, focusing on the internal development of Geelong, enhancing transportation infrastructure, and providing residents with a safe, convenient, and aesthetically pleasing living environment. Therefore, designating areas around Geelong, particularly those with favorable natural conditions, as Urban Growth Areas (UGAs) is justified.

Recommendations for GIS-Based Land-Use Suitability Analysis

Based on the research findings, several recommendations are proposed to improve the land suitability analysis process:

1) Timely Data Collection: Given the variety of data sources, ensuring the timeliness of collected data can be challenging, leading to potential inaccuracies in results. Therefore, it is advisable to gather the most current data possible to achieve results that accurately reflect the actual conditions in Geelong.

2) Addressing Euclidean Distance Limitations: Although Euclidean distance is useful for calculating the extent of influence from source points, it does not assess their reachability comprehensively. Field assessments or other supplementary methods should be employed to obtain more accurate evaluations.

3) Cautions with Weighted Overlay: When outputting values in raster format, it is important to consider the varying influences of different criteria. Positive influences should have larger representative values for favorable outcomes, while negative influences should have smaller values to indicate advantage. However, there is no standardized formula for entering percentage values in the criteria, necessitating reference to localized data for competent judgment. As a result, the outcomes may vary widely based on different inputs.

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Exploring the Effect of Urban Blue-Green Spaces on Housing Prices: Considering Interactions and Spatial Heterogeneity

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Abstract

A comprehensive understanding of land economic value of urban blue-green spaces (UBGS) holds immense significance for urban sustainable development and spatial equity. Based on MGWR model, this study discussed the heterogeneous effects of UBGS on housing prices in Hangzhou. Then, the interaction effect between blue and green spaces was examined at the district level, and the specific locations and spatial patterns were identified. Results show:(1) different types, features and accessibility of UBGS have different degrees and spatial scale of effect on housing prices, and will be affected by other attributes of UBGS; (2) in 30.92% of the main urban area of Hangzhou, the effect of blue spaces and green spaces on housing prices exhibits an interactive effect. The spatial patterns are divided into blue-green positive synergistic, antagonistic and negative synergistic; (3) green space has positive and negative effects on housing prices, while blue space has positive effects at the regional level. The water bodies can promote the positive effect of green spaces on housing prices or alleviate the negative effect. The planners should transcend the singular focus on blue or green space planning and instead consider both in an integrated manner. This outcome can provide valuable references for UBGS planning.

Keywords: Urban blue-green spaces, MGWR; hedonic price model, housing prices, interaction effect, urban planning

1. Introduction

Urban blue-green spaces (UBGS), including water bodies such as rivers, lakes, and wetlands, as well as recreational green spaces such as urban parks, natural parks, and green open spaces, are the core elements of the urban landscape pattern (Ghofrani et al., 2017). In terms of economic value, UBGS can have a positive impact on local residential property prices by improving the living environment (Zhang et al., 2021). This could lead to an increase in revenue, prompting local governments to make further infrastructure investments to promote social well-being. In recent years, the integrated construction and balanced distribution of UBGS have been taken into account in the territorial spatial planning of many Chinese cities. However, in the context of housing marketization in China, the inequitable allocation of UBGS may exacerbate unequal access to environmental resources (Wolch et al., 2014). Therefore, measuring the land economic value of UBGS and understanding the preference of residents in different geographical locations for UBGS are of great practical significance to the urban decision-making of providing social public welfare fairly and realizing the sustainable development of economy and society.

Scholars have extensively utilized the hedonic pricing model (HPM) to assess the economic value of UBGS across various cities (Chen et al., 2019; Panduro & Veie, 2013). They demonstrates that accessibility (Chen et al., 2022; Tuofu et al., 2021), type (Peng et al., 2023; Zhang et al., 2021), as well as the scale and quality of UBGS (Wu & Rowe, 2022; Ben et al., 2023), all exert a significant effect on housing prices. Despite numerous studies, the effect of UBGS on housing prices remains contentious due to the disparities in the classification standard, research scope, and geographical considerations utilized by different scholars (Crompton & Nicholls, 2020).The HPM based on the traditional linear regression function is also prone to resulting in biased outcomes due to its deficiencies. Moreover, it fails to capture the spatial autocorrelation of housing prices (Basu & Thibodeau, 1998). The complexity of the effect of UBGS on housing prices, necessitating the adoption of more advanced methods to conduct landscape value studies that account for spatial heterogeneity.

As geographic technology advances, researchers have adopted spatial statistical techniques to address the limitations of traditional HPM, with the geographically weighted regression (GWR) model standing as a prime example. It possesses the advantage of capturing spatial autocorrelation in the housing market, thereby affording a distinct demonstration of spatial variations in the degree of effect exerted by each variable (Anselin, 1990). The multiscale geographic weighted regression (MGWR) model, an advancement of the GWR model, incorporates the concept of geographical scale, thus generating outcomes that are more aligned with real-world phenomena (Wolf et al., 2018; Yu et al., 2020). In recent years, numerous scholars have applied the MGWR model to the study of China's housing market, yielding findings that demonstrate its superior fit compared to the GWR model (Liu & Strobl, 2023). MGWR model has advantages in identifying spatial heterogeneity and local regression relationships in the housing market. But there is a scarcity of research exploring the impact of landscape on property values using the MGWR method. Consequently, within a broader geographical area, there remains a need to evaluate the disparities in landscape economic value according to the MGWR model.

Moreover, in the present study, the economic value of blue or green spaces was evaluated independently. Despite the inclusion of blue spaces and green spaces indicators concurrently on a large geographical scale by some scholars, the categorization of these indicators was relatively rough (i.e., forestland or water body) (Gibbons et al., 2014), which has limited effect on guiding practical planning policies. Currently, there is still a lack of comprehensive and systematic research in response to the context of integrated planning of UBGS.

More importantly, the interaction effect between blue spaces and green spaces in terms of economic value has been neglected. As ecological infrastructures, these spaces interact with each other in landscape value, with strong correlation and coherence (Yuan et al., 2023). The interrelationship between the two has gained increasing attention in ecological, social, and health research. Some scholars have discussed them jointly and found that there is a mutually reinforcing synergistic effect between them (Jiao et al., 2023; Liang et al., 2024). But when it comes to the economy and land values, there is little discussion about the huge benefits of the combination of the two, especially for housing prices. In particular, there may be spatial variations in such interaction effects (Liu et al., 2019). It is essential to take into account subtle spatial variations. Because the effect of UBGS on housing price may vary considerably in different geographical locations, depending on the type of land, socio-cultural and natural resource qualities, as well as the positioning of the city's development. The existence of spatial autocorrelation in housing prices is another factor that has to be considered. In the current literature, the examination of interaction effect predominantly relies on global regression techniques applied to interaction terms in the ordinary least squares (OLS) models (Li et al., 2021) and neglected the subtle spatial variations in diverse interaction effect at the urban scale. Therefore, the second objective of this study is to reveal the interaction effect of blue and green spaces and their spatial pattern at the scale of smaller spatial units (grid units), employing spatial regression methods.

Our contributions are as follows: Firstly, previous studies on the landscapes economic value rarely included various elaborate characteristics of UBGS on a larger geographic scale. In this study, four MGWR models were established from the housing level to discuss the heterogeneous effects of various attributes (accessibility, features and quality) of UBGS on housing prices. Secondly, previous studies rarely focused on the interaction effect between blue spaces and green spaces in terms of economic value. On the scale of 1km*1km grids, the study explored the interaction effects between blue spaces and green spaces on housing prices at the district level, as well as the different spatial patterns of the interaction effects. The study results can help planners and decision makers to accurately identify specific geographical locations requiring improvement and intervention in the process of UBGS planning.

2. Material and Method

2.1 Study area

Hangzhou is the capital of Zhejiang Province, China. It is an important city in the Yangtze River Delta, located in the northern part of Zhejiang Province. The study area consists of four districts: Shangcheng District, Xihu District, Gongshu District, and Binjiang District, including 47 subdistricts. This main urban area with an area of approximately 625.63 km^2 has experienced rapid expansion of population and built-up areas in the past 40 years, and is currently home to 4.245 million people.

2.2 Method

2.2.1 Hedonic price model

HPM believes that housing are multi-attribute commodities, so their prices are determined by their characteristics, which can be divided into structural characteristics, location characteristics, and neighborhood characteristics (Freeman III et al., 2014). HPM has been widely used in previous studies to measure the value of landscape elements related to housing prices (Reynaud & Lanzanova, 2017).

$$\ln p = \beta_0 + \sum \beta_k S_k + \sum \beta_j L_j + u \qquad (1)$$

where ln p is the natural log of the housing price of location; S_k is a matrix of structural characteristics and neighborhood characteristics; L_j is a matrix of landscape characteristics (urban blue space and green space); β_0 is the intercept coefficient, β_k, β_j, are the corresponding parameters and u is the random disturbance term.

2.2.2 MGWR model

MGWR model is a local linear regression model based on spatial variation relationship model. It can effectively explain the local spatial relationships and spatial heterogeneity of variables, thus reducing the endogeneity issues that are inevitably caused by omitted variables in traditional HPM (Anselin, 1990; Fotheringham et al., 2017). MGWR model allows different bandwidths for each independent variable, which can analyse the influence scale of different factors.

$$y_i = \sum_{j=0}^{m} \beta_{bwj}(u_i, v_i)x_{ij} + \varepsilon_i, i = 1, 2, ..., n \qquad (2)$$

where: x_{ij} is the observation of the j independent variable at location i; β_{bwj} is the jth coefficient; bwj in β_{bwj} indicates the bandwidth used for calibration of the jth conditional relationship; (u_i, v_i) is the spatial coordinate of the i sample point; ε_i is the error term, and y_i is the housing price of location i.

2.3 Data collection

The 1,461 second-hand housing transaction data was collected in the study area from 2019 to 2022 through Python from Lianjia.com. The second-hand housing with 70-year property rights was selected, and multi-storey villas and apartments were excluded. The housing units were selected as the research unit, and the logarithmic form (LnP) of the unit price of each housing transaction data was used as the dependent variable to construct HPM. The final selection of independent variables was drawn from structural characteristics and neighborhood characteristics, and blue spaces characteristics and green spaces characteristics. We explored the effect of blue and green space on housing prices in terms of accessibility, features and quality. The POI data were collected via Gaode Map. Green space data and water bodies data came from Baidu Maps. The blue spaces were divided into rivers and lakes. The green spaces were divided into four categories: small parks (less than 2 ha, pocket parks), medium parks (2–10 ha, community parks), large parks (10–50 ha, comprehensive parks), and mega parks (more than 50 ha, country parks and scenic areas). The normalized difference vegetation index (NDVI) of the study area was calculated using ENVI 5.3 and used to measure the green spaces quality. The remote sensing images used to calculate NDVI come from Sentinel-2 satellite images in the Geospatial Data Cloud in March 2023. The Water quality data came from the Hangzhou Hydrology Bureau and was used to measure the blue space quality (Table 1).

Then, four MGWR-based hedonic price models were established. Model 1 and Model 3 were both from the perspective of accessibility. Model 1 was used to reveal the effect of distance from different types of rivers and lakes on housing prices. Model 3 was used to explored the effect of distance from different types of parks on housing prices. Model 2 and Model 4 respectively examined the effect of the features and quality of blue and green spaces on housing prices.

On the second part, we divided the study area into 676 1 km*1 km grids as research units, trying to exploring the interaction effect from the district scale. Using inverse distance weighted (IDW) interpolation, the average housing price of each grid was obtained as the dependent variable. The blue spaces area ratio (Blue_ratio), green spaces area ratio (Green_ratio) and green-blue spaces area ratio (GB_ratio) of each grid were calculated and used as independent variables. Then, four MGWR models were established to explore the effects of blue-green spatial pattern on the spatial heterogeneity of housing prices (Table 2). The interaction effect of blue and green space on housing prices was also explored, by adding an interaction term (Green*Blue) in the regression model.

Table 1. Descriptions of the independent variables

Characteristic types	Variables	Definition	Mean	SD
Structure characteristic	Area	Total area of a house (m^2)	91.288	41.744
	Orientation	Dummy variable: 1 = south, southeast, and southwest, 0 = otherwise	0.970	0.180
	Decoration degree	luxury decorations (2), common decorations (1), and no decoration (0)	1.420	0.554
	Lift	Dummy variable: 1 = With lift, 0 = otherwise	0.520	0.500
Neighborhood charact eristic	Subway	Number of subway within 1 km around the community	7.990	7.186
	Supermarket	Number of supermarket within 1 km around the community	20.495	10.738
Blue spaces characteri stic	DIS-West Lake	Distance to the West Lake (km)	5.247	3.254
	DIS-Lake	Distance to urban lake (km)	2.328	1.429
	DIS-Qiantang River	Distance to Qiantang River (km)	6.407	4.040
	DIS-Grand Canal	Distance to Grand Canal (km)	3.711	3.322
	DIS-urban river	Distance to urban river (km)	0.318	0.283
	RiverWidth	The width of the nearest river (m)	52.894	152.406
	LakeArea	The area of the nearest lake(ha)	123.954	249.465
	Water quality	The water quality of the nearest water: Grade V(1), Grade IV(2), Grade III(3), Grade II(4), Grade I(5)	2.860	0.899
Green space characteristic	DIS-small urban park	Distance to the nearest small urban park(km)	0.820	0.788
	DIS-medium urban park	Distance to the nearest medium urban park (km)	1.047	0.718
	DIS-large urban park	Distance to the nearest large urban park (km)	2.708	1.575
	DIS-Mega urban park	Distance to the nearest mega urban park (km)	3.035	1.880
	Park NDVI	Normalized Difference Vegetation Index of the nearest park	0.233	0.072
	Park area	The area of the nearest park (ha)	91.896	379.149

Table 2. Descriptions of the independent variables

Variables class	Variables	Formula	Definition
Blue space	Blue_ratio	A_{blue}/A_{grid}	The proportion of blue spaces area of each grid
Green space	Green_ratio	A_{green}/A_{grid}	The proportion of green spaces area of each grid
Blue-green relation	GB_ratio	A_{green}/A_{blue}	Ratio of green spaces area to blue spaces area of each grid
	Green*Blue	Green_ratio*Blue_ratio	Interaction terms of blue and green spaces

3. Findings and Discussion

3.1. The heterogeneous effects of blue and green space on housing prices

The results of Models 1–4 show the heterogeneous effect of various attributes of UBGS on housing prices from the housing level. Adjusted R^2 shows that the selected independent variables can explain 68.6% to 71.5% of housing prices.

3.1.1 Accessibility, types and features of blue spaces

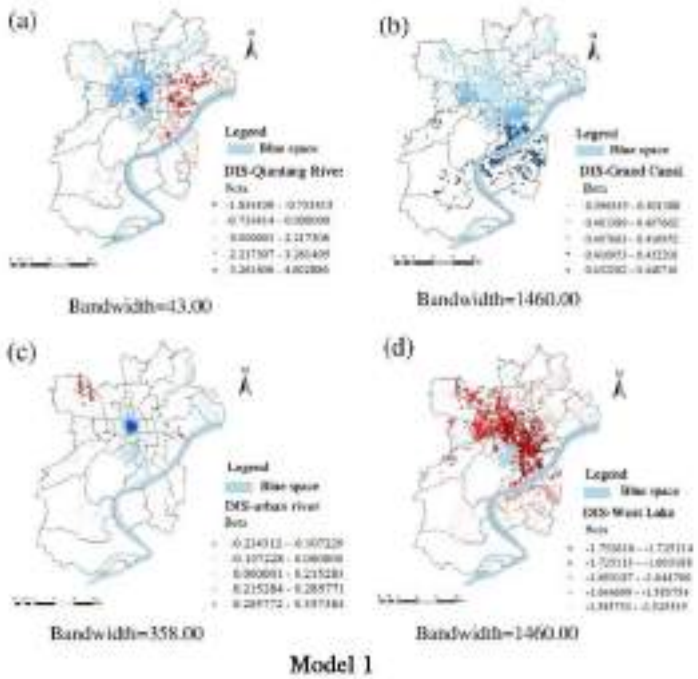

Figure 1. Spatial distribution of regression coefficients for Model 1 (p < 0.05)

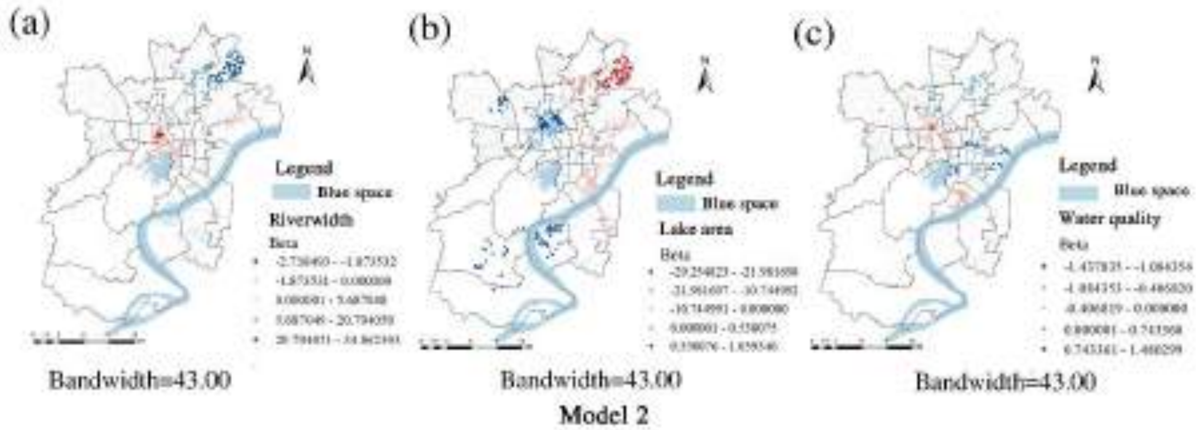

Figure 2. Spatial distribution of regression coefficients for Model 2 (p < 0.05)

The types and accessibility of blue spaces, the width, area and quality of water bodies all have significant heterogeneous effects on housing prices. The spatial scales of the influence of various blue space on housing prices are in descending order: the West Lake/the Grand Canal, urban rivers, the Qiantang River. Urban lakes (except West Lake) have no significant effect on housing prices.

3.1.2 Accessibility, types and features of green spaces

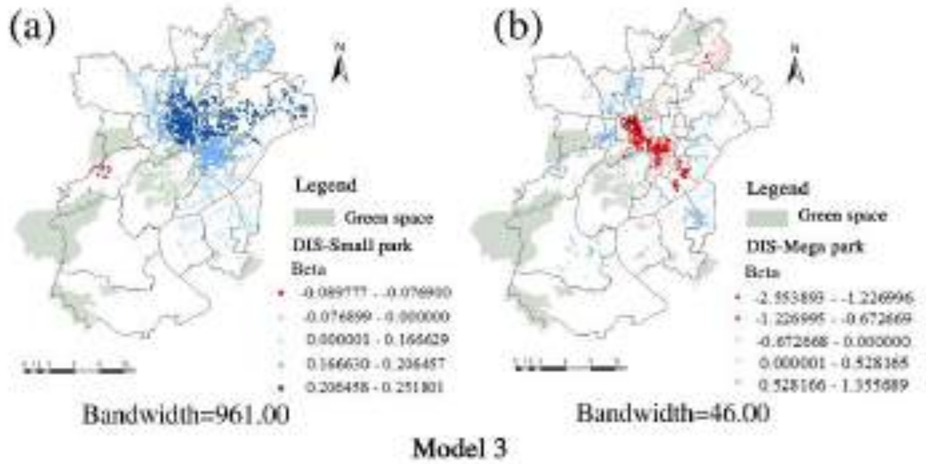

Figure 3. Spatial distribution of regression coefficients for Model 3 ($p < 0.05$)

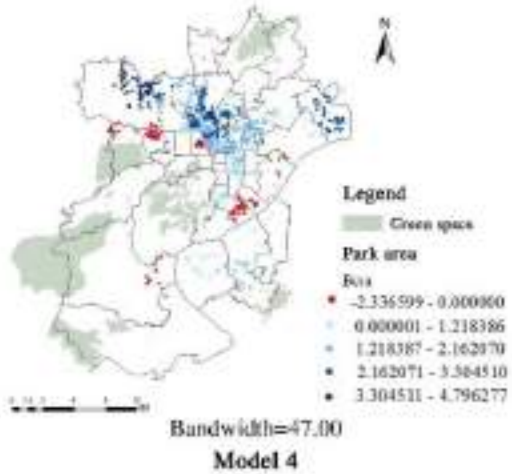

Figure 4. Spatial distribution of regression coefficients for Model 4 ($p < 0.05$)

The NDVI of the park does not significantly affect housing prices, whereas the accessibility and area of the park does. Mega parks exhibit a significant positive effect on housing price, while smaller parks do not.

3.2. Interaction effects and spatial patterns of blue and green spaces

The regression results of Models 5-8 show the effect of the distribution of blue and green spaces at the district level on housing prices. The adjusted R^2 reaches 0.701–0.831. The interaction term in Model 8 is significant at the 5% level. And after adding the interaction term, the adjusted R^2 of Model 8 increased to 0.855, which confirmed that there is an interaction effect between blue spaces and green spaces on housing prices (Table 3).

Table 3. MGWR regression results for Models 5–8

	Variable	Max	Min	STD	$p \leq 0.05(\%)$	AICc	Adj. R^2
Model 5	Blue_ratio	1.964	–0.665	0.518	52.96	799.209	0.831
	Intercept	1.755	–1.132	0.696	84.47		
Model 6	Green_ratio	1.627	–1.924	0.502	45.56	742.332	0.844
	Intercept	1.434	–1.586	0.721	91.42		
Model 7	GB_ratio	2.402	–2.865	1.058	20.85	369.038	0.701
	Intercept	1.120	–1.282	0.656	85.78		
Model 8	Blue_ratio	1.941	–0.577	0.498	48.82	742.134	0.855
	Green_ratio	0.748	–1.959	0.427	44.97		
	Green*Blue	2.297	–1.456	0.614	30.92		
	Intercept	1.401	–0.962	0.577	85.80		

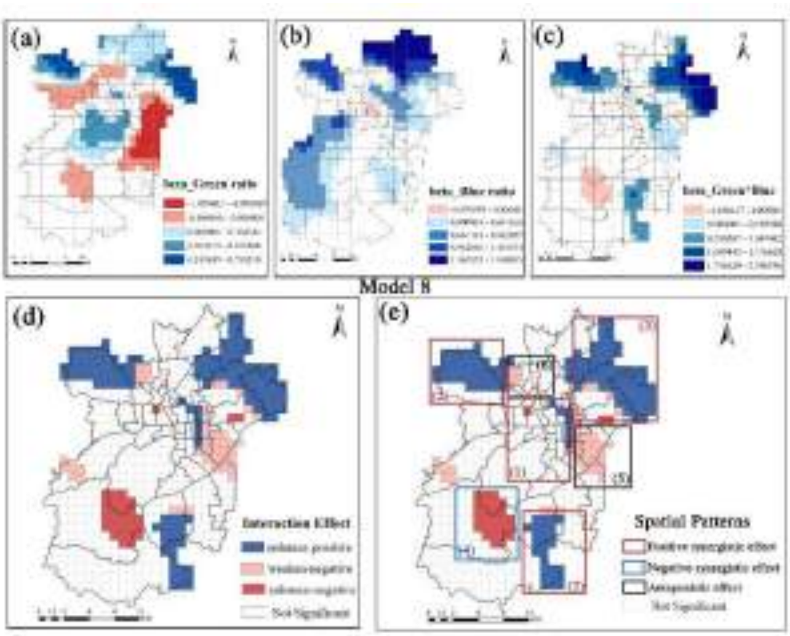

Figure 5. Spatial distribution of regression coefficients for Model 5-7 ($p < 0.05$)

At the district level, the blue spaces area almost exerts a positive impact on housing prices on all observation points (Figure 5b). But green space has positive and negative effects on housing prices (Figure 5a). In 30.92% of the main urban area of Hangzhou, the effect of blue spaces and green spaces on housing prices exhibits an interactive effect. The spatial patterns of interaction effects can be categorized into three distinct types: the blue-green positive synergistic effect (enhance-positive, 19.97%), the blue-green negative synergistic effect (enhance-negative, 4.44%), and the blue-green antagonistic effect (weaken-negative, 6.51%) (Figure 6d-6e). Furthermore, no areas were identified in the study area where blue spaces inhibited the positive effect of green spaces on housing prices (weaken-positive).

4. Conclusion

This study comprehensively evaluate the effect of UBGS on housing prices in Hangzhou housing market. Based on 1,461 second-hand housing transaction data, this study extended the traditional HPM model by using MGWR model, and comprehensively considered the spatial heterogeneity and interaction effect of UBGS on housing prices. Results showed:
(1) The types and accessibility of blue spaces, the width, area and quality of water bodies all have significant heterogeneous effects on housing prices. The spatial scales of the influence of various blue space on housing prices are in descending order: the West Lake/the Grand Canal, urban rivers, the Qiantang River. Urban lakes (except West Lake) have no significant effect on housing prices.
(2) The NDVI of the park does not significantly affect housing prices, whereas the accessibility and area of the park does. Mega parks exhibit a significant positive effect on housing price, while smaller parks do not.
(3) In 30.92% of the main urban area of Hangzhou, the effect of blue spaces and green spaces on housing prices exhibits an interactive effect, and the spatial patterns are divided into blue-green positive synergistic, antagonistic and negative synergistic regions.
(4) In urban core areas and planned development zones, the co-figuration of blue and green spaces will generate higher housing premiums. However, near ecological conservation areas, they jointly suppress housing premiums. The water bodies can promote the positive effect of green spaces on housing prices or alleviate the negative effect, except for unexploitable areas under ecological protection.
(5) Green space has positive and negative effects on housing prices, while blue space only has positive effects at the district level. The economic value of blue space does not vary as much as green space due to land use and ecological control, but is more influenced by its internal features and specific types.

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Research on Street Environment Behavior and Perception in Public Community

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Abstract

The street public space is a crucial component of urban areas and an important site for human activities. This paper takes street public space as its focal point and explores the relationship between public space design and perceived safety from the perspectives of social security needs and crime opportunity risks. The study focuses on Fangzhuang in Fengtai District, Beijing, as the research area. Using methods such as ArcGIS and Depthmap, the paper analyzes street public spaces and conducts psychological safety perception surveys via the Likert scale and SPSS. The study identifies the influence of spatial location attributes, morphological attributes, and atmospheric attributes on both macro and micro levels of street space safety. The research proposes a dynamic, bidirectional promotion mechanism that activates streets to reduce objective crime opportunity risks and enhances public participation to improve subjective psychological safety perception. The findings offer insights for the design of street public space updates from a safety-oriented perspective.

Keywords: Urban renewal, public space, criminal opportunity risk, psychological security perception, spatial characteristics

1. Introduction

Jane Jacobs (2006) pointed out that an individual should feel safe even when passing through streets filled with strangers. American psychologist Abraham Maslow (Maslow, 1987) suggested that the need for security ranks just below basic physiological needs. With the continuous development and deepening of urban renewal and social governance, public space, as an essential site for human outdoor activities (Jalaladdini et al., 2012), should not only focus on the layout and empowerment of the physical environment but also prioritize human experience. A key aspect of this experience is the need for safety, which encompasses both the spatial attributes of safety and the public's perception of safety in that space. Public space safety is often linked to the road network (Wang et al., 2020), the types of external building spaces, and the distribution of functions. As important sites for daily leisure and social interaction, street public spaces possess open and public attributes that complicate social governance. Their diverse and mixed nature exacerbates the negative impact of disorder on safety perception. In light of these challenges, alongside the rapid development of urban renewal, the rich and varied layout of urban spaces, and heightened social tensions during periods of transformation, social security demands are on the rise.

Spatial safety is reflected in both objective safety attributes and subjective safety perception. Reducing the objective risks associated with crime opportunities in street public spaces and enhancing subjective psychological perceptions of safety are key factors in improving the quality of residents' daily street-level activities. Crime space theories, including Crime Prevention Through Environmental Design (CPTED), Defensible Space Theory, and Situational Crime Prevention, along with relevant modern theoretical research and practices, have demonstrated that criminal behavior is closely linked to environmental factors such as time, location, and context, and that crime can be prevented through environmental modifications (Long et al., 2017). Environmental psychology, first proposed in the 1960s, examines the reciprocal influence between the environment and human behavior and perception. The derived Environmental Stress Theory posits that various environmental factors can provoke physiological and psychological responses in individuals. Subsequent scholars, building on this theory, have studied pedestrian reactions to negative urban environmental factors, such as noise, chaotic conditions, and gray spaces, which led to the development of Urban Environmental Stress Theory (Lin, 2000). Additionally, Environmental Perception Theory and Behavioral Setting Theory explore the relationship between the environment and human psychological perception, supporting the notion that various spatial factors influence psychological experiences. Today, China's increasingly comprehensive Sky Net surveillance system has significantly enhanced the safety of urban public spaces (Lu, 2021). However, maintaining safety in the multifaceted urban public spaces still requires the construction of informal safety networks (Lin, 2010), thereby creating a positive feedback loop in which spatial safety attracts public movement and participation, ultimately activating a safer spatial atmosphere.

The development of geographic information technology has advanced the progress of crime mapping. Nowadays, many scholars use ArcGIS to study the spatial distribution characteristics of crime, including kernel density, point clustering, spatial interpolation, and other road network-based analyses of crime distribution patterns (Wang et al., 2020), as well as analyses based on POI (Point of Interest) frequency density to explore the relationship between urban land use diversity and urban safety (Peng, 2021). Researchers such as Behzadfar et al. (2014), Kawshalya et al. (2021), Razzaghi-As et al. (2017), Lin et al. (2023), and Dai et al. (2021) have employed methods like the ANP model, nighttime illumination images, and street view image segmentation to demonstrate that the quality of physical space design, including factors such as trees, building facades, lighting, and traffic, as well as psychological factors, have a major impact on pedestrian-oriented urban spaces. Pérez-Tejera et al. (2022) and others have used systematic observation methods to study the relationship between park usage and safety perception, while Xie et al. (2022) and others have analyzed the characteristics of psychological safe spaces within old residential neighborhoods using Depthmap spatial syntax and other analytical methods. Survey methods for investigating subjective emotional perception include wearable physiological sensors, eye-tracking technology, computer vision analysis (Chen, 2023), and questionnaires.

In summary, existing research has mostly focused on a single aspect, either the analysis of crime space characteristics or the extraction of psychological safe spaces. There is still a need for in-depth study on the coordinated safety of public spaces from both objective and subjective perspectives, further exploring the integration of diverse urban public spaces and the macro- and micro-level methods of renewal design. This study conducts a preliminary analysis of existing crime case data using ArcGIS, a more comprehensive and accurate tool for macro spatial layout analysis, and combines it with urban functional space layout to determine macro crime opportunity risks, providing a basis for selecting street micro-spaces. Depthmap spatial syntax is more closely aligned with the analysis of micro-spatial features and related indicators in crime space theory. The use of questionnaire surveys more effectively reflects subjective psychological perceptions of safety. By employing Depthmap spatial syntax to delineate the spatial characteristics of areas with high crime opportunity risks and utilizing spatial psychological safety perception surveys, the study investigates how street public space features influence psychological safety perceptions. The findings aim to provide insights for social governance and urban public space renewal.

2. Material and Method

2.1. Study area

The study selects Fengtai District in Beijing as the research site. Located at the southern end of Beijing’s central urban area, it lies at the boundary between developed and undeveloped zones. According to the "Seventh National Population Census Bulletin of Fengtai District, Beijing," the population age distribution and the population size of various streets and townships show that areas such as Lugouqiao, Xincun, and Dahongmen, which are closer to the densely built northern urban zone, have higher population densities (Figure 1). Based on the statistical data from the Beijing Court Approval Information Network regarding criminal judgments from 2016 to 2022, Fengtai District has a higher crime rate compared to other districts in central Beijing (Figure 2).

Figure 1. Population of each township in Fengtai District

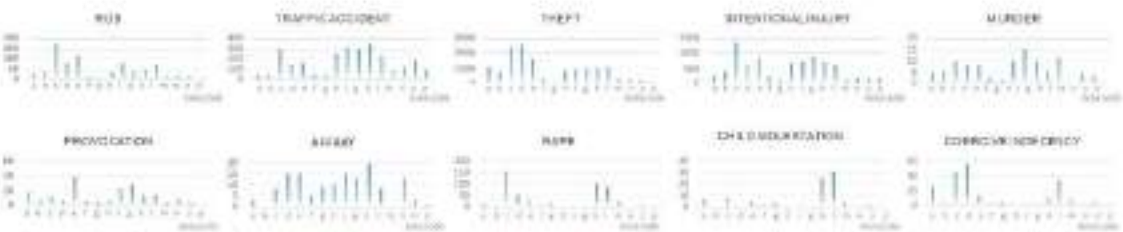

Figure 2. Number of judgment documents related to outdoor criminal crimes in each district of Beijing

2.2. Spatial attributes and macro crime opportunity risk evaluation

2.2.1 Urban functional space layout and spatial attribute indicators

Based on POI data from Baidu Maps, the urban functional space layout characteristics of Fengtai District were extracted, including commercial, transportation, river green spaces, public security, traffic police, and community areas (Figure 3). Among these, multiple functional points are concentrated in the northeastern part of the district, while the western and southern parts, which are farther from the city center's built-up areas, have lower levels of development and construction, as well as lower population density.

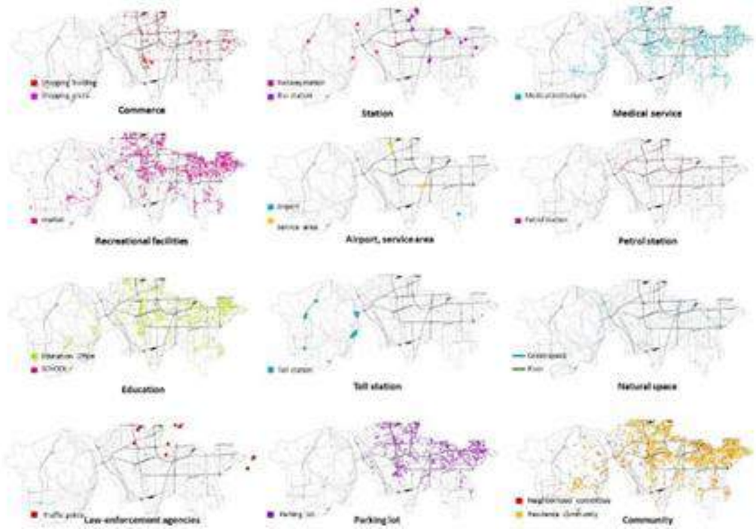

Figure 3. Spatial layout of urban functions

Combining population distribution and current functional layout characteristics, the study constructs a spatial attribute evaluation system based on theories such as CPTED (Crime Prevention Through Environmental Design) (Table 1). The evaluation system is structured in two layers. The first layer includes three primary indicators: spatial location attributes, spatial form attributes, and spatial atmosphere attributes. These primary indicators are further subdivided into seven secondary indicators: permeability, sense of location, degree of marginality, territoriality, visibility, attractiveness, and cohesiveness. The study integrates urban spatial functional layout with on-site perceptions, using a 200m x 200m precision grid to assess the seven indicators for regional site evaluation. This results in the creation of a spatial attribute evaluation atlas for the research site (Figure 4).

Table 1. Spatial attribute index evaluation system

First grade indexes	**Second grade indexes**	**Detail**
Spatial location attribute	Trafficability	Site traffic condition. The better the traffic, the better the trafficability
	Location	The location conditions of the street where the site belongs in the city, The more convenient the location conditions, the higher the sense of location
Spatial form attribute	Fringe	The urbanization development degree of the site, the higher the development degree, the lower the fringe degree.
	Territorialism	The higher the enclosing degree of the space around the site, the higher the territoriality.
Space atmosphere attribute	Visibility	The visual permeability of the human viewpoint, the fewer obstacles, the higher the visibility.
	Attraction	The vitality of the site material space and the flow of people, the greater the flow of people, the higher the attraction.
	Cohesion	The cultural characteristics of the site and the willingness of people to communicate, the stronger the willingness to communicate, the higher the cohesion.

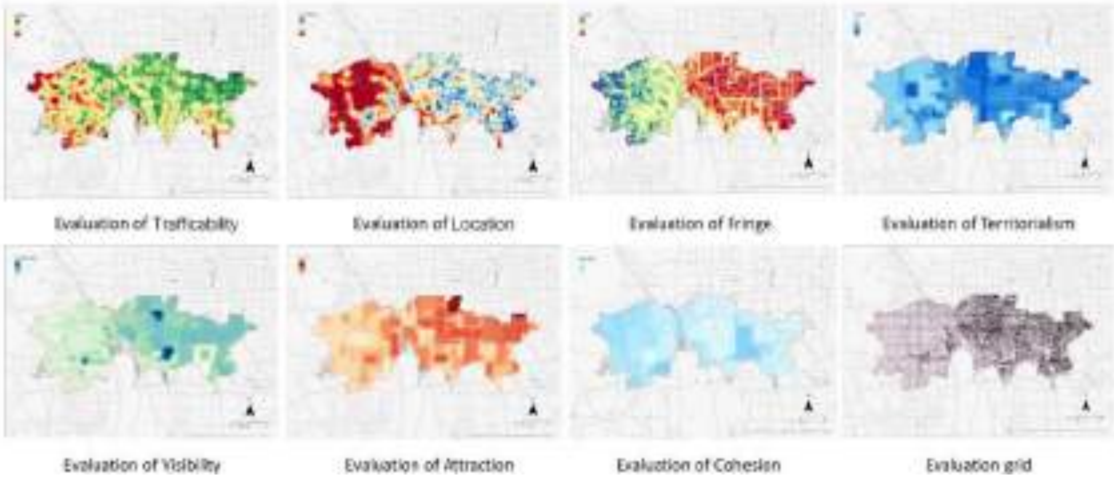

Figure 4 Spatial attribute index evaluatio

2.2.2 Crime opportunity risk evaluation

(1) Data collection

Risk is the combination of the likelihood of crime and its potential harm. The basis for evaluating the likelihood of crime in risk assessment is historical crime event locations, with data sourced from the desensitized judgment documents from the Beijing Court Approval Information Network. The data covers the period from January 1, 2016, to December 31, 2022, and includes crimes such as theft, intentional injury, traffic accidents, robbery, provocation, affray, rape, intentional homicide, forced molestation, and child molestation. Python was used to perform text analysis on the data, extracting information on crime types, defendant details, and crime occurrence time and location. Geographical locations were converted into latitude and longitude coordinates, forming a regional crime dataset for the past five years.

(2) Risk evaluation and classification

The damage evaluation in risk assessment relies on public perceptions of different crime types. A crime behavior attitude assessment questionnaire was created to evaluate the public's perception of the severity of various outdoor criminal behaviors. The average score (on a scale of 1 to 5) given by the public for each crime type was used as the severity impact coefficient (Table 2) and applied to past outdoor crime event locations (Figure 5). Kriging interpolation was then used to generate a crime opportunity risk map for Fengtai District (Figure 6). This map was subsequently reclassified into low-risk, lower-risk, moderate-risk, higher-risk, and high-risk areas (Figure 7).

Table 2. Influence coefficient of badness

Rob	Traffic accident	Theft	Intentional injury	Murder	Provocation	Affray	Rape	Child molestation	Coercive indecency
3.98	3.14	3.26	4.13	5	3.48	3.06	4.21	4.37	4.04

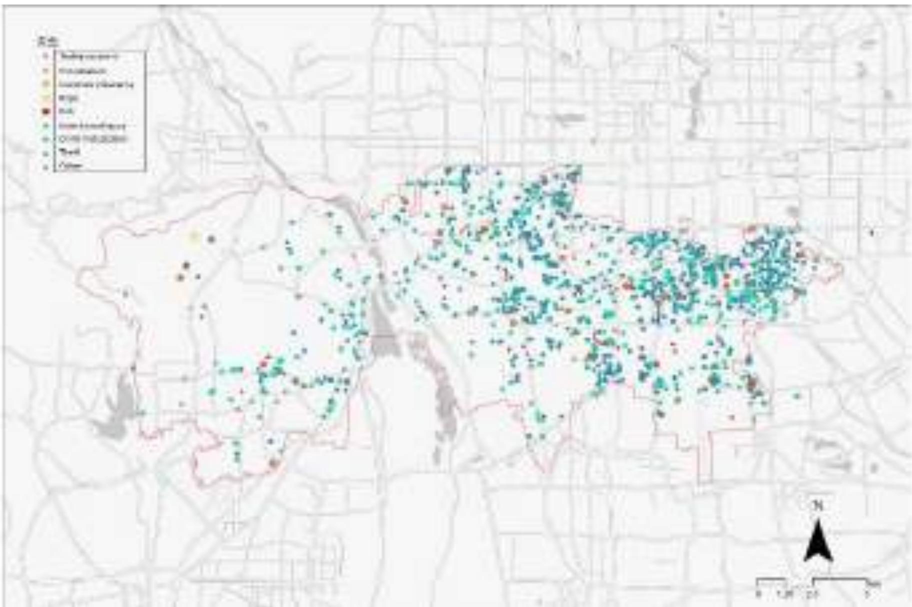

Figure 5. Occurrence points of past outdoor crime data in Fengtai District

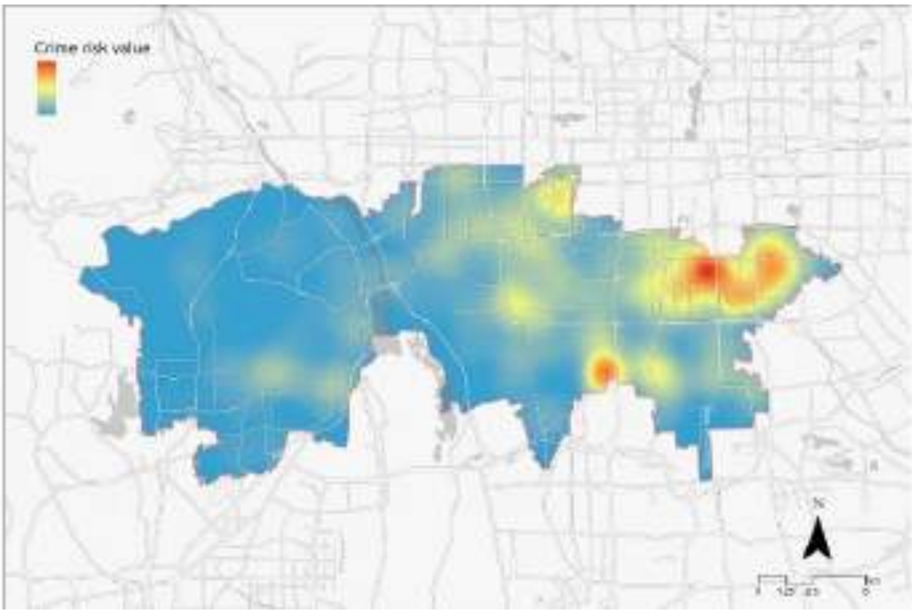

Figure 6 Outdoor crime opportunities and risks in Fengtai District

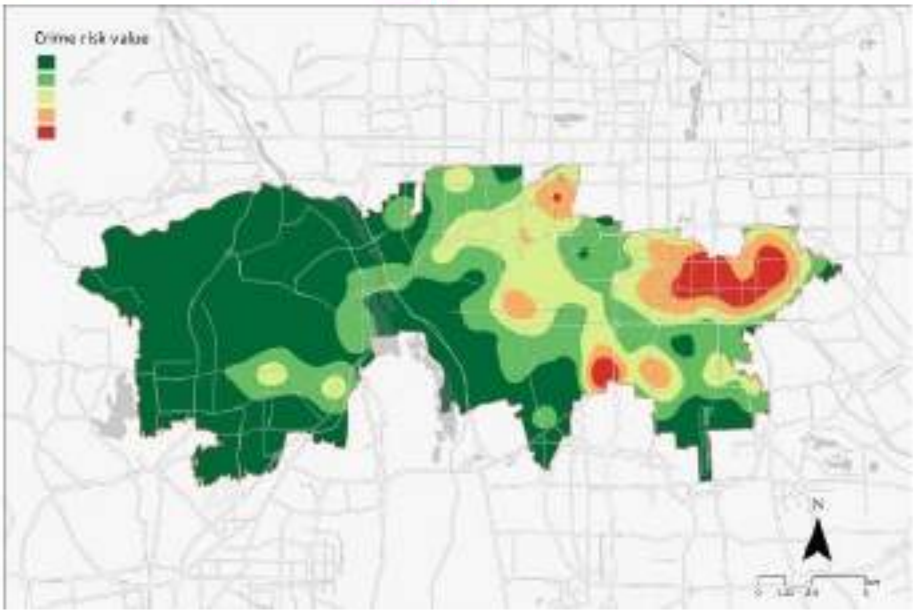

Figure 7. Outdoor crime opportunity risk level in Fengtai District

2.3. Micro street space indicator distribution and psychological safety perception

2.3.1 Spatial indicator distribution

The study extracts the Fangkang District, located in the high-risk crime opportunity area, as the research area. Fangkang is Beijing's first fully planned residential district, located on the eastern side of Fengtai District, between the South Second Ring and South Third Ring. The area is densely populated with residential buildings and offers a variety of activity functions, such as shopping malls, hospitals, schools, and parks, contributing to its overall high vitality. The street network is multi-level, with high accessibility across all levels of transportation.

The spatial indicator distribution of this area was analyzed using Depth Map (Figure 8). Key indicators include:

Road Choice (Choice): This refers to the number of times a node appears on the shortest path, reflecting the likelihood of street passage and used to measure spatial attribute permeability. A higher choice value indicates higher permeability.

Mean Depth: This represents the average minimum number of steps from a node to all other nodes, reflecting the spatial distance and used to measure spatial attributes of location sense and marginality. The higher the mean depth value, the lower the location sense and the higher the marginality.

Visual Integration: This indicates the visual surveillance potential of a space, reflecting its visibility as a destination. It is used to measure spatial territoriality. A higher integration value implies lower territoriality.

Visual Clustering Coefficient: This expresses the concealment of a space. The higher the clustering coefficient, the stronger the boundary limitation effect in visual terms, and it is used to measure the visibility aspect of spatial atmosphere. A higher coefficient means lower visibility.

Road Integration (Integration Value): This measures the potential for spatial connectivity in terms of transportation and is used to assess the cohesion and attractiveness of spatial atmosphere. A higher integration value correlates with higher cohesion and attractiveness.

By quantifying the spatial structural features through these parameters, the study further investigates the correlation between psychological safety perception and spatial structure characteristics.

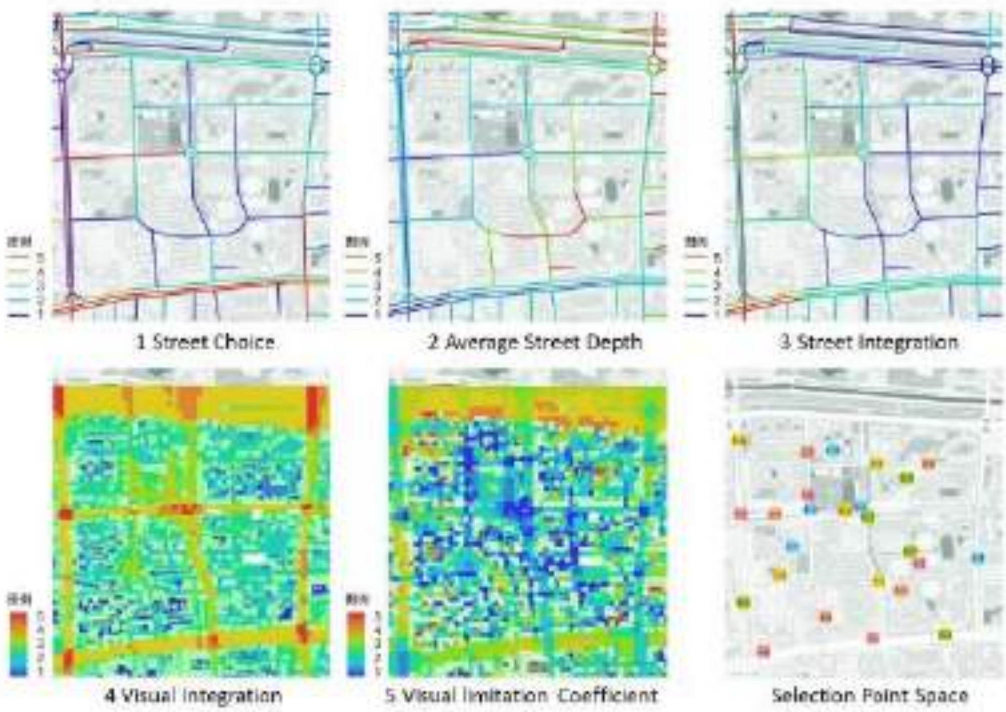

Figure 8. Depth map parameter analysis and point selection

2.3.2 Psychological safety perception space extraction and study

The study involved grading and selecting points based on the relevant Depth Map parameters (Figure 8). Each parameter was divided into five levels, and street-level space scenes were extracted for each level (Figure 9). The 25 extracted street spaces were then assessed on a 1-5 psychological safety perception scale using the Likert scale.

Through a combination of online and offline methods, 188 valid questionnaires were collected. The data from the scale were classified and integrated, and a correlation study was conducted between each parameter and psychological safety perception using SPSS. Since both variables are ordinal data, the Kendall correlation coefficient was used as the primary reference. Parameters with significant correlations were then estimated through a Logistic curve model.

Figure 9. Depth map parameter selection point space

3. Findings and Discussion

3.1. Macro urban spatial ındicators and crime opportunity risk

Using the GISPRO band set, a correlation matrix between crime opportunity risk and spatial attribute indicators was established (Table 3). The results indicate that: (1) Distribution of Potential Crime Opportunities: The distribution of potential crime opportunities follows a concentric structure, radiating outward from urban areas with high population density and rich functional attributes to the periphery, with crime risk decreasing as the distance increases; (2) Correlation with Crime Risk: The correlation between crime risk and edge degree is the most significant, followed by visibility, both showing a negative correlation. In contrast, there are positive correlations with passability, location sense, territoriality, attractiveness, and cohesion, with the weakest correlation observed with cohesion; (3) Spatial Attribute Relationships: The correlation matrix also reveals the relationships among spatial attribute indicators. Although there is a clear association between crime risk and spatial location attributes, changes in spatial morphological attributes and atmospheric attributes can also reduce the risk of crime opportunities to some extent.

Table 3. Correlation matrix of spatial attribute index

	Crime risk	Trafficability	Location	Fringe	Territorialism	Visibility	Attraction	Cohesion
Crime risk	1	0.5092	0.5541	-0.5696	-0.4133	0.5552	0.5182	0.5452
Trafficability	0.5092	1	0.523	-0.6103	-0.5431	0.5413	0.5619	0.4549
Location	0.5541	0.523	1	-0.8093	-0.57	0.682	0.5852	0.4827
Fringe	-0.5696	-0.6103	-0.8093	1	0.5715	-0.7165	-0.5815	-0.506
Territorialism	-0.4133	-0.5431	-0.57	0.5715	1	-0.601	-0.4172	-0.4231
Visibility	0.5552	0.5413	0.682	-0.7165	-0.601	1	0.5648	0.5031
Attraction	0.5182	0.5619	0.5852	-0.5815	-0.4172	0.5648	1	0.4429
Cohesion	0.5452	0.4549	0.4827	-0.506	-0.4231	0.5031	0.4429	1

3.2. Micro street spatial indicators and psychological safety perception

The results of the Kendall correlation coefficient analysis (Tables 4-8) show the following: (1) Significant Correlation: The correlation between mean road depth, road integration, and visual clustering coefficient with psychological safety perception is significant, meaning that location sense, edge degree, cohesion, attractiveness, and visibility are the main factors influencing subjective safety perception in micro street spaces; (2) Positive and Negative Correlations: The mean road depth and visual clustering coefficient are negatively correlated with safety perception, while road integration is positively correlated with safety perception. Specifically, location sense, cohesion, attractiveness, and visibility have a positive correlation with safety perception, while edge degree has a negative correlation; (3) Regression Analysis: Using mean road depth, road integration, and visual clustering coefficient as independent variables (X), and safety perception as the dependent variable (Y), regression analysis was conducted. The results from the Logistic curve model estimation (Figures 10, Tables 9-11) indicate the following constant correlation values: mean road depth with psychological safety perception is 0.288, road integration with psychological safety perception is 0.378, and visual clustering coefficient with psychological safety perception is 0.353. These results show that the influence of spatial attribute indicators on psychological safety perception in micro spaces decreases in the following order: cohesion, attractiveness, visibility, location sense, and edge degree.

The Fangzhuang district has a high degree of urbanization and was developed early, with a rich array of residential areas and supporting facilities. However, the spatial fragmentation and aging infrastructure from early construction have led to localized street disorder, with low cohesion and poor visibility. The variation in street scale significantly impacts subjective location sense and edge degree perceptions. The creation of a spatial atmosphere in areas with low edge degree is key to improving psychological safety perception.

Table 4. Correlation between road choice degree and safety perception

			Street Choice	security perception
Kendall tau_b	Street Choice	correlation index	1	-0.002
		Significance (double tail)	—	0.951
		N	940	940
	security perception 1	correlation index	-0.002	1
		Significance (double tail)	0.951	—
		N	940	940
**. At level 0.01 (two-tailed), the correlation was significant.				

Table 5. Correlation between average road depth and safety perception

`			average street depth	security perception
Kendall tau_b	Street Choice	correlation index	1	-.296**
		Significance (double tail)	—	< .001
		N	515	515
	security perception 1	correlation index	-.296**	1
		Significance (double tail)	0	—
		N	940	940
**. At level 0.01 (two-tailed), the correlation was significant.				

Table 6. Correlation between road integration degree and safety perception

`			street integration	security perception
Kendall tau_b	**Street Choice**	**correlation index**	1	.104**
		Significance (double tail)	—	0.004
		N	515	515
	security perception 1	**correlation index**	.104**	1
		Significance (double tail)	0.004	—
		N	940	940
**. At level 0.01 (two-tailed), the correlation was significant.				

Table 7. Correlation between visual integration degree and security perception

`			visual integration	security perception
Kendall tau_b	**Street Choice**	**correlation index**	1	0.023
		Significance (double tail)	—	0.385
		N	940	940
	security perception 1	**correlation index**	0.023	1
		Significance (double tail)	0.385	—
		N	940	940
**. At level 0.01 (two-tailed), the correlation was significant.				

Table 8. Correlation between visual limitation coefficient and security perception

`			visual limitation coefficient	security perception
Kendall tau_b	**Street Choice**	**correlation index**	1	-.081**
		Significance (double tail)	—	0.002
		N	940	940
	security perception 1	**correlation index**	-.081**	1
		Significance (double tail)	0.002	—
		N	940	940
**. At level 0.01 (two-tailed), the correlation was significant.				

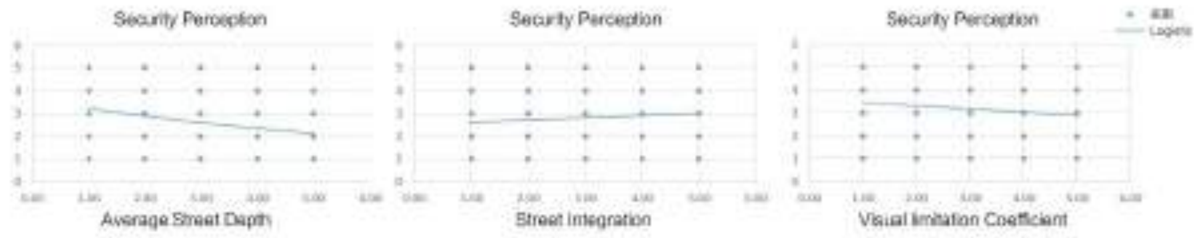

Figure 10. Logistic curve model estimation

Table 9. Logistic model summary and parameter estimation of correlation between average road depth and safety perception

Dependent variable: Securuty Perception							
Equation	**Model Summary**					**Parameter estimation**	
	R2	**F**	**Degree of freedom 1**	**Degree of freedom 2**	**Significance**	**Constant**	**b1**
Logistic	0.097	55.157	1	938	< .001	0.288	1.095
The independent variable is the mean road depth.							

Table 10. Logistic model summary and parameter estimation of correlation between road integration degree and safety perception

Dependent variable: Securuty Perception							
Equation	**Model Summary**					**Parameter estimation**	
	R2	**F**	**Degree of freedom 1**	**Degree of freedom 2**	**Significance**	**Constant**	**b1**
Logistic	0.004	2.002	1	938	0.158	0.378	0.981
The independent variable is road integration degree.							

Table 11. Logistic model summary and parameter estimation of correlation between visual limitation coefficient and security perception

Dependent variable: Securuty Perception							
Equation	**Model Summary**					**Parameter estimation**	
	R2	**F**	**Degree of freedom 1**	**Degree of freedom 2**	**Significance**	**Constant**	**b1**
Logistic	0.014	12.927	1	938	< .001	0.289	1.034
The independent variable is the visual qualification coefficient.							

4. Conclusion

Rapid urbanization has led to problems such as regional development imbalances and disordered street spaces. This study begins with a macro-level analysis, focusing on the subjective safety perception of street spaces, and explores the impact of spatial attributes on both macro-scale street crime risks and micro-scale psychological safety perception in street spaces. The study suggests strategies to enhance spatial defense by reducing crime opportunity risks and improving spatial safety attributes. It also proposes enhancing psychological safety perception to increase space usage rates, promote outdoor activities and social interactions among residents, and create a bidirectional dynamic mechanism that simultaneously reduces objective crime risks and enhances public participation in improving subjective psychological safety perception. At the macro level, urban street governance in medium- to high-risk areas should be strengthened, and urban functional layouts should be optimized. At the micro-level, the following measures should be taken: (1) increase street open spaces and integrate activity facilities to promote public interaction, enhancing attractiveness and cohesion; (2) reduce street traffic congestion and disorderly public facility layouts, and avoid clustering buildings with the same function to improve visibility; (3) strengthen the repair and renewal of dilapidated streets, reduce gray spaces, and enhance the vitality of low-density streets to reduce street edge degree.

Note

Figure/Table Source: Created by the author.

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Exploring the Impacts of Environmental Features in historical neighbourhood on Spatial Use and Perception: Mapping Hot Routes and Perceived Landscape Values of City Walk in the Old Town of Beijing

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Abstract

Nowadays, the outdoor recreational trend known as "City Walk" has gained immense popularity in Chinese cities, with hundreds of thousands of posts tagged with #citywalk flooding various Chinese social media platforms.Differing from other studies that focus on walking behaviors for active transportation or health benefits, "City Walk" emphasizes the essence of tourism and leisure, fostering a deeper connection with the urban environment.There is also a dearth of information on the urban environmental features that characterize the surroundings of popular routes of City Walk and explain the intensity of activity-specific use. Additionally, urban managers lack reliable data on the landscape values perceived by the public during their diverse experiences of City Walk and the points of interest (POIs) associated with these experiences. Using Public Participation GIS (PPGIS), we studied City Walk routes and landscape values in Beijing's old town with over 200 participants. Kernel density analysis identified five hot routes, while random forest analysis showed that POI diversity and building density significantly impact route popularity. Recreational and aesthetic values were most frequently mapped, with historical buildings, parks, and cafes as key POIs influencing landscape values. This study offers insights for urban renewal and tourism strategies, blending modern vibrancy with historical charm.

Keywords: Citywalk, public perceptions, environmental features, historical neighbourhood, PPGIS

1. Introduction

Presently, a novel style of outdoor recreation known as "city walk" has gained substantial popularity in Chinese cities, with hundreds of thousands of posts tagged with #citywalk in all kinds of Chinese social media (Wu, 2023). Differing from other studies that focus on walking behaviour for active transportation or health benefits, "City Walk" emphasizes the essence of tourism and leisure, fostering a deeper connection with the urban environment(Wu,2023). Insights into "City Walk" behaviour during the walking process could be leveraged to meet the growing societal demands for outdoor recreation and enhance the vitality of urban spaces.

In addition, urban planners face the challenge in urban renewal to integrate multiple functions including cultural heritage conservation, public living, building sense of place, and recreation in historical neighbourhood for enhancing public social well-being (Bethmann et al., 2018). Furthermore, people always show a high appreciation for the multiple perception in historical neighbourhood provide (Bieling et al., 2014) and feel strongly attached to their nearby environmental features (Creighton et al., 2008). Consequently, in historical neighbourhoods, citizens are increasingly sceptical about specific urban renewal projects (e.g. setting new POIs and facilities) in general (Valkeapää and Vehkalahti, 2012). This is related to people's strong connectivity to historical neighbourhood, an increase in heritage and environmental conservation awareness.

Nowadays, increasing trend of Citywalk brings new opportunities for people to build stronger connection with urban context and historical neighbourhood. Many studies have examined the relationships of walking behaviour with built environmental attributes in the last two decades., such as:The key environmental attributes affected walking behaviours include the features like land-use mix and accessibility, street connectivity, facilities and residential density (Sun et al., 2024, Cao et al., 2006). However, previous studies focus on walking behaviours for active transportation or health benefits. There is still a lack of knowledge regarding public "city walk" behaviours and perceptions, and urban environmental features that characterize the surroundings of public city walk routes for explaining the intensity of city walk activity-specific use. In addition, there is a knowledge gap on the hierarchy of importance of multiple POI facilities and landscape features for explaining multiple public perceptions during their Citywalk experiences.

Against the background of the above-described knowledge gap, we used Public Participation Geographic Information Systems (PPGIS) to explore the spatial pattern of public Citywalk use intensity and their perceptions of multiple landscape values during their Citywalk, and the hierarchy of importance of multiple environmental features for explaining spatial City walk behaviours and various POI contributing public perceived landscape values. Furthermore, the main aim of this study was to understand public Citywalk behaviours, and their perception as "City Walk" emerges as a catalyst for novel leisure formats within the local cultural tourism sector. Therefore, we invited people who had City walk experiences in the old town of Beijing to map their city walking routes and report the landscape value they perceived there. Moreover, we performed a random forest analysis to explore exploring the impacts of environmental features on spatial use and perception for public City walk. We aims at answering the following research questions:

1.How is the spatial pattern of public most frequent Citywalk use and multiple landscape values they perceived during their Citywalk in old town of Beijing?

2.What is the relative importance of different environmental features for public Citywalk use intensity?

3.What’s is the respective contribution of multiple POIs in various public perceived landscape values during Citywalk?

2. Material and Method

The research area is the old city area of Beijing (Fig1a). As the capital of China, Beijing is located in the northern part of the North China Plain and is a world-famous ancient capital and modern international city. Traditionally, the old city area of Beijing refers to the area surrounded by the Beijing city wall during the Ming and Qing dynasties, mainly including Dongcheng District and Xicheng District. These two areas are located in the central urban area of Beijing and preserve many historical and cultural relics, as well as traditional Beijing-style architecture such as hutongs and courtyard houses. Beijing is one of the popular City Walk cities in China. However, there is still a lack of understanding in the current formulation of cultural and tourism policies and urban renewal management regarding the public's Citywalk activities, routes, perception experiences, and environmental impacts in the old city. For data collection, we selected four historical neighbourhoods in old town of Beijing with densely populated blocks in Dongcheng District and Xicheng District for PPGIS-based survey (Fig1).

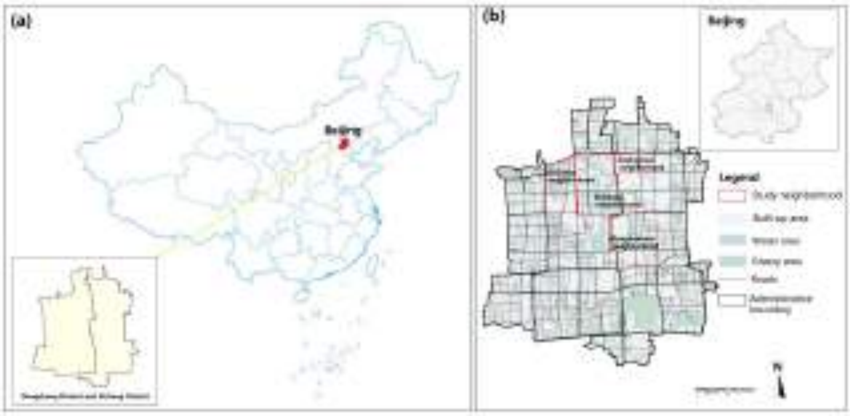

Figure 1. Study area and historical neighbourhoods in the old town of Beijing

The main research is divided into three parts (Fig2). Firstly, data collection is conducted. Secondly, data analysis is performed, and finally, the relationship between historical neighborhood’ city walk, landscape values perception, and urban built environment is explored using a random forest model to draw research conclusions.

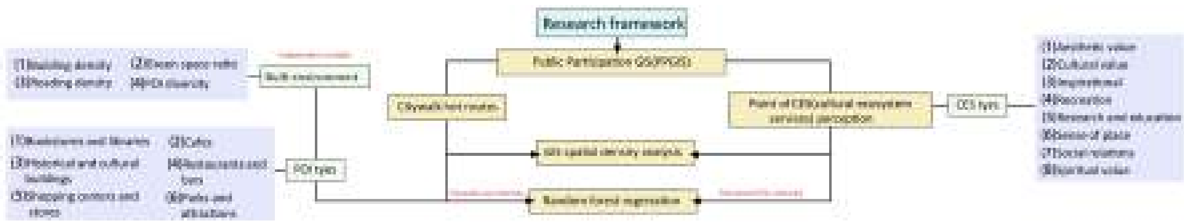

Figure 2. Research framework

3. Findings and Discussion

A total of 237 questionnaires were distributed, with all 237 being returned, resulting in 203 valid responses. Our findings indicate that city walk activities are particularly popular among young individuals, especially females (72.77%), and those with higher levels of education. Notably, engagement in city walk appears to be less constrained by socioeconomic factors. In comparison, residents of Xinjiekou Street demonstrate a higher participation rate in city walk activities than those in the other three study streets .

In aggregate, our data set encompasses a collection of 203 distinct itineraries, with the Wudaoying Hutong (n=58) and Dongjiaominxiang Street (n=50) being the most frequently mapped routes within the Citywalk pathways. Subsequently, the Shichahai shoreline (n=49), followed by along Shichahai (n=49), the hutongs around the White Pagoda Temple (n=42), and Guozijian Street (n=20)(seeTable1). City walk behavioural routes revealed a notable concentration of routes in the historical areas of Shichahai, Wudaoying Hutong, Dongjiaominxiang Street, and the surrounding hutongs near White Pagoda Temple in the old city district. We attribute this to the public's desire to explore urban history, culture, and local charm through City walk behavior.

Table 1. Descriptive statistics of the five highest-density “City walk “routes

No	City walk hot routes	Neighborhood name	Strongly perceived landscape values	Built environment features
1	Wudaying Hutong	Andingmen neighborhood	Recreation, Spiritual value	Hutong,Cafe
2	Guozijian Street	Andingmen neighborhood	Spiritual value	Historic street,Cultural building
3	Dongjiaominxiang Street	Donghuamen neighborhood	Aesthetic value, Cultural value, Recreation, Research and education, Social relations	Historic street,Cultural building
4	Hutongs around Baida Temple	Xinjiekou neighborhood	Inspirational, Recreation, Sense of place, Social relations, Spiritual value	Hutong,Religious building, Cafes
5	Shichahai Ring Line along the east	Shichahai neighborhood	Inspirational	Water body, Snack street

In general, recreational (n=1170) and aesthetic values (n=1089) emerged as the most frequently mapped landscape values points during public city walk experiences, followed closely by spiritual value (n=982) and sense of place (n=956). Figure 4 depicts the spatial distribution heatmaps of different types of public-perceived landscape values points, with darker shades indicating stronger spatial distribution intensity. Across the old city area, high-density points of various landscape values types are distributed and tend to be concentrated. This suggests that the surrounding areas of city walk routes in the old city area have the capacity to provide various types of landscape values. In general, the spatial distribution of different types of landscape values is concentrated in areas with dense city walk paths, such as the hutongs around the White Pagoda Temple, Shichahai, Wudaoying Hutong, and Dongjiao Minxiang Street. Aesthetic value, cultural value, and research and educational significance are distributed across multiple points in the old city area, with high densities mainly concentrated in Dongjiaomingxiang Street. The high-density concentrations of entertainment value and spiritual value are observed around the hutongs near the White Pagoda Temple, Wudaoying Hutong, and Dongjiao Minxiang Street. The sense of place is concentrated in the hutongs around the White Pagoda Temple, such as the Gong'er Alley and the east alley of the White Pagoda Temple. Additionally, social value is concentrated in Dongjiao Minxiang Street and the hutongs around the White Pagoda Temple, while artistic and inspirational value are concentrated in the Houhai area of Shichahai. Compared to other areas, the hutongs around the White Pagoda Temple and Dongjiaomingxiang Street provide more landscape values and are more intense. These areas feature a rich distribution of POIs and historical cultural buildings, such as cafes, bookstores, and churches. Furthermore, in the study area, aesthetic value, entertainment value, cultural value, research and educational value, social value, spiritual value, and artistic and inspirational value are distributed in the Nanluoguxiang, Beiluoguxiang, Zhonglou, and Gulou areas. These areas have well-developed leisure facilities, providing more opportunities for the perception of landscape values.

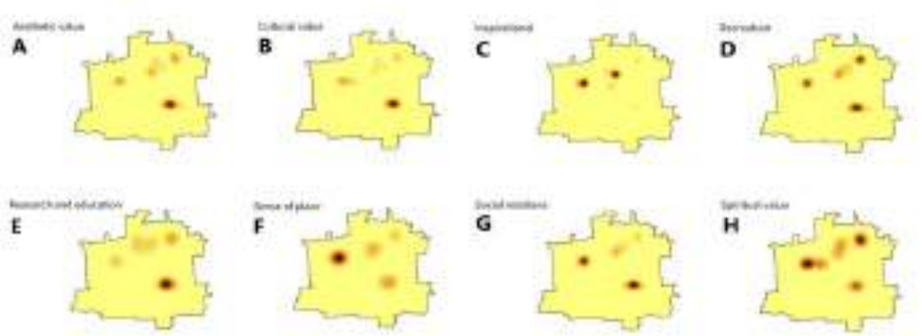

Figure 3. Heat maps of the spatial distribution of A)-H)each individual landscape values.

The outcomes derived from the random forest regression model reveal the relative importance of built environment features on city walk use intensity (Figure 4). Notably, indices demonstrating heightened relative importance exhibit commensurately greater impacts on city walk behaviour. Specifically, diversity of Points of Interest (POIs) emerges as the primary contributor to city walk use intensity, followed closely by road density, whereas the influence of building density on city walk use intensity is comparatively subdued. Lower levels of building density correspondingly manifest a propensity to enhance city walk behaviour.Our random forest analysis further revealed the environmental features influencing public city walk behaviours. Previous studies indicated that the mix of land use and street connectivity are associated with higher levels of walking activity (Cowie C T et al., 2016). Similar to previous findings, our study indicated that POI diversity and road density play key roles influencing public city walk behaviours. POI density was the most important environmental feature. In the Shichahai area, City walk hot routes are concentrated in the center of Shichahai, which can be explained by the abundance of POIs along the waterfront roads, such as historic buildings, restaurants, bars, etc. Additionally, Dongjiaominxiang Street is also an area with dense City walk routes, which is related to the comfortable and pleasant streetscape and the diverse styles of historical and cultural buildings. Furthermore, around White Pagoda Temple, Wudaoying Hutong, and Guozijian Street, there are spaces provided for people to stop and meet the demands of taking photos, shopping, enjoying food, and other activities along the City walk routes. Moreover, our research findings indicate a significant correlation between road density and City walk use intensity, consistent with existing studies on walking behavior (Cowie C T et al., 2016).

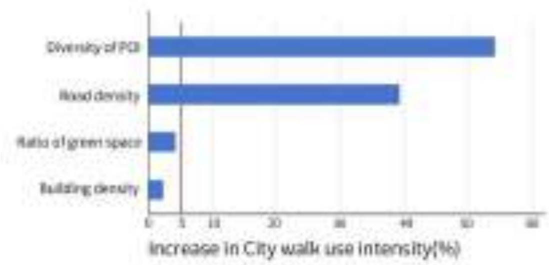

Figure 4. Random forest regression analysis of city walk use intensity and built environment features. The contribution degree is greater than or equal to 5%, it is regarded as an important influence factor.

Through the utilization of the random forest model, we have been able to assess the specific contributions of Points of Interest (POIs) to the various categories of landscape values perceived by participants along their city walk paths (Figures 5.a-h). In general, Parks and attractions, Historical and Cultural Buildings, and Cafes each offer a diverse array of landscape values. However, Parks and attractions notably demonstrate the greatest contribution to the public's perception of Aesthetic Value along city walk paths (Figure 5-a). Similarly, within the random forest model constructs for Cultural Value and Research and Education, Parks and attractions exhibit substantial importance (Figure5-b). Historical and Cultural Buildings emerge as primary contributors to Cultural Value, Research and Education, and Spiritual Value (Figure 5-b, e, h), with their significance notably pronounced in inspiring aspects (Figure5-c). Cafes are found to have the greatest contributions to Sense of Place and Social Relations (Figure 5-f, g), while Shopping centers and stores predominantly contribute to Recreation (Figure 5-d), and Bookstores and Libraries notably contribute to Inspiration (Figure 5-c). Restaurants and bars emerge as significant influences across various landscape values. Additionally, Bookstores and Libraries exhibit the weakest capacity to provide other types of landscape values, while Cafes demonstrate the least importance in fostering inspiration.

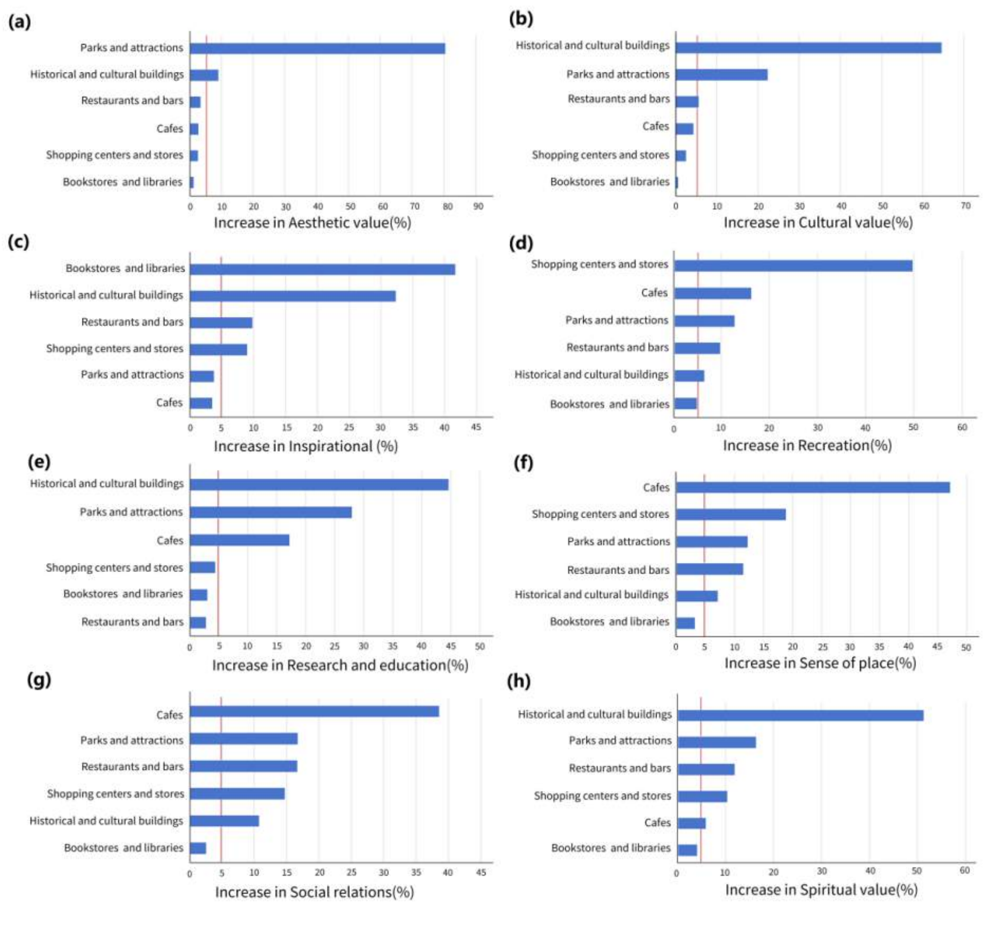

Figure 5. Random forest regression analysis of public perceived landscape values and POI features. The contribution degree is greater than or equal to 5%, it is regarded as an important influence factor.

4. Conclusion

This study aims to conduct a preliminary exploration of the City walk travel mode within the context of China. We utilized the PPGIS method to acquire spatial distribution information regarding hot routes for City walk in Beijing's old urban areas. Based on this, we analyzed and understood public preferences for City walk behavior from the perspectives of the built environment and landscape value perception. From the spatial pattern of City walk routes, we observed that urban green spaces, water bodies, historical streets, and other public spaces in neighbourhoods all provide certain City walk experiences for the public. Different types of landscape values are generally concentrated in areas along City walk hot routes. Furthermore, we found that the richness of Points of Interest (POIs) and road density significantly contribute to the intensity of City walk usage. Moreover, specific types of POIs such as historical cultural buildings, parks and scenic spots, and cafes are important influencing factors for landscape value perception.

Our findings suggests that urban managers can promote outdoor City walk behaviours by optimizing the road network in old urban areas, preserving historical cultural buildings in historical neighbourhoods, and maintaining the quantity of parks and scenic spots. In recent years, there has been a significant increase in City walk activities, which has changed the entertainment forms of outdoor urban spaces. Therefore, while preserving the historical appearance of ancient buildings and streets, attention should be paid to the dynamic needs of the public, improving the public service system, enriching the essence of leisure walking, and injecting a vibrant modern atmosphere into urban communities. The research findings, based on public use of urban walking and its perception of enhancing outdoor experiences and social well-being, offer new insights to support urban renewal policies and tourism management in Beijing's old urban areas. Finally, exploring City walk travel modes in different cities worldwide will be an interesting investigation and comparison in the future.

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Exploration of Methods and Applications of LLCA and PPGIS

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Abstract

Humans and landscapes have always been engaged in a dynamic process of interaction. The intense urbanization process has led to significant changes in landscape, subsequently affecting human perception and behavior. Landscape serves not only as an objective carrier of human behaviour and perceptions, but it also as a social construction that links 'people' and 'places'. By understanding the landscape and its character, it is possible to obtain a deeper comprehension the changes in the landscape and their impacts on human. Landscape assessment character(LCA) is a programmatic approach to gain an insight into local landscape character, and PPGIS provides an effective tool for public participation in local level landscape surveys.

The purpose of this practice is to clarify the relationship between LCA and LLCA, while learn from the Local Landscape Character Assessment (LLCA) methodology, taking the Guangzhou Higher Education Mega Center (HEMC) as a case study. Following this, we will analyze the results of the surveys to discuss the spatial relationship between landscape values and landscape character assessment. In the end, determine the applicability and feasibility of this method to China and emphasize the significance of public participation in landscape planning and management.

Keywords: Landscape Character Assessment, Local Landscape Character Assessment, PPGIS, landscape perception, landscape value

1. Introduction

Landscape change has long been a subject of discussion. Antrop (Antrop, 1998) believes that landscapes are in a constant state of flux, reflecting a dynamic interaction between cultural and natural processes. This change is holistic and complex, resulting from both natural spontaneous processes and human-planned actions. There are two primary driving forces behind landscape change: human-driven and natural-driven factors (Antrop, 1998). Under the influence of these forces, landscape change can be gradual, adapting to the original landscape structure (Butler & Sarlöv-Herlin, 2019), or it can be drastic and unpredictable, potentially threatening both the landscape itself and the surrounding environment (Antrop, 2004). Research indicates that landscape change inevitably leads to alterations in landscape character, which can affect people's perceptions and experiences. This can result in a diminished sense of belonging to familiar places (Svobodova et al., 2018).

The European Landscape Convention (ELC) defines 'landscape' as 'an area perceived by people whose characters are the result of the interaction of natural and/or human elements' (Council of Europe, 2000). This definition highlights the multifaceted nature of landscape, which integrates various dimensions. It represents a complex and holistic system that encompasses psychological, social, and symbolic elements through perception, interpretation, and expression. Edward Relph concludes that landscape serves as the material and visual form of a place, with 'place' being experienced through the landscape, he also thinks that the essence of a place is embedded within its landscape (Edward, 2021). As the most intuitive attribute of a place, landscape functions not only as an objective carrier of human behavior and perception but also as a social construct that connects 'people' and 'place' (Edward, 2021; Tuan, 2021).

Landscape Character Assessment (LCA) is a mature and systematic tool for understanding and identifying landscape character (The Countryside Agency & Scottish Natural Heritage , 2002). Public Participation Geographic Information System (PPGIS) serves as an effective tool for public involvement in local landscape surveys. This practice draws on the methods of Local Landscape Character Assessment (LLCA) and uses PPGIS as a tool attempts to apply in Guangzhou Higher Education Mega Center (HEMC).

This paper aims to: (1)Clarify the relationship between LCA and LLCA, and determine the definition, purpose and technical path of LLCA; (2)Explore LLCA application in HEMC through PPGIS tools, analyze the data obtained from the survey; (3)Propose strategies to protect the character of HEMC and enhance identity recognition based on the findings of the investigation; (4)Summarize the advantages of the LLCA and PPGIS.

2. Experience of LCA and LLCA in England and Scotland

Landscape character exist as the foundation for landscape change, making landscape character crucial for reflecting the outcomes of such changes. Therefore, the core of landscape change research lies in the process of identifying and describing these character changes through LCA.

2.1 Relationship between LCA and LLCA

In 2004, the Countryside Agency published 'Landscape Character Assessment: Guidance for England and Scotland', which outlined the definition, principles, objectives and methods (The Countryside Agency & Scottish Natural Heritage , 2002). According to the document, LCA is defined as a technique for classifying and describing landscapes. It identifies and articulates the processes of change in landscape character while attempting to explain the unique combination of elements that contribute to a landscape's distinctiveness. As a tool for monitoring and managing landscape change, LCA enables the division of landscapes into units for effective oversight. It encompasses all aspects of the landscape and can be applied at various levels. The LCA can be conducted at any level—from national/regional to local/site levels—resulting in different LCA outcomes. The assessment's purpose is to serve as a vital criterion for selecting the appropriate level for analysis.

As shown in Figure 1, LLCA is the smallest level of LCA. LLCA is designed for local assessments grounded in LCA principles (The Countryside Agency & Scottish Natural Heritage, 2002). Character and background studies at the local level can be further divided into categories such as borough-wide surveys, neighborhood or area-based studies, and site-based assessments (Greater London Authority, 2014). Each level of the LCA level increases in detail compared to the previous one, ensuring that the LCA is suitable for the specific area it addresses and the purpose it serves.

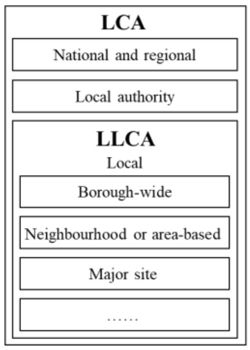

Figure 1. Relationship between LCA and LLCA

2.2 Definition, significance and purpose of LLCA

In 2012, Hampshire published 'Assessing and Maintaining Local Distinctiveness: Advice to Communities on Undertaking a Local Landscape Character Assessment', which formally introduced LLCA. This document points out that LLCA is a technical method that captures local people's perspectives on the special qualities of their environment. It aims to identify objectives for maintaining and enhancing landscape quality and addresses issues that affect local distinctiveness, helping to define unique geographical areas known as landscape distinctive areas (The Strategic Environmental Delivery Group, 2012). The guide provides practical advice for communities on how to carry out local landscape character assessments and preserve local distinctiveness. It also serves as a reference for developing community policies and actions (The Strategic Environmental Delivery Group, 2012).

Public participation is essential to every part of LLCA and plays a irreplaceable role in assessing landscape characters at the local level. This approach was first adopted in Hampshire, based upon the published local authority-level LCA, involving local residents in various stages of the assessment process. The process included suggestions on how to conduct local landscape character assessments, define landscape character areas, and effectively engage the entire community in the assessment (Hampshire County Council, 2012; Lanner Parish Council, 2016; St Erme Parish Council, 2017). The landscape perception in an important content of LLCA. It gathers local people's perceptions and experiences to ensure that the place becomes a place for living, working, and tourism that has a strong 'sense of place'. This approach could strengthen environmental, social, and economic vitality, strengthens landscape identity, and ultimately contributes to the sustainable development of the area.

2.3 The pocess of LLCA

As shown in Figure 2, LLCA focuses on public participation and site investigation, the process can be summarized into four phases. The first phase involves launching the program and gathering evidence, including preliminary preparation work. The second phase emphasizes engaging the community, with a key focus on documenting the local landscape character through field surveys with local people. This is followed by assessing and prioritizing actions, and the final part includes monitoring the entire LLCA project cycle.

LAUNCH/CORE GROUP/ GATHERING EVIDENCE	**Stage 1**	Initiating a local landscape character assessment (LLCA)
	Stage 2	Briefing the parish council and setting up the core group
	Stage 3	Collecting relevant environmental information
	Stage 4	Briefing and workshop for the core group and wider community
	Stage 5	Developing a strategy for involving the whole community
COMMUNITY INVOLVEMENT	**Stage 6**	Field survey work and recording the local landscape character
	Stage 7	Involving the wider community to support a LLCA
	Stage 8	Writing the LLCA
EVALUATION AND PRIORITISE ACTIONS	**Stage 9**	Action planning
DELIVER AND MONITOR ACTIONS	**Stage 10**	Monitoring and review

Figure 2. The process of LLCA (The Strategic Environmental Delivery Group, 2012)

The key to LLCA is the identification and delineation of local landscape character, which completes the content of LCA and allows for further site investigation. A dataset of character elements is constructed through three dimensions of the landscape: natural, cultural/social, and perceptual/aesthetic (The Countryside Agency & Scottish Natural Heritage, 2002). Different study purposes determine which local character elements require attention, as not all elements are equally important in a specific area. The level of research also influences the degree of detail of the local character elements. Thus, landscape character classification elements are selected according to the level and purpose of the study, culminating in the completion of a landscape character map.

3. Material and Method

3.1 Study area

The study area is located in HEMC, Guangzhou, Guangdong, China, covering about 17.9 km² (Shi & Xie, 2013), as shown in Figure 3. The island is surrounded by water and has a regular outer shape. Before 2000, the island was known as 'Xiaoguwei', which was a tidal flat formed by the alluvial deposits of the Pearl River. The island featured the traditional Lingnan water village landscape, Lingnan garden landscape, and modern historical relics that had developed over time. Xiaoguwei has largely remained in a natural state, with landscape changes mainly resulting from natural evolution. After 2003, policies and human planning became the main influences on landscape changes. Xiaoguwei was transformed into a university town, the original farmland, ponds and woodlands mainly disappeared, with roads now interspersed among the plots. The layout of HEMC features important axes and radial clusters, the spatial structure consists of three levels: town, cluster, and campus (Wang et al., 2002).

Figure 3. Scope*

3.2 Methodology

The technical path is adjusted based on Figure 4 and the character of the research area. The technical path has four parts and night stages: the purpose and scope of the research, desktop study and fild survey, community involvement, as shown in Figure 4. Two important points about the technical path are: (1) The boundaries of the landscape character areas are not modified founded on the existing or previous level landscape character assessment. Because the boundaries are mainly set by desktop research, and modified through public participation are limited. (2) The LLCA results provide a basis for investigating the landscape value for local people. These results aim to promote the public's preception of local landscape character, provide relevant knowledge, and assist local people in evaluating landscape values.

PREPARATION	**Stage 1**	Defining the purpose and confirm the scope of the research
	Stage 2	Setting up a research group
DESK STUDY FIELD SURVEY	**Stage 2**	Collecting relevant environmental information
	Stage 3	Building a database of landscape character elements
	Stage 4	Field survey work and recording the local landscape character
	Stage 5	Classifying the landscape character types and areas of the place
COMMUNITY INVOLVEMENT	**Stage 6**	Developing a strategy for involving the whole community
	Stage 7	Creating a survey questionnaire
	Stage 8	Collecting and analyzing data
DELIVER	**Stage 9**	Summarizing and proposing strategies

Figure 4. Pocess of LLCA of HEMC (The Strategic Environmental Delivery Group, 2012)

The landscape character types are defined by several key factors: (1) Buildings: This includes information about the types. Locations, floor space and height of buildings; (2)Land Use/Land Cover: Data that shows how land is used, like for commercial, agricultural and residential; (3)Roads: The layout and types of roads that affect access within the area; (3)Essential Urban Land Use Categories: Information that classifies different types of urban land; (4)Historical Assets: Information that highlights the historical importance and changes in the landscape.

These factors help create a clear understanding of the local landscape characters, as shown in Table 1.

Table 1. Character themes of scope

ELEMENTS	CHARACTER THEMES	
NATURAL/PHYSICAL	Topography and Geology(DEM)	Vegetation and Soil
	Building(bottom profile and height)	Roads/Movement and connectivity
	Landuse/Landcover	Essential Urban Land Use Categories
	Local climate	Satellite imagery
CULTURAL&SOCIAL& ECONOMICAL	Heritage assets	History development
	Population, economic, etc.statistical	Point of Interest
PERCEPTUAL AND AESTHETIC	VIIRS DNB	Acoustic environment zoning

3.3 Data collection

After the initial investigation, the groups in the study are divided into four groups: university students, local residents, migrant workers, and visitors. The Maptionnaire platform was chosen as a tool for collecting data. This platform combines mapping, questionnaires, and discussion functions to improve research efficiency and data accuracy, which is widely used in research (Huang et al, 2019). The questionnaire has three parts: basic information, spatial survey, and non-spatial survey, as shown in Table 2. The landscape values survey is founded on the case of Hampshire and Cornwall in England (Hampshire County Council, 2012; Lanner Parish Council, 2016; St Erme Parish Council, 2017) as well as the eight landscape value evaluation indicators developed by Greg Brown (Greg et al., 2020). The interviews are divided into three parts: perceptions of changes in the landscape, effects of changes, and opinions and actions regarding the past, present, and future.

Table 2. Design of the questionnaire

BASIC INFORMATION	SPATIAL SURVEY MAPPING	NON-SPATIAL SURVEY QUESTIONNAIRE
Gender, age, occupation and identity, etc.	Landscape value evaluation (Wilderness Value, Aesthetic Value, Therapeutic Value, Economic Value, Cultural Value, Historic Value, Recreation Value, Life Sustaining Value)	1)Perceptions of changes in landscape character. 2)Effects of changes in landscape character. 3)Perceptions and actions regarding the past, present, and future.

4. Findings

4.1 Basic information

As shown in Figure 5, among the 116 valid survey samples, 54 are male and 69 are female, accounting for 46.55% and 59.48% of the total participants. The survey asked four categories about their knowledge of the area, and nearly half of them felt that their knowledge of the place was 'neither familiar nor unfamiliar'.

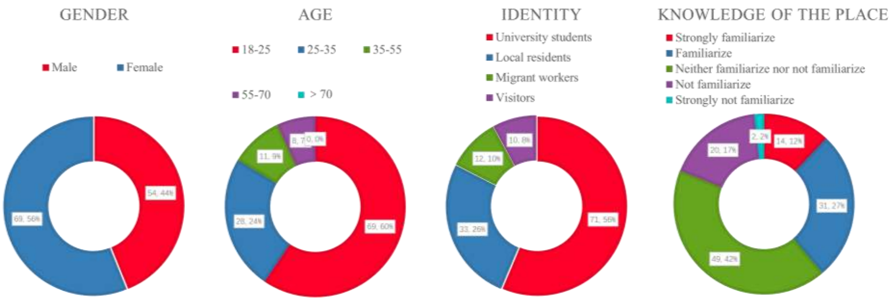

Figure 5. Statistics of basic information

4.2 LLCA

The result of LLCA play the role of the foundation for public participation, enabling participants to better understand the place and identify points of landscape value. Once the overall landscape character map is completed, a secondary classification is conducted to ensure the accuracy of the character areas. Vegetation, river, land use, road networks, historical buildings and heritage are selected to define the character types and areas of the overall map. For the detailed map, the factors considered include vegetation type, road grade, planning layout, building height and density, functional zoning and points of interest (POI).

As shown in Figure 6, there are 22 landscape character types in the HEMC, with 15 identified as the main types. Among these, green space occupies the largest area, while transportation facilities account for the smallest proportion. Building on the landscape character types from the overall map, further divisions into more detailed types and areas are made. As illustrated in Figure 7, the final outcome includes 50 landscape character types and 329 landscape character areas.

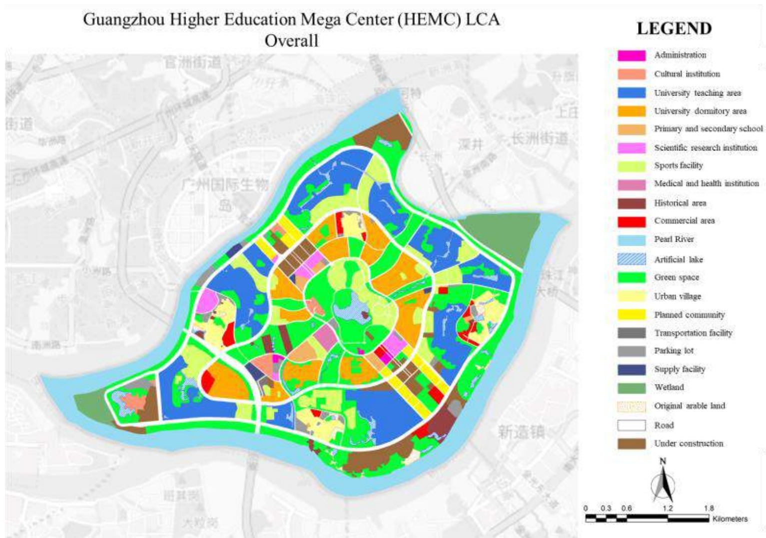

Figure 6. HEMC LCA(overall)*

4.3 PPGIS

As shown in Figure 8, the points most commonly marked by participants are 'aesthetic value' and 'recreation value,' receiving 183 and 171 points, respectively. These categories also achieved the highest scores, with 682 and 623. Conversely, the least marked categories are 'wilderness value' and 'life-sustaining value,' which received 108 and 96 points, respectively. Notably, 'wilderness value' garnered the lowest score of 366, while 'life-sustaining value' received a score of 398. According to the number of points and the score, HEMC is generally perceived as a place with beautiful scenery and social value, reflecting the needs of local residents for daily landscapes and activities. It is not regarded as possessing 'wilderness value' or 'life-sustaining value', indicating that it is not a pristine natural landscape, but rather a cultural landscape, implying that people have ascribed significant meaning to the area.

As shown in Figure 9, the scores assigned to each value and the groups that provided those scores are clearly visible. It was observed that the scores for values that participants were willing to rate are generally high, with over 40% of the points rated at 5. However, wilderness value stands out as an exception, with 22.20% of the points rated at 3 and 36.33% rated at 5. It is evident that people generally recognize at least six values that reflect the character of a place, aside from wilderness value and life-sustaining value. Especially, participants typically mark points that hold recognized values and rarely indicate places lacking value. Even in designing the questionnaire, participants were encouraged to identify locations that should have a certain value but currently do not.

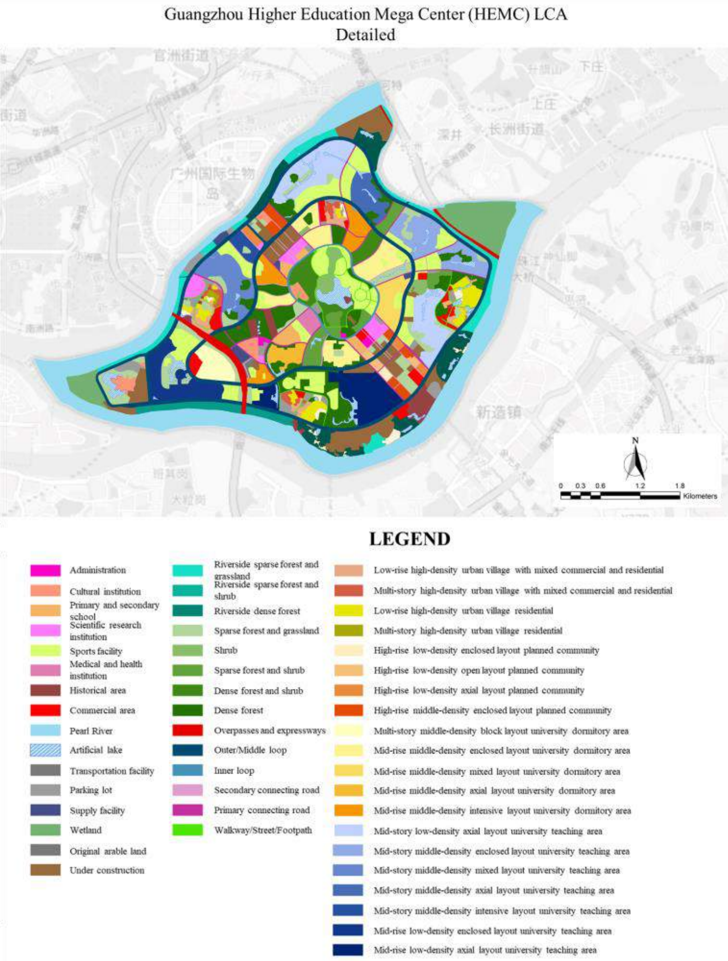

Figure 7. HEMC LCA(detailed)*

As shown in Figure 10, the survey collected a total of 1,098 value points, averaging 9.47 points per person. Figure 11 illustrates the results of the overall LCA map linked to the scores of landscape value points, encompassing 20 landscape character types. The landscape type that shows the strongest correlation with the landscape value is 'green space,' which also received the highest score from participants, followed by 'urban village' and 'university teaching area.'

In public areas, 'green space', 'commercial areas' and 'historical areas' are receiving the highest landscape value scores that reflect the local character of HEMC. In residential areas, both local residents and migrant workers rate the landscape of their living environment, specifically the 'urban village'. University students, in contrast, give highest evaluations to the 'university areas', where they live. This reveals that most participants tend to focus on evaluating the areas they frequently visit and recognize the significance of these landscape types to their experiences. In brief, 'green space' is viewed as the landscape character type with the highest value, followed by 'urban village' and 'university areas'. This suggests that the landscape value of public areas is generally higher than that of residential areas, reflecting people's greater demand for and attention to public spaces.

4.4 Interview

A total of 20 participants were interviewed, comprising 6 local residents, 6 university students, 5 migrant workers, and 3 tourists. Figure 12 displays the responses from a representative sample of each of these four groups.

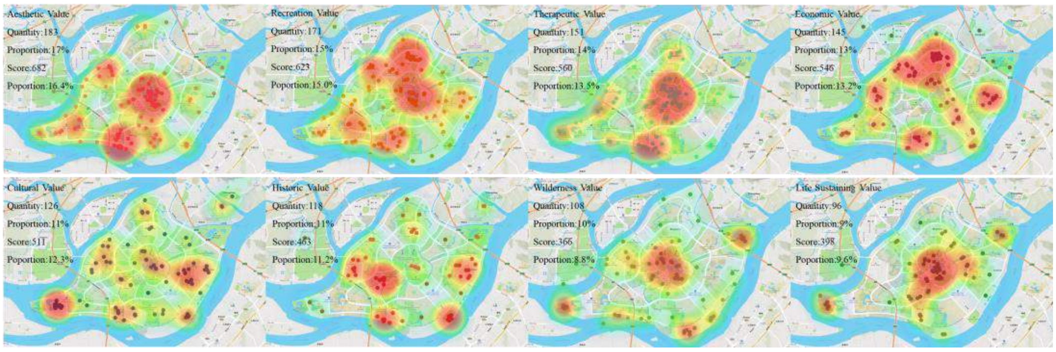

Figure 8. Visualization of landscape value(partial)

Figure 9. Statistics of lanscape values(partial)

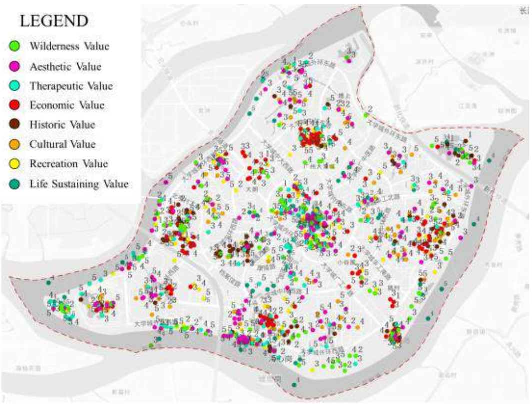

Figure 10. Visualization of landscape value(complete)

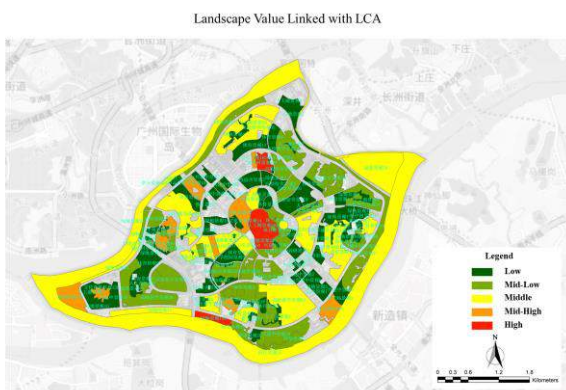

Figure 11. Landscape values link with landscape character areas*

According to the interview survey, three distinct attitudes towards HEMC were identified among the different groups: 'returning to the past', 'maintaining the status quo' and 'looking forward to the future'. For local residents in the university town, particularly the elderly, there is a strong desire to return to their past way of life. Farmland has been an integral part of their lives, but the development of HEMC has diminished their sense of identity with the area. In opposition, university students predominantly express a forward-looking attitude, expressing hope that the environment of HEMC will continue to develop and improve, which holds significant importance for them. Migrant workers, on the other hand, who do not plan to stay in the place long-term, express a preference for maintaining the status quo, viewing the development of the university town as unimportant to their lives.

NO.	LR_M05	US_F01	MW_F03	TO_F02
PERCEPTIONS OF CHANGES IN LANDSCAPE	**(1) Before the construction of HEMC, what kind of place was this place in your eyes?** Before 2000, this island belonged to the village, but now only less than one-third of the original area remains. This area is full of fields and banyan trees, and every household has its own farmland for planting. There are almost no tall buildings to be seen, basically there are fields and low village houses.	**(1) What kind of place is here? What are the character of this place?** This is a paradise with abundant water and grass, dense green plants, well-arranged buildings and fresh air. Many universities are located here, and the academic atmosphere is good. It is a relatively young urban area with vitality and creativity.	**(1) What kind of place is here? What are the character of this place?** I think this is a small island with many universities, middle schools, and primary schools. The environment is beautiful and quiet, and there are many young people. The riverside and the central lake are beautiful, and the other places seem to be similar, and there is nothing particularly good to see.	-
	(2) After the construction of HEMC, what changes do you think have taken place in the island's landscape? Farmland has disappeared, many houses in the village have been demolished, and the village has shrunk a lot. Many roads have been built, and transportation options have become more diverse, but we rarely go out. Schools occupy most of the area, and there are more shopping malls and parks, but there are also many undeveloped and developing wastelands. There used to be more indigenous residents here, but now there are more students and some migrant workers.	**(2) During the time you have been living here, what changes do you think have taken place in this place's landscape?** I have lived on the island for a year now, and there have been few improvements to the landscape. The main thing is that the transportation system has been improved, and many bicycle paths have been added. Students can ride more freely and experience the local customs and culture of the island. Many wastelands are also being developed, including residential areas and some public facilities.	**(2) During the time you have been living here, what changes do you think have taken place in this place's landscape?** I've lived here for a few years and I feel like there have been almost no changes. The only change is that some metro are under construct in the area close to transportation. Many places are either abandoned or still under construction, but there have been basically no major changes in the past few years. But it seems that a lot of infrastructure has been improved during this period, including the science center and wetland park.	-
EFFECTS OF CHANGES IN LANDSCAPE	**(1) Before the construction of HEMC, what was your daily life? Where did you move around?** In the past, we worked from sunrise to sunset. I basically just hang out around the village, occasionally going to other places. We were farmers and had nothing else to do except farming. I basically farm or fish during the day and return home in the afternoon or evening, and go to the market to buy things and take care of the children.	**(1) What is your daily life? Where do you move around?** My main task is to go to school, and my activities are concentrated on the campus, but I often ride around the island, go shopping and eat in the commercial area. Occasionally, I will explore other places on the island, such as the Central Lake Park, the Sculpture Park and the historical buildings, but I don't go there often.	**(1) What is your daily life? Where do you move around?** I mainly live in the urban village, go to work and go home every day. It is too tired when i finished the work, so i rarely go out on weekdays. I may only go to the riverside on weekends, and basically don't participate activities here. I usually go to the city center. There are almost no activities suitable for young people in this place, but we can go to other nearby towns to listen to the concerts and see some exhibitions.	-
	(2) After the construction of HEMC, what impact do these changes have on your daily life and activities? The construction of HEMC has brought development here, and life is more convenient and faster than before, but it is based on sacrificing the original lifestyle. We are old and have lived here for a long time, we don't want to go out often. Occasionally, I will go for a walk in public places with my family, or play cards and chat in the small park in the urban village with some friends.	**(2) During the time you have lived here, what differences have you felt about the changes of the landscape?** I feel that it is more convenient to go out and play. When I ride every week, I can see smoother roads and more diverse vegetation, which gives me a sense of surprise. Compared with before, I spent more time experiencing nature. I think the changes in this year have helped me to have a healthier lifestyle and a more peaceful state of mind.	**(2) During the time you have lived here, what differences have you felt about the changes of the landscape?** The landscape has not changed much, I just know that many universities have expanded their campuses, which I sometimes see when walking along the river. If there were no parks or other shopping malls for consumption built here, I would not come to this place, and other changes have basically no impact on me.	-
OPINIONS AND ACTIONS REGARDING THE PAST, PRESENT AND FUTURE	**(1) Do you miss the old days? Are you satisfied with your current living/working/learning environment?** I miss the old days, because the living environment now is not as beautiful and peaceful as before. The village has become smaller and I need to share the same place with other people. Before, I could choose to farm or go out to work, but now I have to find another way to make a living. However, it's good that some people can make a living by renting out houses.	**(1) Are you satisfied with your current living/working/learning environment?** I'm very satisfied, except that it's a little far from the city center and the transportation is not very convenient. But this is a necessary sacrifice for a peaceful life, which I think is understandable. There are too many construction sites, which makes the air a little bad, and the roadside plants are also covered with a lot of dust.	**(1) Are you satisfied with your current living/working/learning environment?** I am quite satisfied. The accommodation and sanitary conditions in the urban village are slightly worse. There are also fewer places for entertainment and consumption in the university town. Sometimes the noise from the construction sites nearby is quite loud. But overall, it does not have much impact on my daily work and making money.	**(1) Are you satisfied with the current tourism environment?** I am quite satisfied. I usually come here to see the exhibitions held by the Academy of Arts, or to have a picnic with friends at the riverside lawn park. There are many young people here, and the artistic atmosphere is strong, which is very suitable for my profession (model photography). Although it is a bit far from other town, it is also convenient to drive here, so I think it is okay.
	(2) If you are not satisfied, what aspects do you think need to be changed in this place? We hope to improve the environment of the urban villages and create more spaces for activities and exchanges. Now we are moving the furniture out spontaneously, and we hope to have more squares or parks near the urban villages. I hope that more places with history can be preserved, although many of them have been forgotten, including some abandoned ancestral halls and dilapidated houses.	**(2) If you are not satisfied, what aspects do you think need to be changed in this place?** There are many food streets on the island, which bring a lot of convenience, but the sanitary conditions still need to be improved.. I hope that the schools on the island can be more open, realize campus sharing, and increase space for communication. It was only after participating in this questionnaire that I learned that this place has such a long history. I hope that there will be more activities to introduce this island to students in the future.	**(2) If you are not satisfied, what aspects do you think need to be changed in this place?** We should continue to improve the environment and clean up the environment of the urban villages, add some activities that young people can participate in, or build more entertainment venues for consumption. There is a historical archway in the urban village where I live, and I think it should be protected.	**(2) If you are not satisfied, what aspects do you think need to be changed in this place?** Basically it's okay. I come here a few times a month and don't have too many requirements. There may be some lawns along the river that need daily maintenance and trimming, and some activities such as lawn music festivals can be held to attract young people.

LR = local residentials, US = university students, MW = migrant workers, TO = tourists.
M = male, F = female.

Figure 12. Excerpts from interviews

5. Discussion

On the basis of the data and in-depth analysis, three strategies are proposed to protect the character of HEMC and strengthen the identity of its residents: (1)Adding more public spaces. It's essential to investigate people's subjective evaluations and ensure that the landscape value matches with the appropriate landscape character types and areas. By recognizing the types of public spaces required, future planning can preserve and expand relevant areas, thereby enhancing the landscape value of HEMC.

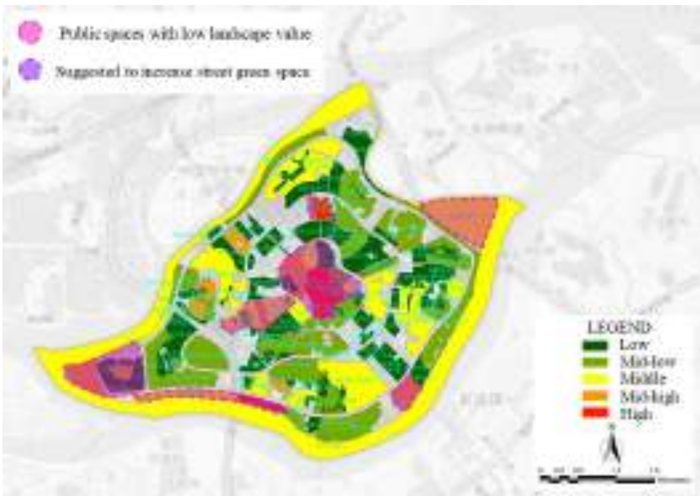

Figure 13. Suggestions for improvement

(2)Recognizing the relationship between value demand and identity. Future construction and planning should focus on recognizing the diverse needs of various groups regarding local values. By protecting and creating landscapes in a targeted manner, can better shape the local character. Activities and behaviors inspired by specific landscapes will strengthen community ties and contribute to a cohesive local identity. (3)Establish consensus among the groups. The three groups within HEMC are somewhat independent, with significant differences in attitudes and needs towards the area. Future construction and planning should prioritize forming consensus and connections between them. This collaborative approach will enhance individuals' sense of identity and foster a more unified community. Figure 9 explains areas that present lower landscape values, as well as regions where there is a desire to enhance the landscape character of public spaces. Figure 13 presents recommendations for enhancement.

6. Conclusion

LCA is a well-established and systematic tool for understanding and identifying landscape character. LLCA acts as an extension of LCA at the local level. It builds on the general methods of LCA by integrating both subjective and objective aspects to comprehend landscape character and the interactions between humans and their landscapes. LLCA can be applied to the study of natural and cultural landscape characters at the local level, gradually adding detail at the town, neighborhood, and site levels. In addition to categorizing and identifying landscape character types and areas, LLCA emphasizes the importance of perception and experience, which will facilitates a deeper insight of local character. In summary, LLCA plays a crucial role in capturing and protecting local character, shaping a sense of place, and strengthening identity. It ultimately guides local planning, protection, and development efforts.

PPGIS provides an effective tool for engaging public participation in local-level landscape surveys. Involving local communities is essential for understanding landscape characters and capturing how people feel about and reflect on the local landscapes. Traditional public participation methods, such as interviews, questionnaires and workshops, largely fall short in systematically integrating investigators' personal feelings and experiences into accurate landscape areas. It addresses this limitation by combining online interactive maps with traditional data collection methods, which not only enhances engagement but also provides valuable technical support for offline workshop mapping. By making use of PPGIS, communities can contribute more effectively to the assessment of landscapes, ensuring that local voices are heard and integrated into the planning and development process.

Currently, China lacks a comprehensive, multi-level and hierarchical landscape character assessment method, and public participation is not widespread. Nevertheless, the implementation of LLCA in HEMC has demonstrated its feasibility. The true value of landscape lies in establishing a meaningful connection between 'people' and 'places'. By adopting LLCA practices, there is potential to promote a greater emphasis on landscape, as well as on human perception and experience.

Note

A fraction of texts and images of this paper are included in another paper of the author, which was included in Proceedings of the 2024 Annual Conference of the Chinese Society of Landscape Architecture. But it has not been published yet, so there is no citation in the text. This paper was funded by Guangzhou Philosophy and Social Sciences 2024 Research Project (2024GZYB15).

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Exploring Pathways for Child-Friendly Play Spaces in Undeveloped Regions

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Abstract

In undeveloped regions, children often lack adequate infrastructure, educational and medical resources, and space for activities. That makes them more susceptible to illness or stunted development, and they may face multiple challenges to their physical and mental health. An extensive literature from Cognitive Science has established that children's social, cognitive, and motor development is promoted by play,and play spaces are inexpensive and flexible. For undeveloped areas that struggle to provide quality education, play is critical for children to acquire skills, promote physical and mental development, and foster creativity.

This article is based on cognitive and developmental science and proposes a way for constructing child-friendly play spaces which are adapted to the undeveloped regions. First,the article reviews the body of knowledge from Cognitive and Developmental Science concerning the association between play and learning. It studies the learning mechanism through play from three aspects::Physical opportunities and challenges, active exploration, and social interaction,investigating the designs usher the most beneficial play behavior. Second, considering the current development status of undeveloped regions and following the principles of low-cost, localization, and sustainability, we propose practical solutions such as repurposing abandoned facilities, utilizing locally-sourced materials, and constructing simple, creative venues,encouraging the construction of non-elaborated, non-uniform play spaces.Besides, The article also provides practical examples to illustrate these ways. This article aims to investigate an effective approach to improving the living conditions of children in undeveloped regions. This involves not only improving infrastructure but also promoting fairness, justice, and sustainable development for the future.

Keywords: Child-friendly play spaces, underdeveloped regions, unstructured play, low-cost solutions, inclusive environments

1. Introduction

Play is fundamental to childhood and is recognized as a universal right under the United Nations Convention on the Rights of the Child. Beyond its recreational value, play serves as a vital component of cognitive, physical, and emotional development. It helps children explore the world, develop problem-solving skills, and build social connections. However, in many underdeveloped regions, children face significant barriers to accessing structured and safe play environments.

According to global reports, poverty disproportionately affects children, limiting their opportunities for education, healthcare, and recreational activities. In these contexts, play assumes an even more critical role. It becomes a cost-effective means of fostering development, addressing educational gaps, and supporting mental well-being. Despite its importance, the lack of resources, infrastructure, and awareness often results in the neglect of play spaces in such regions.

This study aims to bridge this gap by exploring effective approaches to designing and implementing child-friendly play spaces in underdeveloped areas. Through a combination of theoretical analysis and practical case studies, we identify principles, models, and processes that can transform underutilized or neglected spaces into vibrant hubs for children’s play and learning.

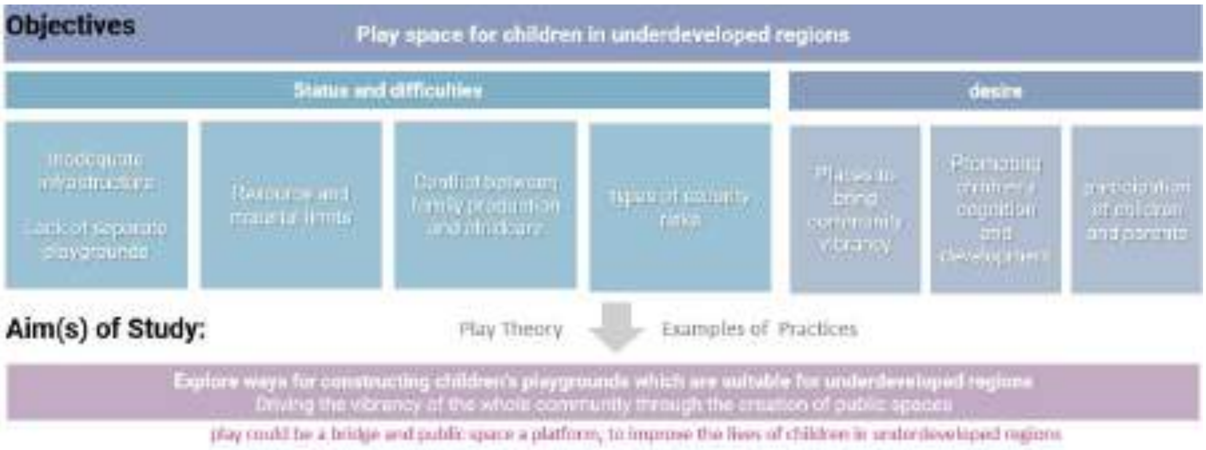

Figure 1. Research Background and Objectives

2. Material and Method

This study employs a mixed-methods approach to explore the pathways for creating child-friendly play spaces in underdeveloped regions, integrating qualitative and quantitative research techniques. The research focuses on understanding the developmental benefits of play, identifying disparities in play opportunities, and proposing actionable interventions that are inclusive, sustainable, and culturally sensitive. To achieve these objectives, the study combines a literature review, field observations, stakeholder interviews, and participatory workshops to collect and analyze data.

A comprehensive review of existing literature was conducted to establish the foundational understanding of the cognitive, physical, and socio-emotional benefits of play. The review also explored the role of experiential learning in resource-constrained settings and analyzed existing frameworks for designing inclusive play spaces in marginalized communities. This theoretical groundwork informed the development of the research framework and contextualized the findings within a broader academic and practical discourse.

Fieldwork was a critical component of this study, involving observations in underdeveloped regions to document children′s play behaviors, the physical characteristics of available spaces, and the social dynamics influencing play activities. These observations were supplemented by semi-structured interviews with key stakeholders, including caregivers, educators, community leaders, and policymakers. The interviews provided valuable insights into the needs and constraints faced by local communities, highlighting the socio-cultural and economic factors shaping the availability and quality of play spaces.

Figure 2. Case Study: Ruben Centre Playground

To ensure the research was participatory and reflective of community preferences, workshops were organized involving children, parents, and community members. These workshops allowed participants to engage in the co-design of play spaces, ensuring that the proposed solutions were aligned with local traditions, needs, and aspirations. The workshops also served as a platform to validate initial design concepts and gather feedback to refine the interventions.

Through this multidisciplinary and participatory methodology, the study offers actionable insights and design solutions that address the unique challenges of underdeveloped regions while maximizing the developmental benefits of play. The approach ensures that the proposed interventions are both evidence-based and contextually relevant, laying the groundwork for sustainable and impactful change.

Figure 3. Children's Play Types Based on Cognitive Science

Figure 4. Design Principles for Children's Playgrounds

3. Findings and Discussion

The research findings suggest that the development of child-friendly play spaces in underdeveloped regions requires a holistic approach that not only addresses the content of the spaces but also the processes involved in their creation and sustainability. This dual focus ensures that the play spaces are both functionally effective and deeply integrated within the social fabric of the communities they serve. Based on the analysis of existing practices, field observations, and stakeholder inputs, we propose a series of pathways for designing and implementing these spaces, focusing on key principles, materials, models, and operational steps.

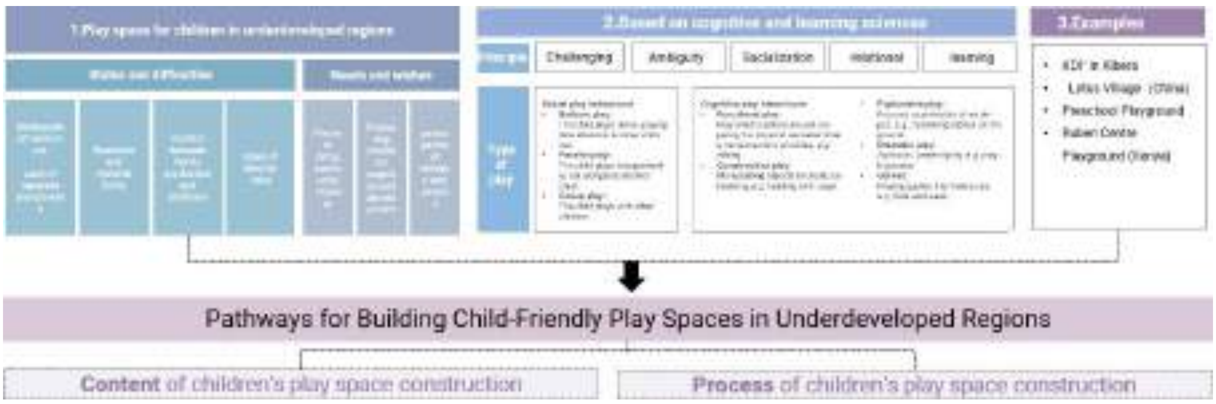

Figure 5. Technical Approach for Constructing Children's Playgrounds

3.1 Core principles for play space development

The study identified three core principles essential for the creation of effective child-friendly play spaces. First, the efficient use of available resources is paramount. In underdeveloped regions, where financial and material resources are often limited, the design of play spaces should prioritize low-cost solutions that require minimal maintenance. This principle ensures that the spaces remain sustainable and accessible over time, even with limited ongoing funding.

Second, it is crucial to balance play opportunities with the everyday needs of families. Play spaces should be located near residential areas and schools, where children naturally spend time. By integrating play spaces within these existing daily routines, they become more accessible and embedded in the community's life. Moreover, multi-functional and movable spaces offer flexibility, adapting to various activities and user groups, which further enhances their utility and longevity.

Lastly, the materials used in the construction of these spaces must be locally sourced and sustainable. The use of local materials like wood, stone, and repurposed items such as old tires can help reduce costs while also connecting children to their natural surroundings. This approach not only makes play spaces more affordable but also encourages environmental consciousness and creativity in both the design and usage of the space.

3.2 Innovative models for play space design

The study also identified five models for creating diverse and engaging play opportunities for children. Each model emphasizes the importance of creativity, social interaction, and fostering a sense of ownership among children.

The first model is the combination of simple materials in versatile ways to create multifunctional play structures. For instance, waste tires can be transformed into various play equipment such as swings, climbing structures, and hiding spots. By using inexpensive materials creatively, these structures offer diverse opportunities for physical play, promoting motor development and imaginative use.

The second model advocates for exploring familiar surroundings and integrating nature into the play space. This model encourages children to engage with the natural environment, fostering curiosity and a sense of discovery. Play spaces designed to incorporate elements like trees, rocks, and natural pathways allow children to interact with their environment in ways that stimulate their imagination and sense of wonder.

The third model focuses on promoting unstructured and creative play. Materials like building blocks, mud, and drawing tools can be used to facilitate open-ended play, where children can express themselves freely and explore their creativity. This type of play supports cognitive and emotional development, as children learn to problem-solve, negotiate, and experiment.

The fourth model emphasizes the importance of fostering team-based games that encourage social interaction and collaboration. Role-playing and games like "catch and run" promote teamwork, communication, and empathy, all of which are vital aspects of social and emotional growth. These activities also provide children with the opportunity to practice conflict resolution and develop leadership skills.

The fifth model empowers children by involving them in the design and decision-making process. Allowing children to express their ideas and preferences for play spaces encourages a sense of ownership and responsibility. This participatory approach not only makes the play space more meaningful to the children but also ensures that the design reflects their actual needs and desires.

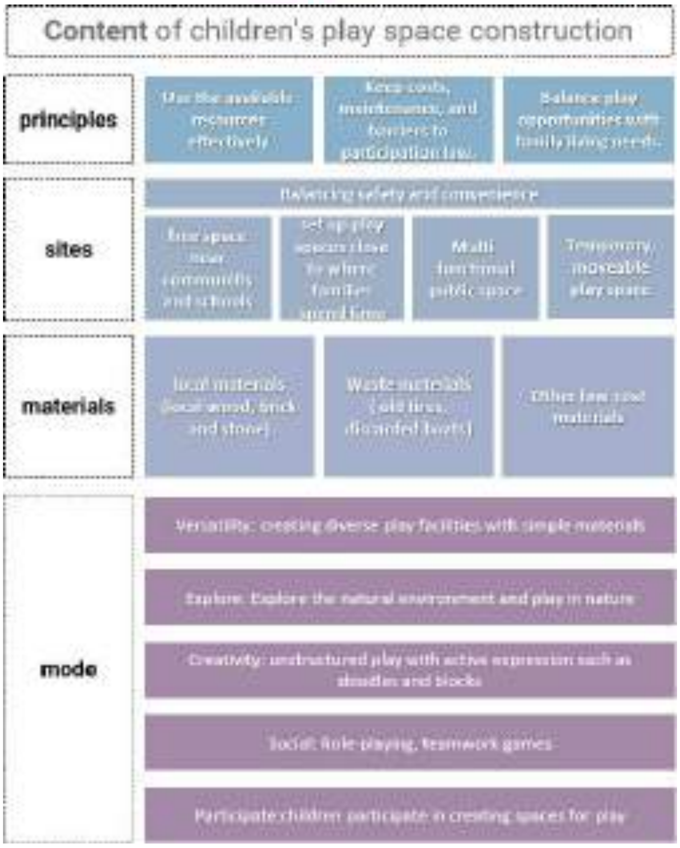

Figure 6. Pathways to Build Children's Playgrounds in Underdeveloped Areas

3.3 Key steps for implementation

The process of creating child-friendly play spaces is as important as the content and design models. The study identified six critical steps for initiating and sustaining these spaces effectively.

The first step is to build a case for the importance of play. Communicating the developmental benefits of play, such as fostering cognitive, physical, and emotional growth, is essential for gaining support from community leaders, educators, and potential funders. The case for play should also highlight its potential to improve health outcomes, promote social cohesion, and provide children with essential life skills.

Next, securing funding is a crucial step. Partnerships with philanthropic organizations, local schools, and community groups can provide the financial resources needed to build and maintain play spaces. Additionally, exploring opportunities within environmental, economic development, and health sectors can unlock additional funding streams that align with the broader goals of sustainable development.

Once funding is secured, the design and construction of the play space should proceed. Collaboration with the community during this phase is vital for fostering a sense of ownership and strengthening social ties. The process of collectively building the space can enhance local engagement and ensure that the space meets the needs of those who will use it most.

After the play space is constructed, its operation requires ongoing collaboration and community involvement. Local leadership should be engaged in maintaining the space, ensuring that it remains accessible, safe, and welcoming for all users. A collaborative approach to funding and maintenance helps sustain the space long-term, even after the initial construction phase.

Finally, monitoring the space is essential for ensuring its continued effectiveness. By observing how the space is used and soliciting feedback from children, families, and community members, adjustments can be made to improve its functionality. Regular monitoring also helps identify potential issues early, ensuring that the space continues to serve its purpose for years to come.

4. Conclusion

The findings from this study underscore the importance of designing child-friendly play spaces that are both accessible and adaptable to the unique needs of underdeveloped regions. By using available resources efficiently, incorporating locally sourced materials, and engaging children and communities in the design process, these spaces can foster holistic child development. The key models and steps outlined in this research provide a framework for creating play environments that are not only functional but also sustainable and empowering for children. With these insights, we hope to inspire future efforts to create inclusive, impactful play spaces that serve as vital hubs for learning, growth, and community cohesion in underserved regions.

Note

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Green Space Inequalities in İstanbul: An Assessment of Spatial Justice

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Abstract

Green spaces in urban areas are critically important for ensuring social and environmental equity. Access to green spaces directly impacts the quality of life by offering recreational, ecological, and psychological benefits. This study evaluates the distribution of green spaces in Istanbul from the perspective of spatial justice, utilizing data from the Green Space Management System (YAYSİS) project of the Istanbul Metropolitan Municipality (IMM). The analyses reveal existing inequalities and present strategic recommendations to enhance urban resilience and sustainability. Spatial analyses conducted using Geographic Information Systems (GIS) have identified priority intervention areas and gaps in ecological infrastructure. The findings emphasize the importance of participatory policies, blue-green infrastructure, and improvements in public access. This study provides a strategic roadmap for ensuring social and environmental justice in urban green space planning in Istanbul.

Keywords: Green spaces, spatial justice, blue-green infrastructure, İstanbul, urban planning

1. Introduction

The equitable distribution of green spaces in urban areas is critically important for promoting social and environmental justice. Access to green spaces directly impacts the quality of life of urban residents by offering various benefits, such as recreation, ecological balance, and mental health improvement. However, inequalities in the distribution of green spaces have become a significant issue, especially in rapidly urbanizing metropolises.

The literature frequently emphasizes the importance of access to green spaces for social equity (Harvey, 1996; Wolch et al., 2014). Harvey argues that spatial justice is based on principles of equity in the distribution of natural and urban resources, while Wolch and colleagues (2014) highlight that green spaces can be used as a tool to enhance social justice. Additionally, Schlosberg (2013) states that environmental justice should include not only the distribution of resources but also participation in decision-making processes.

With a population exceeding 15 million, Istanbul faces significant challenges in ensuring equitable access to green spaces. Its historical and geographical structure, coupled with rapid urbanization, has led to imbalanced development patterns, exacerbating green space inequalities. For instance, central districts on the European side are more advantaged in terms of access to green spaces, while certain areas on the Anatolian side face considerable disadvantages (IMM, 2023). Green spaces contribute not only to recreation but also to critical ecosystem functions, such as improving air quality, mitigating urban heat islands, and enhancing biodiversity, all of which influence the quality of life in urban areas.

In this context, a comprehensive analysis is required to evaluate the current state of green spaces in Istanbul from a spatial justice perspective, identify regional needs, and determine priority intervention areas. As other studies in the literature have demonstrated, such analyses can serve as a valuable guide for policymakers (Vickerman, 2019; Soja, 2010).

The objective of this study is to uncover existing inequalities and provide a strategic roadmap to strengthen Istanbul's green infrastructure. Since spatial justice encompasses not only physical distribution but also accessibility and usability, this study offers significant insights for both local governments and international efforts.

2. Material and Method

In this study, data from the Green Space Management System (YAYSİS) project of the Istanbul Metropolitan Municipality (IMM) were utilized. YAYSİS is a comprehensive database and strategic document developed to create an inventory of green spaces across Istanbul, assess their current status, and manage them effectively. Within the scope of YAYSİS, general information about Istanbul was provided through analyses such as User Characteristics and Demographic Structure Analysis, Natural-Environmental Characteristics and Ecological Status Analysis, and Current Land Use. The locations, sizes, and types of existing open and green spaces, along with their governance status, were identified. Maps were created for Urban Open and Green Spaces, Social Infrastructure (Sports) Areas, and Natural/Rural Areas. The adequacy of open and green spaces based on amenity area parameters was evaluated and mapped at the provincial, district, and neighborhood levels.

Open and green spaces designated in current zoning plans and planned open and green spaces were analyzed to produce maps illustrating the implementation status of planned open and green spaces. Spatial analyses also included the ownership status, accessibility, and impact distances of planned open and green spaces, service areas, density analyses based on accessibility, and the identification of land and plot values. A synthesis study was conducted to reflect the relationships between findings obtained through literature reviews, participatory processes, and spatial analyses and to identify problematic areas regarding green spaces. Comprehensive data collected were analyzed using the unit area and overlay methods.

Unit Area Method: Data were standardized and reduced to measurements per unit area. Istanbul was divided into spatially equivalent hexagonal units with a 250-meter radius, and data were mapped onto these units using Geographic Information Systems (GIS). This method ensured that different data types were analyzed under equal conditions.

Overlay Method: When the unit area method was not suitable, the overlay method was used to combine different data types for a holistic evaluation of the results. This method reduced inconsistencies between data types and contributed to the spatial equity analysis.

The transformation of point and area data into unit area data represents the association of data of different scales with unit areas. As shown in Figure 1.

Point data are spatially intersected with unit areas, and their attributes are added to unit area tables using spatial join tools. Numerical data at the neighborhood or district level, such as population or independent unit counts, are proportionally distributed based on the spatial distribution of point data. Large- or small-scale area data can also be transformed into unit area data and used accordingly.

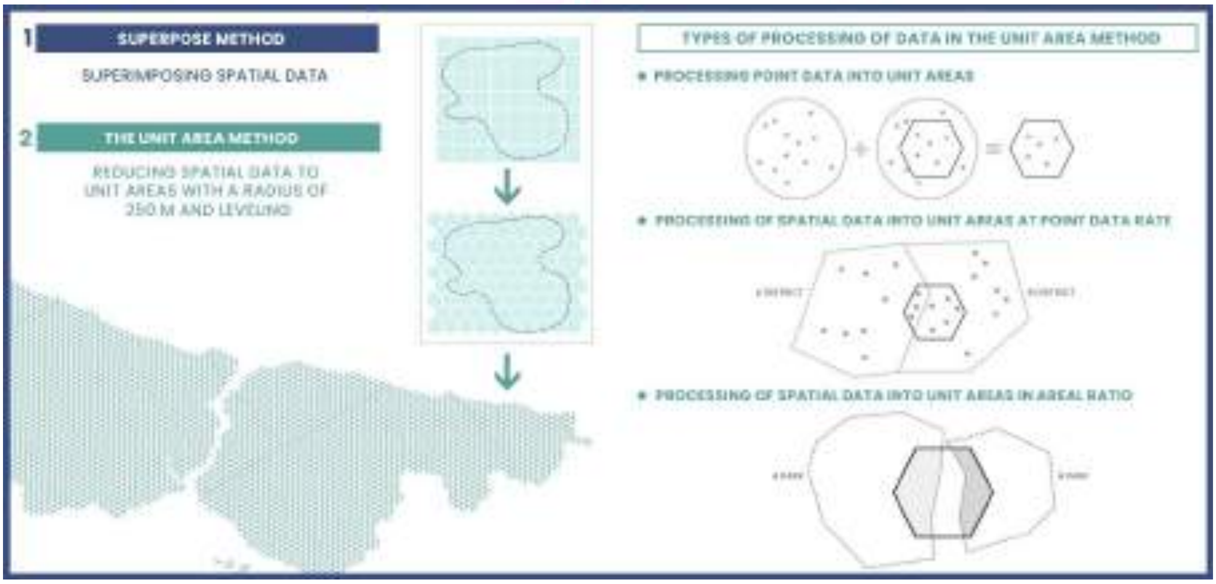

Figure 1. Data Processing Methods/Approaches (YAYSİS,2023)

The data used in this study were obtained from official sources of the Istanbul Metropolitan Municipality (IMM). During the analysis process, GIS software, data visualization tools, and statistical analysis methods were utilized effectively. This process particularly focused on the principles of social equity and ecological sustainability.

This methodological approach aims to ensure the effective utilization of existing green spaces while providing a scientific foundation for planning new green spaces.

3. Findings and Discussion

Analyses conducted across Istanbul's 39 districts have revealed significant inequalities in the current distribution of green spaces. The findings have been elaborated upon by considering socio-economic and environmental indicators. The analysis process involved the following steps:

-The quantity, types, and accessibility of green spaces in Istanbul's 39 districts were analyzed in detail.

-Priority intervention areas were identified by considering socio-demographic factors, existing urban infrastructure, and ecological functions.

-The collected data were visualized and mapped based on criteria such as pedestrian accessibility and the acquisition potential of public spaces.

High Green Space Demand and High Public Acquisition Potential:The study identified areas suitable for public acquisition. After determining areas with a high demand for green spaces in Istanbul, regions with high public acquisition potential were identified. These two maps were overlaid to determine areas with both high green space demand and ease of public acquisition. The synthesis study using the unit area method utilized variables such as ownership, land/plot values, and potential active green spaces to identify the most suitable areas for public acquisition.

Ownership status is one of the most critical factors affecting the public acquisition of open and green spaces. Areas without any development and ownership categorized as "IMM, Public, Shared Parcels, and Legal Entity-Individual-Unclear" were analyzed. Among these, "IMM" received the highest score for acquisition potential, while "Legal Entity-Individual-Unclear" received the lowest. Another factor influencing public acquisition is land/plot values. Neighborhood-level residential zoned land/plot value data obtained from ENDEKSA were categorized into three groups: low, medium, and high. These categories were combined with ownership status and included in the synthesis study (Figure 2).

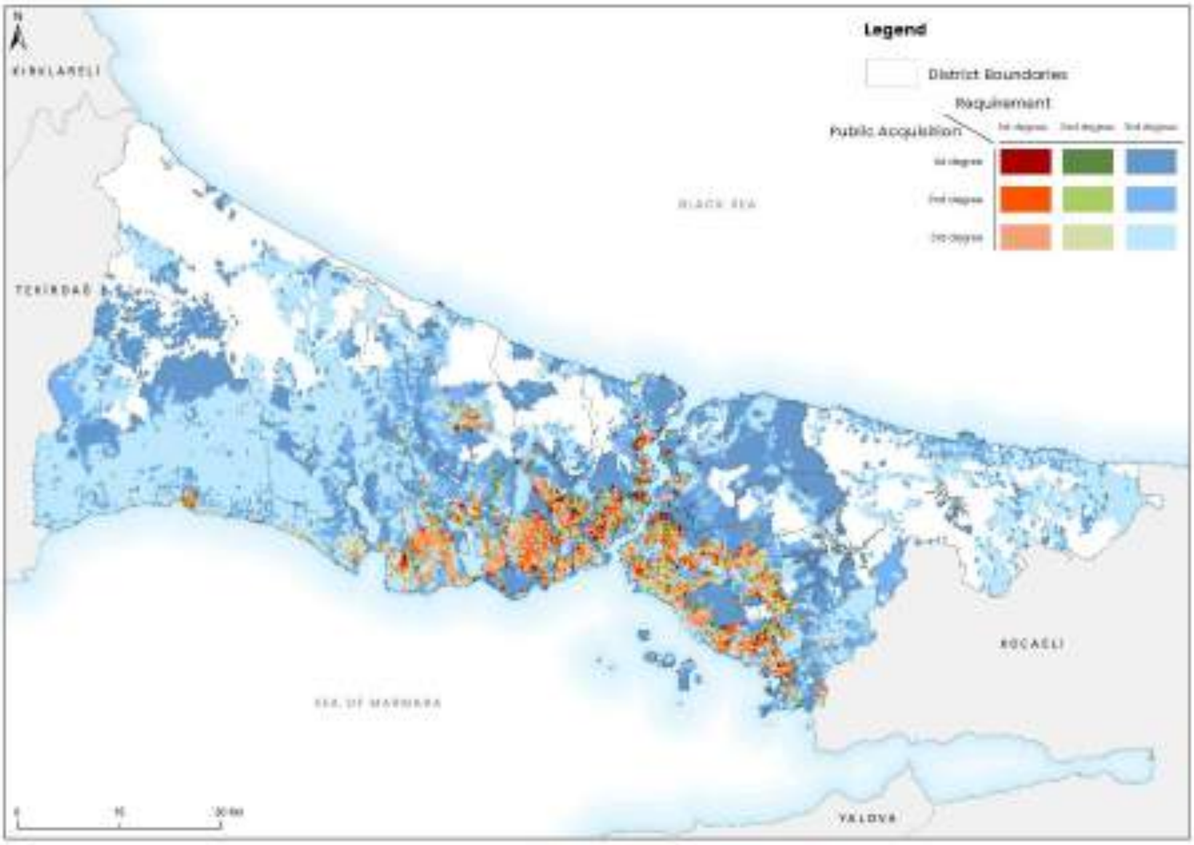

Figure 2. Areas with High Green Space Demand and High Public Acquisition Potential**.** (YAYSİS,2023)

Accessibility to Open and Green Spaces: The total service area accessible to healthy adult individuals is 82,816.40 hectares, whereas the total service area accessible to disadvantaged individuals is 52,674.32 hectares. In the calculations, the walking speed for a healthy adult was assumed to be 6 km/hour on a 5% downhill slope; for disadvantaged individuals such as those with physical disabilities, parents using strollers, small children, the elderly, and individuals with impairments, the average walking speed was considered to be 3 km/hour.

Problematic Areas in Terms of Accessibility and Sufficiency for Vulnerable Populations: When assessing urban vulnerability, parameters such as child population, elderly population, and disabled population were taken into account. Each parameter was individually scored, with equal weighting applied, and an average vulnerability score was calculated per unit area (Figure 3).

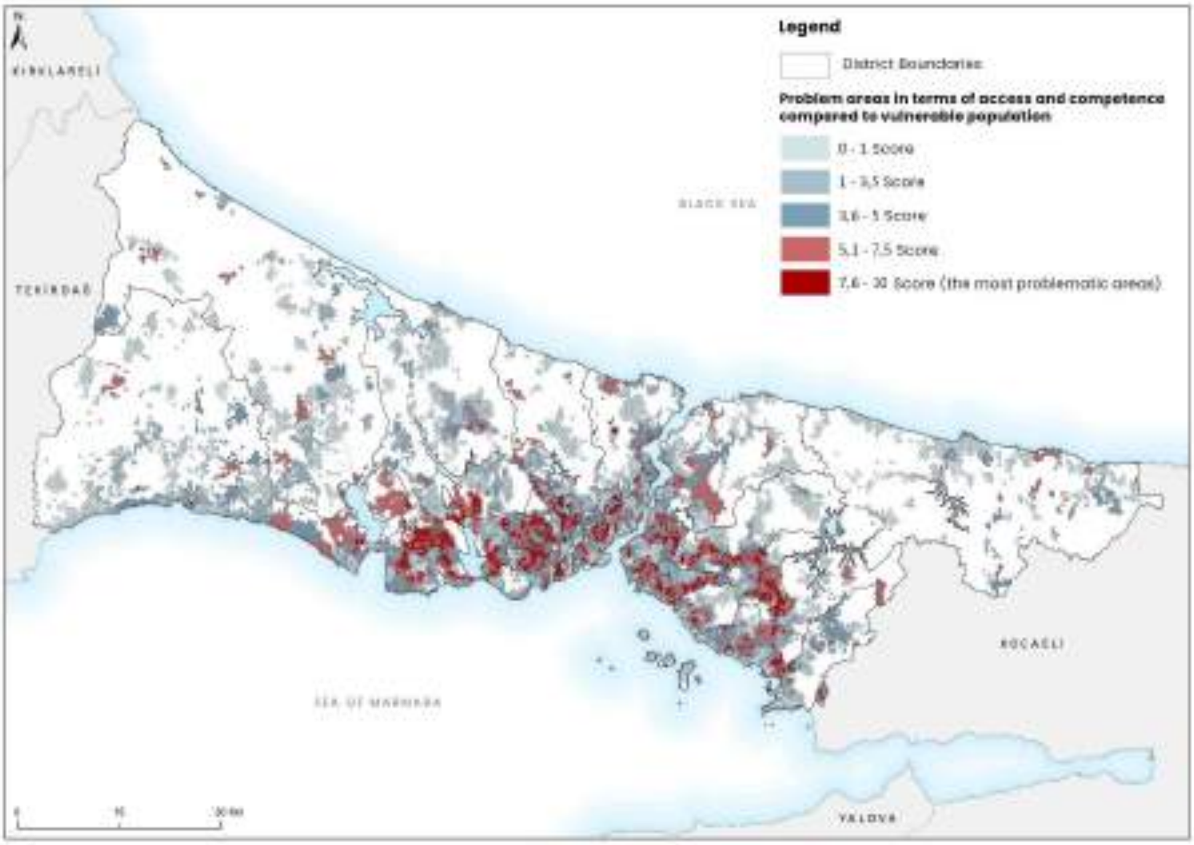

Figure 3. Problematic Areas in Terms of Accessibility and Sufficiency for Vulnerable Populations. (YAYSİS,2023)

Ecological and Blue-Green Infrastructure:Using the unit area model method, a synthesis was produced that required two separate studies to address the differing activities and characteristics across regions, as well as the need for varied intervention approaches. These studies focused on the entire province and metropolitan residential areas.

At the provincial level, a total of eleven variables were used, including forest areas, agricultural areas, water surfaces, watershed boundaries, natural protected areas, wildlife development zones, important plant areas-important nature areas, urban green space inventory, hydrogeology, stream lines, and flood zones.

In metropolitan residential areas, agricultural areas and forest areas were excluded from the scoring process, reducing the variables to nine (Figure 4).

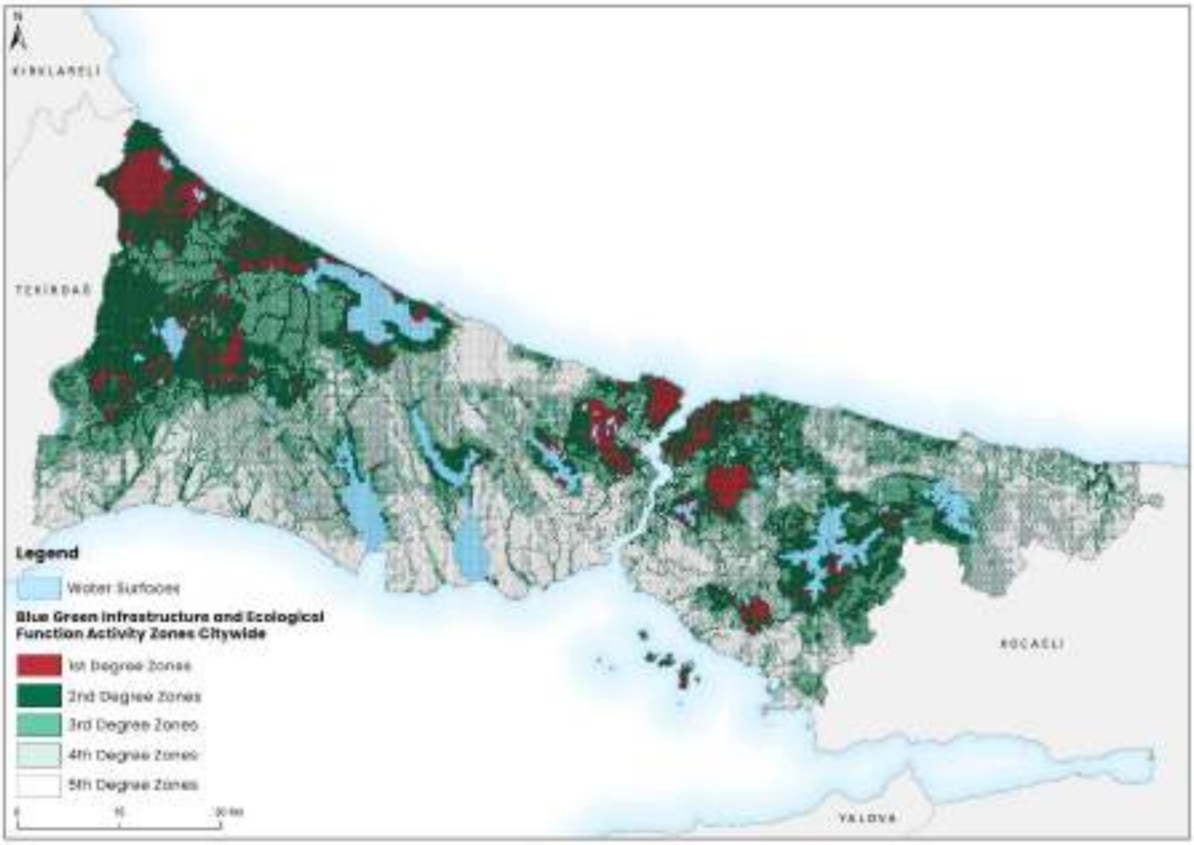

Figure 4. Regions with Blue-Green Infrastructure and Ecological Function Efficiency. (YAYSİS,2023)

Priority Intervention Areas:The maps identified regions A, B, and C as critical in terms of green space deficiency. These regions are typically located in densely populated districts with limited open spaces, highlighting the necessity for intervention. Based on the average scores calculated using the applied formula, sensitive areas were classified into three categories:

Unit areas with scores between 0.01 and 1.50 were classified as 3rd-degree sensitive areas.

Scores between 1.51 and 2.65 were categorized as 2nd-degree sensitive areas.

Scores between 2.66 and 5.88 were identified as 1st-degree sensitive areas (Figure 5).

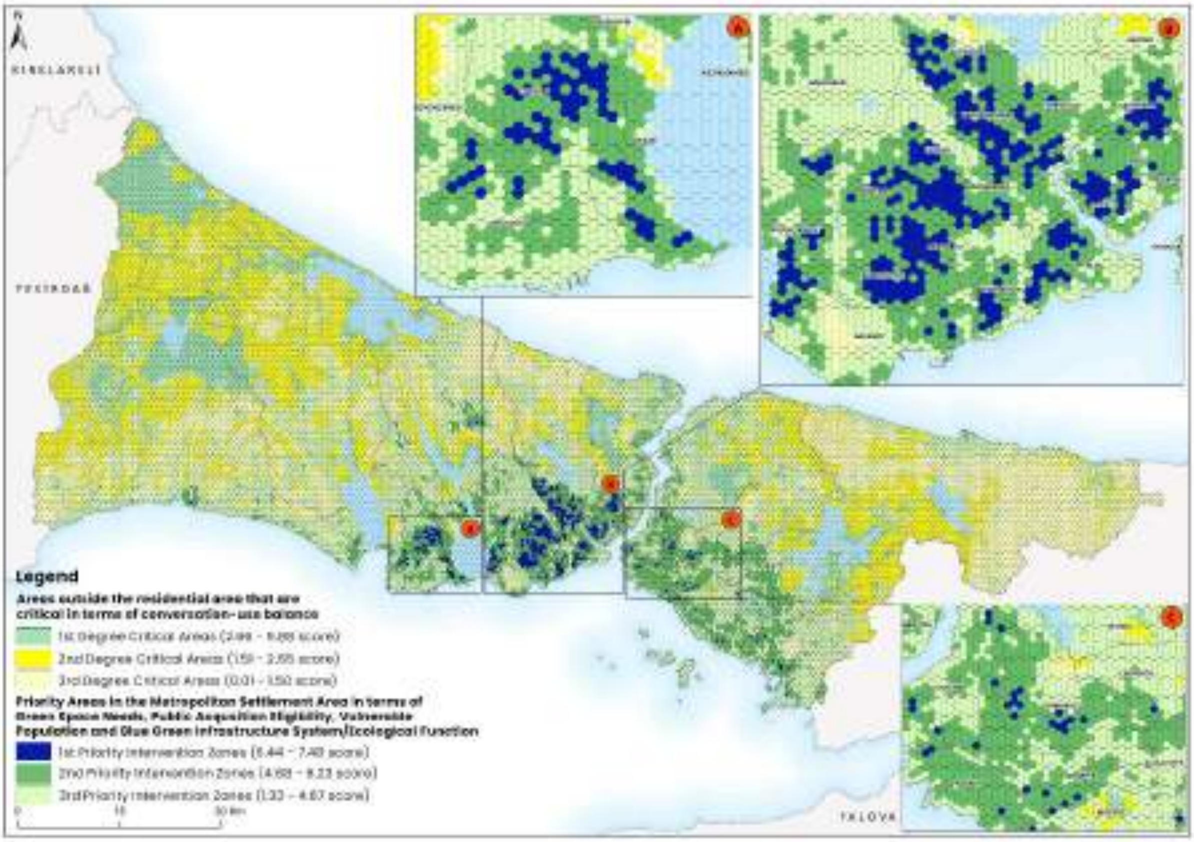

Figure 5. Priority Areas Requiring Intervention (YAYSİS,2023)

4. Conclusion

This study analyzes the inequalities in access to green spaces in Istanbul, offering significant findings from the perspective of spatial justice. The key results demonstrate that existing inequalities are not limited to physical distribution but are also shaped by dynamics such as ease of access, potential for use, and community participation.

Urban Planning: Socio-economic needs and environmental indicators should be prioritized in the planning of new green spaces (Wolch et al., 2014).

Participatory Policies: Local community participation in the planning and management processes of green spaces should be increased, and transparency in these processes should be ensured (Schlosberg, 2013).

Blue-Green Infrastructure: Projects aimed at strengthening ecological connectivity through blue-green infrastructure should be supported (Vickerman, 2019).

Public Accessibility: Transportation and infrastructure projects that facilitate access to green spaces should be prioritized.

By following these recommendations, it will be possible for large cities like Istanbul to create more resilient urban areas based on the principles of social equity and environmental sustainability. Achieving spatial justice will not only enhance the quality of life for individuals but also support the sustainability of urban ecosystems. This study provides policymakers and urban planners with a comprehensive roadmap.

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Perceived restorativeness of small-scale blue spaces

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Abstract

Water is a fundamental landscape element with significant aesthetic, ecological, cultural, and social value. While "blue space" such as large water bodies is believed to have restorative potential for human well-being, there is limited empirical research on the restorative effects of small-scale blue spaces. This study investigates the restorative effects, spatial characteristics, and human behavior of small-scale blue spaces, with a focus on two artificial water features at Tsinghua University. An on-site survey was conducted, followed by spatial analysis and correlation analysis. The research reveals that open views, sufficient resting spaces, freedom of movement, and opportunities to interact with water are strongly correlated with the restorative potential of these spaces. Findings emphasize that the restorative potential of blue spaces is closely tied to their spatial characteristics and functional qualities rather than merely their aesthetic appeal. The study calls for further research into the small-scale blue spaces to offer valuable insights for future design of urban blue spaces.

Keywords: Small-scale blue spaces, restorative effects, spatial characteristics, behavior, water feature

1. Introduction

The rapid global urbanization process and increasing population density pose significant threats to the physical and mental health of urban residents. In this context, cities must optimize the use of limited space to perform diverse functions, thereby creating healthier and more livable environments. Numerous studies have demonstrated that natural environments in urban areas, especially blue spaces, can alleviate mental fatigue (Ulrich, 1984; van den Berg et al., 2003), promote physical activity(Pasanen et al., 2019), foster social interactions (Maas et al., 2009), and ultimately benefiting overall well-being. The restorative potential of blue spaces has consistently been a central focus since the inception of research on restorative environments.

Attention Restoration Theory (ART) serves as one of the foundational theories of restorative environments (S. Kaplan, 1995). Early studies by Kaplan highlighted the strong aesthetic preference for waterscapes due to their sense of order, mystery, and participatory potential (R. Kaplan, 1977). Such preferences may stem from subconscious judgments about the restorative properties of environments (van den Berg et al., 2003). In related studies under Stress Reduction Theory (SRT), Ulrich demonstrated the significant stress-reduction effects of blue spaces through a combination of physiological indicators and semantic questionnaires(Ulrich, 1981). ART and SRT established the theoretical foundation for studying the restorative effects of blue spaces. However, early research primarily focused on natural water bodies, with limited exploration of urban blue spaces. Furthermore, blue spaces were often treated as secondary to green spaces, lacking dedicated studies.

Over the past two decades, advancements in urban landscapes and technology have driven deeper investigations into the restorative effects of blue spaces. Research subjects have expanded from natural waterscapes to urban water features (Deng et al., 2020; J. Luo et al., 2022a; Völker & Kistemann, 2013; White et al., 2010), and methods and perspectives have diversified. While traditional laboratory studies remain mainstream, increasing numbers of scholars are employing field studies using on-site questionnaires (Deng et al., 2020; S. Luo et al., 2023), wearable physiological devices (Huang et al., 2019), and PPGIS (X. Li et al., 2023) to capture more authentic restorative experiences of blue spaces. In defining the characteristics, the extraction of landscape elements has become widespread. Techniques include image semantic segmentation (J. Li et al., 2023; J. Luo et al., 2022b), 3D model construction (Gao et al., 2023; Vassiljev et al., 2020), and semantic analysis of online reviews (Huai & Van de Voorde, 2022). Additionally, some researchers have acknowledged the multisensory characteristics of blue spaces and employed audio-visual interaction methods in their studies (Liu et al., 2022；Gao et al., 2023).

However, large-scale blue spaces, such as oceans, rivers, and lakes, continue to dominate research. Empirical studies on the perceived restorativeness of small-scale blue spaces, particularly artificial water features in urban areas, remain limited. Moreover, research on the restorative effects of blue spaces has mainly emphasized the physical characteristics of landscape elements, overlooking the crucial role of spatial patterns in human perception. Furthermore, reliance on laboratory experiments in such studies impedes the integration of landscape perception with behavior, despite their inherent interconnections.

This study investigated two artificial water features at Tsinghua University to explore the relationship between the restorative effects, spatial characteristics, and human behavior of small-scale blue spaces. The study aimed to address the following questions:

(1) Are there significant differences in restorative effects between the two sites?

(2) What potential correlations exist between restorative effects and the spatial characteristics of the two sites?

(3) What potential correlations exist between restorative effects and human behavior?

2. Material and Method

2.1 Study Sites

The fountain located along the central axis of Tsinghua University’s main building. It is a significant landscape node and one of the most frequently visited blue spaces on campus. The water feature is presented in a highly symmetrical and formal design. The fountain consists of nine nozzles, with a height of approximately 8 meters, and the water cascades into a square pool below, producing a roaring sound. The pool is surrounded by a walking path, and each side of the pool has an opening leading to the surrounding roads. Between the fountain and the roads lies a lawn with tall trees, but the lawn is off-limits to pedestrians, creating a spatial barrier for lingering and resting. This may, however, be in line with the design intention of the fountain, which aims to create a solemn and ceremonial atmosphere rather than a casual, lively recreational space (Figure 1).

The waterfall at the "Lotus Pond Moonlight" is more natural and expansive compared to the fountain. To the south of the waterfall, there is an artificially constructed rockery, with water flowing down and hidden among vines. Because this blue space is separated from the main tourist area by the rockery, it can only be heard from the main path. However, if one follows the sound from the narrow eastern path, it creates a sense of seclusion and intrigue. The pool beneath the waterfall is kidney shaped. It's surrounded by rocks of varying sizes, offering resting spots for visitors. On the opposite side of the waterfall is an open lawn that is accessible to the public, where people often rest and relax (Figure 1).

Figure 1. Current Situation of study sites

2.2 Questionnaire

The survey was conducted over two weekdays and two weekend afternoons in June 2023, between 4:00 PM and 6:00 PM, on clear days. The fountain received 55 valid responses, while the waterfall, being in a more secluded and tranquil setting, received 42 valid responses.

The questionnaire comprised 4 sections. The first section assessed preferences, with respondents rating the statement "I like this place" on a scale. The second section focused on restorative experience, using a shortened version of the Perceived Restorative Scale (PRS), adapted from the full version proposed by Hartig (Hartig et al., 1997). This section evaluated the blue space's sense of Being Away, Extent, Fascination, and Compatibility, with Extent further assessed in terms of scope and coherence (Table 1). The scale used a 9-point Likert system, where 1 indicated strong disagreement and 9 indicated strong agreement. The third section explored the naturalness of the blue space. As literature suggests environments with higher naturalness offer greater restorative benefits (S. Luo et al., 2023; Wang et al., 2021), the study aim to test this conclusion for small-scale blue spaces. The fourth section examined respondents' behavioral intentions through a combination of Likert scales and multiple-choice questions to explore the relationship between behavior and restorative effects.

Table 1. Perceived restorativeness, preference, naturalness, and behavior intentions questionnaire for small-scale blue spaces

Measurement		**Description**	**Scale**
Perceived restorativeness	Being away	This is a place away from daily routine and stress. I can relax myself here.	9-point Likert scale
	Fascination	This place is fascinating. It has a lot of new things that make me want to explore.	
	Coherence	Everything here seems to have a proper place.	
	Scope	There are few hard boundaries here to limit me.	
	Compatibility	I can enjoy myself in this setting and do anything I like.	
Preference		I like this place.	9-point Likert scale
Naturalness		This place is natural.	9-point Likert scale
Behavior intentions		Willingness to stay	9-point Likert scale
		Passing by without stopping. Pausing to observe/listen. Sitting down Walking around the area.	multiple-choice question

Engaging in conversation with others.
Interacting with the water.

2.3 Participants

Over 60% of the participants in the survey were students aged 16-30. The participation rate among middle-aged and elderly individuals was lower, primarily due to a lack of interest in the survey or a reluctance to complete the questionnaire on a mobile device. Overall, the questionnaire response rate was higher at the fountain, likely due to the higher foot traffic and a larger proportion of younger respondents. In contrast, many of the respondents near the waterfall were visitors or residents from the nearby residential area (Table 2).

Table 2. Summary of demographic statistics of sample

Item	Subgroup	n	%
Site1 participants		55	
Sex	Male	31	56.36%
	Female	24	43.64%
Age	16-30	36	65.45%
	31-40	13	23.64%
	41-50	4	7.27%
	51-60	1	1.82%
	>60	1	1.82%
Site2 participants		42	
Sex	Male	20	47.62%
	Female	22	52.38%
Age	16-30	27	64.29%
	31-40	8	19.05%
	41-50	6	14.29%
	51-60	1	2.38%
	>60	0	0%

2.4 Spatial Characteristics Analysis

To standardize the scale of blue space in this study, a 40m * 40m area surrounding the water features was designated for spatial characteristics analysis. We identified 5 spatial elements: water feature, resting space, circulation space, movement barrier, and sightline barrier. The proportions of the first 4 elements were calculated from the plan view, yielding 4 spatial indices: water feature proportion (WFP), resting space proportion (RSP), circulation space proportion (CSP), and movement barrier proportion (MBP). The primary viewing path, located along the road with the highest foot traffic, was used to calculate the sightline openness index (SOI), which is the ratio of the visible range profile length to the total length of the blue space (Figure 2). The results are shown in Table 3.

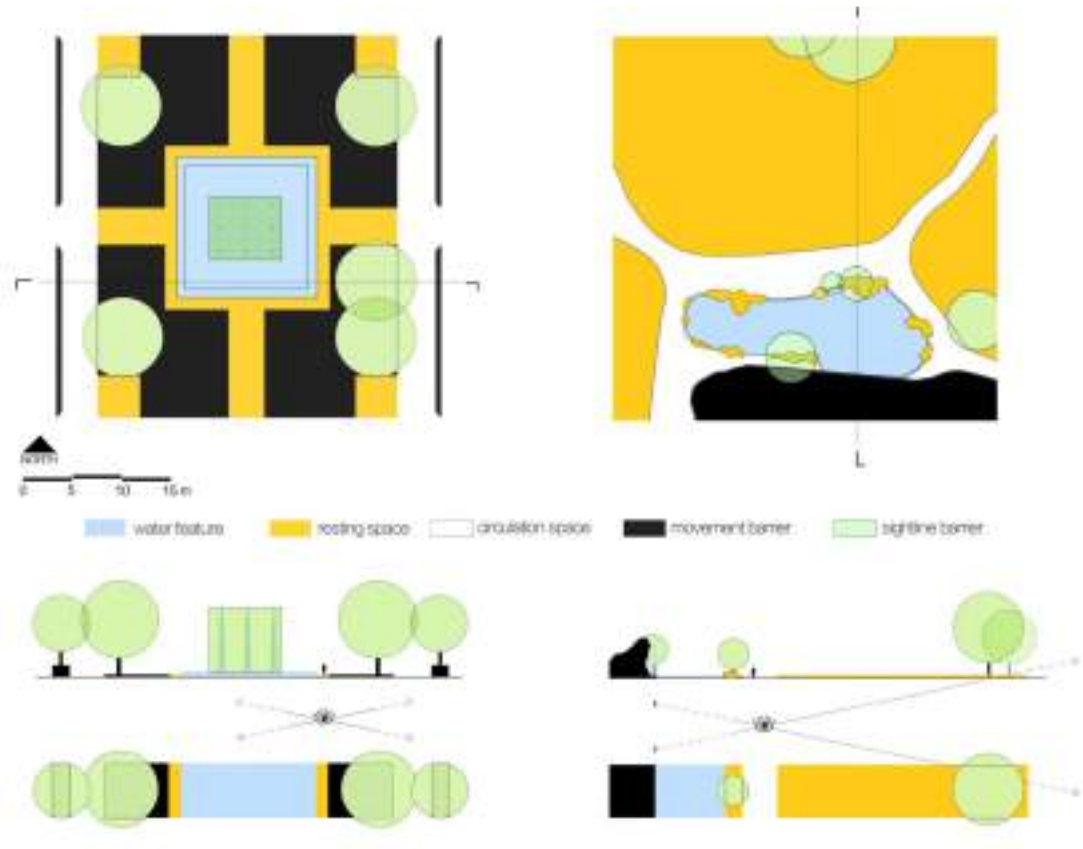

Figure 2. Spatial analysis from plan and sectional perspectives

Table 3. Spatial characteristics of study sites

	WFP（%）	RSP（%）	CSP（%）	MBP（%）	SOI（%）
Fountain	11.4	17.6	25.1	5.9	23.5
Waterfall	9.8	62.1	18.3	8	58.8

3. Findings and Discussion

3.1 Restorative Effects of Small-Scale Blue Spaces

Analysis of 97 completed questionnaires revealed significant differences in the restorative effects of 2 study sites. The average score for the fountain is 6.04 and for the waterfall is 7.24. A comparison of the scores across the 5 restorative dimensions showed that the fountain's scores were lower than those of the waterfall in all aspects. The highest score for the fountain was in the dimension of coherence, which reached 6.67, while the lowest scores were fascination (5.22) and compatibility (5.69). The solemnity and symmetry of the fountain may have been key factors influencing these scores. In contrast, the waterfall scored above 7 in all dimensions, with the highest score in being away (7.62) and the lowest in compatibility (7.02) (Table 4).

Pearson correlation analysis revealed a significant positive correlation between the naturalness and preference of blue spaces and their restorative effects (Table 5). Previous studies have suggested that environments with higher naturalness tend to have stronger restorative effects (S. Luo et al., 2021), and this study partially supports this conclusion. In the case of the fountain, the water feature exhibited strong artificial characteristics, such as exposed nozzles and a blue rubber mat beneath the pool, which detracted from the aesthetic and natural qualities of the landscape. In contrast, the waterfall was relatively untainted by artificial materials, evoking a more authentic sense of natural beauty. During interviews with passersby, some mentioned, "Although I know the waterfall is artificial, it still looks beautiful because such places are too rare in the city."

Furthermore, the willingness to stay was also significantly correlated with restorative effects, preference, and naturalness. Currently, few studies have examined the connection between behavior and the restorative potential of blue spaces, making this an area worth further investigation.

Table 4. Perceived restorativeness, preference, naturalness, and willingness to stay of study sites

Measurement		Fountain (M±SD)	Waterfall (M±SD)
Perceived restorativeness	Being away	6.16±2.19	7.62±1.56
	Fascination	5.22±2.32	7.12±1.78
	Coherence	6.67±1.84	7.07±1.61
	Scope	6.44±2.22	7.38±1.91
	Compatibility	5.69±2.34	7.02±1.96
Total mean		6.04	7.24
Preference		6.80±1.51	7.57±1.63
Naturalness		5.20±2.41	7.45±1.67
Willingness to stay		4.42±2.42	7.62±1.68

Table 5. Correlation analyses of perceived restorativeness, preference for naturalness, and willingness to stay

	Perceived Restorativeness	**Preference**	**Naturalness**	**Willingness to Stay**
Perceived Restorativeness	1			
Preference	0.689**	1		
Naturalness	0.702**	0.514**	1	
Willingness to Stay	0.691**	0.387*	0.543**	1

Note: **p < 0.01, *p < 0.05

3.2 The Impact of Spatial Characteristics and Behavior on Restorative Effects

In the spatial analyses, RSP (17.6% vs. 62.1%), MBP (45.9% vs. 9.8%), and SOI (23.5% vs. 58.8%) significantly differentiated between the fountain and the waterfall, suggesting that adequate resting spaces, freedom of movement, and spatial openness were likely crucial factors contributing to the restorative quality of a blue space.

As for behavioral intentions, six types of behaviors were listed for participants to choose from. The results indicated that for the fountain, the most common behaviors were "pausing to observe/listen," "walking around the area," and "engaging in conversation with others." For the waterfall, the most selected behaviors were "sitting down to rest," "pausing to observe/listen," and "interacting with the water" (Figure 3).

Spearman correlation analysis revealed significant correlations between "passing by without stopping," "sitting down," and "interacting with the water" and the restorative experience in small-scale blue spaces (Table 6). Specifically, "passing by without stopping" was negatively correlated with restorative effects, further confirming that the degree of stayability of a blue space positively influences its restorative impact. Conversely, "sitting down" and "interacting with the water" were positively correlated with restorative effects, indicating the importance of adequate resting facilities and the accessibility of water features for enhancing restorative experiences.

Issues such as the lack of seating and the perceived disconnection between people and water were commonly raised by participants regarding the fountain. While the waterfall offered open lawns for resting, fostering positive interaction between people and the environment. These findings further highlight that the restorative potential of blue spaces is strongly linked to its inherent functional qualities, not merely its aesthetic appearance.

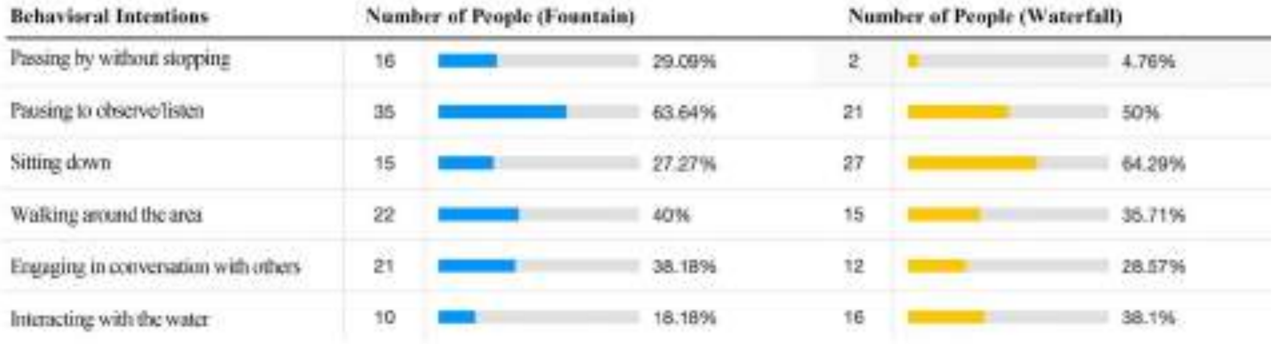

Figure 3. Questionnaire results of behavioral intentions

Table 6. Correlation analyses of perceived restorativeness and behavioral intentions

	PWS	POL	SD	WA	EC	IW
Perceived Restorativeness	-.279**	0.134	.261**	0.103	-0.007	.238*

Note: **p < 0.01, *p < 0.05. Passing by without stopping (PWT), Pausing to observe/listen (POL), Sitting down (SD), Walking around the area (WA), Engaging in conversation with others (EC), Interacting with the water (IW)

4. Conclusion

Large-scale blue spaces such as rivers, lakes, or oceans are not commonly found in urban environments, whereas small-scale blue spaces are relatively more accessible. Therefore, their restorative effects warrant greater attention. This study investigates the restorative effects, spatial characteristics, and behavioral intentions in two small-scale blue spaces through field surveys. It was found that factors such as open views, adequate resting areas, freedom of movement, and the possibility of interacting with water all show strong correlations with the restorative effects of small-scale blue spaces. Future research should pay more attention to landscape characteristics beyond the physical features of landscape elements, further exploring the potential impacts of spatial characteristics and functions. However, this study has its limitations, including a small sample size and an index system that requires further refinement. It is hoped that further exploration of small-scale blue spaces will be conducted, providing systematic and theoretical support for the development of urban blue spaces.

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ENGAGING WITH THE DIGITAL

Comparative Evaluation of Mountain-landscapes in Beijing Based on Social-media Data

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Abstract

An important part of Beijing's ecological pattern, mountain landscapes are also the most important natural tourist destinations in Beijing. The unique mountain environment in Taihang and Yan Mountains attracts Beijing and foreign tourists alike. Tourists publish travel photos and comments on social media, which provides a new opportunity for a systematic evaluation of these mountain parks based on social media data. To fully understand the developmental status of mountain landscapes in Beijing, this paper comparatively evaluates 45 mountain landscapes in Beijing based on social media data. Using big data capture, semantic network analysis, importance-performance analysis (lPA), etc., it explores the composition of tourist groups in mountain parks, the preferences of the tourist groups, and the relationships between park tourists and different influencing factors, and evaluates the recreational experiences of tourist groups. The development of recreational activities was found to be more important to local tourists than scenic sites for foreign tourists. According to gender differences, women were more interested in recreational experiences than men, while men were more interested in the park's landscapes. According to the lPA, tourists were satisfied with the overall recreation offered by mountain landscapes. The perceptual experience was dominated by visual perception, followed by smell; touch, hearing, and taste were of minor importance. Using social media data to analyze mountain landscape resources in Beijing can provide useful insights into the advantages of these landscapes under a variety of site conditions, strengthen local mountain resource development and tourism publicity, integrate tourism management and planning resources in a targeted and attractive manner, and enhance ecological leisure services.

Keywords: Mountain landscape, perceived destination image, social media data, important-performance analysis, tourism sustainability

1. Introduction

The construction of urban forests is an important measure for adapting to China’s national conditions and developmental stage, promoting urban and rural ecological construction, and enhancing residents’ ecological welfare. Beijing, as the capital city, is responsible for the construction of the ecological civilization. In 2020, Beijing formulated the Beijing Forest City Development Strategy (2018-2035). As an important mountain resource in Beijing, Taihang-Yan Mountain also plays an important role in the forest city development strategy. Mountain tourism is an important part of contemporary tourism. Because of their biodiversity, rich environmental resources, and rich history and culture, mountain landscapes can satisfy peoples desire to be close to nature and pursue health, so mountain tourism is playing an increasingly important role in global tourism patterns(Tian & Ming, 2020). The development and use of a mountain landscape are of great significance in the construction of a forest city, so it is necessary to pay more attention to and study them. Research and analysis of mountain landscape resources play an important role in urban development. Mountain landscape tourism resources are important for attracting tourists, and the richness of the landscapes is an important factor in developing them (Kotler, 2018). From the perspective of tourism, many studies focus on factors related to tourist identity, such as gender, age, mode of travel, and so on. However, further empirical research is required to explore how the factors related to tourists themselves influence broader tourism decisions and results. Therefore, studying what landscapes tourists prefer in mountain parks is of great significance in promoting ecological service function and developing mountain tourism.

The arrival of the era of big data has also provided a new opportunity for the evaluation of mountain park landscapes. In recent years, taking users as the research object, research using big data basically focused on four aspects: mobile phone signaling data, satellite positioning, social media data, and photo analysis with geographical location information(Dang et al., 2015; Dang et al., 2018). The development of modern information technology, especially the popular Internet technologies, such as social media, as a platform for the public to obtain information and publish opinions, has a large number of valuable comments on people, events, products, etc. (Zhao et al., 2010), making it an important source of data that can help evaluate personal emotions, perceptions, opinions, and interests (Do, 2019). A large amount of content for evaluation is posted on social media; this data enables textual analysis and sentiment analysis and allows one to study people's preferences for places(Evenson et al., 2016; Liu et al., 2017; Shao et al., 2018).

In short, mountain landscapes play an important role in the construction of Beijing's forest city, the promotion of the functions of ecological services, and the development of related tourism resources; social media data are used to understand the landscape preferences of modern tourists in mountain tourism, identify the differences in landscape evaluations by crowds with different characteristics, and evaluate recreational experiences. The aim of this research is to investigate the demographic characteristics and landscape preferences of tourists visiting the 45 mountain landscapes in Beijing by classifying photos based on the associated text uploaded by users to social media. Through an in-depth semantic network analysis of social media comments published by users, the relationships between the evaluations of the mountain landscapes in Beijing and the demographic characteristics and geographical locations of the users will be identified. In addition, the differences in tourists landscape evaluations based on the different genders and regions will be explored. The landscape characteristics of different mountain systems and 10 administrative divisions are also compared. Finally, through an IPA, tourists satisfaction in terms of (1) recreation provided by the mountain landscapes in Beijing and (2) experiencing these landscapes via the five senses will be analyzed. This study will provide a theoretical basis for the key points and developmental directions of the construction and improvement of mountain landscapes, leading not only to a new research area but also helping policymakers and tourism managers improve the attractiveness of regional tourism. The Taihang-Yan Mountain area of Beijing is of great significance for the sustainable development of mountain landscape resources.

2. Material and Method

Using big data to study tourists behavior is beneficial for the planning and management of tourist attractions, especially in the field of landscape architecture. In this study, we selected

Dianping (https://www.dianping.com, accessed on 10 June 2022), Trip.com Group (https://www.ctrip.com, accessed on 10 June 2022), and Mafengwo (https://www.mafengwo.cn, accessed on 10 June 2022), all of which are the mainstream social media websites for tourism in China. This research is based on the quantitative analysis of photos and evaluation of texts published by tourists on social media. Content analysis is a digital research method for objectively, systematically, and quantitatively analyzing the contents of texts. People upload photos that they like or are interested in on social platforms. Therefore, the contents of the photos were coded and analyzed according to landscape features, and the specific landscape elements that attracted tourists were studied by comparing the frequency of each element. The relationships between various landscape elements and preferences of crowds with different characteristics were analyzed. At the same time, keyword extraction, emotional and semantic network analysis, and IPA were performed on the comments published by tourists on social platforms; then, the differences in landscape evaluations under different factors were explored.

In all, 45 representative mountain landscapes in Beijing were selected as the research objects (Figure 1).The data collected in this paper are from 45 representative mountain landscapes in Beijing (visited on 10 June 2022) that were manually searched on the website of the Beijing Municipal Bureau of Landscaping and Greening. They included national-level scenic spots and representative tourist destinations of Grade 3A or above. From high to low, China’s tourist attractions are classified into five levels, from AAAAA (the highest level) to A (the lowest). After AAAAA and AAAA, AAA (3A) is the third highest level of quality for tourist attractions. In addition, web crawler tools were utilized on Dianping, Trip.com Group, and Mafengwo to crawl for information on the evaluation of the 45 mountain landscapes and photos of the 45 selected mountain landscapes released by tourists. By analyzing users’ evaluative social media texts and uploaded and shared travel photos, tourists’ demand for recreational activities and their landscape preferences can be understood. From the perspective of data content screening, first, the comments adopted were those published by tourists without any commercial activities, and the language that expressed their feelings and emotions was used as the criterion. As mentioned above, tourists’ travel preferences were influenced by gender, mode of transportation, travel mode, and landscape preferences. Therefore, we also collected information about users’ gender, transportation mode, and travel mode. Finally, we eliminated comments with prominent advertising information and copyright marks. The sample period was from January 2021 to June 2022. There were 37,572 photos of the 45 mountain landscapes, totaling more than 2.82 million words. Most of the crawled comments were made between January 2021 and June 2022.A total of 31,367 valid images were obtained from 13,990 users, along with 1,631,972 characters.

(1) Text Analysis

A total of 45 representative mountain scenery spots in Beijing were analyzed based on their average star ratings. In order to highlight the differences between different mountain landscapes, the study utilized the tools of “word frequency analysis” and “social network and semantic network analysis” in ROSTCM6 developed by Wuhan University in order to quantify image data in order to generate a collinear network diagram of keywords in tourists’ comments on parks and scenic spots, further exploring the core factors that affect mountain landscape evaluations. Using a network diagram, the core elements and deep reasons that affected the evaluation of the mountain landscapes were explored further and the correlation between each element and the evaluation was explored using SPSS tools.

(2) IPA Model Building

To further explore the present situation, problems, and development directions of mountain landscapes in Beijing, the importance-performance analysis (IPA) method was used to analyze tourists' satisfaction and experience in terms of the five senses.In the satisfaction survey, the IPA method requires respondents to evaluate the indicators of the designated survey object in terms of importance and satisfaction in order to form the IPA matrix. The IPA matrix takes tourists' expectations(importance) as the horizontal axis, tourists' satisfaction (performance) as the vertical axis and the total average as the separation point of the X-Y axis. The space is divided into four quadrants, and the meanings of each quadrant are as follows: the first quadrant is the area of advantage retention, the second quadrant is the area that can be maintained without too much improvement, the third quadrant is the slow improvement area, and the fourth quadrant is the area that needs to be improved.

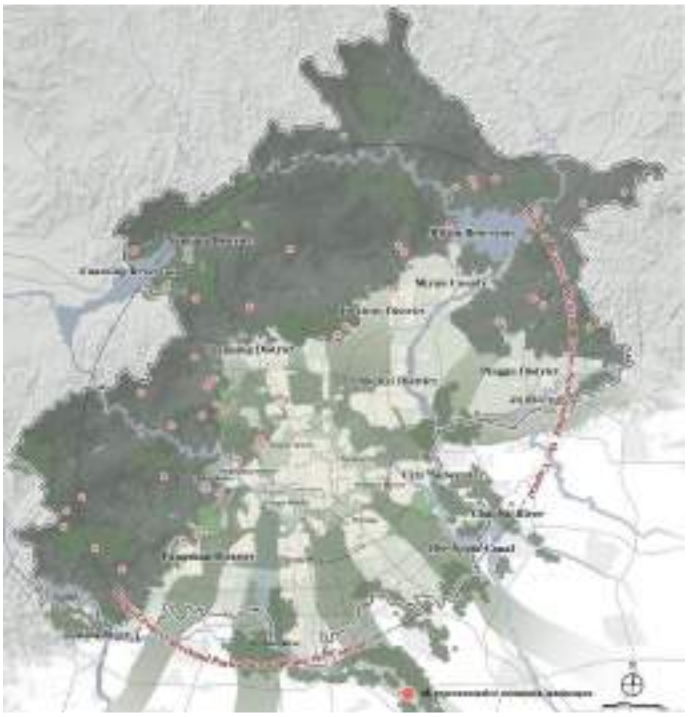

Figure 1. Distribution of the 45 representative mountain landscapes in Beijing.

3. Findings and Discussion

Among the 13,990 users who submitted reviews, there were 2882 men (32.4%) and 6014 women (67.6%). It was not possible to distinguish the gender of the remaining users by using public data. It can be seen that women were keener to share their travel experiences on social media.

From the point of view of the mode of transportation, among the review users, 3485 (94.2%) were self-driving tourists, accounting for far more than walking tourists (16, or 0.4%), subway tourists (62, or 1.7%), bus tourists (115, or 3.1%), and taxi tourists (23, 0.6%). Most tourists chose to travel by car, which is probably related to the unique geographical location and landscape characteristics of the mountains. Self-driving is more convenient for reaching the destination and enjoying the beautiful natural scenery along the route.

From the perspective of travel patterns, among the review users, 56.3% chose to travel with their families and only 1.8% chose to travel with their partners. See Table 1 for a statistical analysis of the tourist groups.

Table 1. Statistical analysis of the tourist groups.

	Type	Quantity	Percentage
Gender	Male	2882	32.4
	Female	6014	67.6
Transportation	Walking	16	0.4
	Using the subway	62	1.7
	Using a bus	115	3.1
	Using a taxi	23	0.6
	Using a self-driven vehicle	3485	94.2
Travel mode	Alone	417	12.1
	With friends and classmates	1025	29.8
	With family	1937	56.3
	As a couple	65	1.8
Family	Had children	946	48.9
	Had an elderly person	68	3.5
	Had both children and elderly people	120	6.2
	Had other relatives	803	41.4

Table 2 presents an analysis of the images shared by people of different genders; men preferred physiographic landscapes, followed by biological landscapes and buildings and facilities, while women preferred water landscapes, followed by astronomical and climatic landscapes and cultural activities. From the perspective of humanistic activities, compared to men, women showed a greater preference for recording their personal activities during travel.

Table 2. The frequency with which landscape types were visited by each gender.

Types of Landscape Resources	Number of People		Number of Photos		Average Value	
	Male	Female	Male	Female	Male	Female
Physiographic landscape	894	1993	2663	4576	2.98	2.30
Water landscape	345	837	848	2185	2.46	2.61
Biological landscape	501	1094	1284	2446	2.56	2.24
Astronomy and climatic landscape	77	175	180	440	2.34	2.51
Buildings and facilities	826	1674	2109	4091	2.55	2.44
Historical sites	153	313	299	520	1.95	1.66
Tourist purchases	30	61	46	81	1.53	1.33
Cultural activities	56	205	108	506	1.93	2.47

To further understand tourists preferences for recreation types and feelings regarding Beijing's mountain landscapes, word segmentation and word frequency analysis were performed by using ROSTCM6 to evaluate the texts of the review users.The authors of this study extracted the texts of positive reviews by users for semantic network analysis and generated a positive semantic network diagram (Figure 2). The texts of negative user evaluations were also extracted for semantic network analysis, and a negative semantic network diagram was generated (Figure

3). The nodes represent high-frequency vocabulary elements, and the density of connections between elements represents the co-occurrence frequency. The factors of positive evaluations of the mountain landscape were mainly reflected in the beautiful scenery, suitability for outings, traffic accessibility, recreational facilities, and parent-child experiences. The negative factors of the evaluations were mainly reflected in tickets, transportation, infrastructure, and park management services. Although the overall evaluation of the mountain landscape is high, it does not necessarily imply that the parks are well-managed. The management of a forest park involves many complex aspects that are not readily apparent to the public. Negative feedback recorded on social media indicates that tickets, transportation, infrastructure, and park management services may not need to be improved, rather, the meaning implies that the management mode may need to be reviewed.

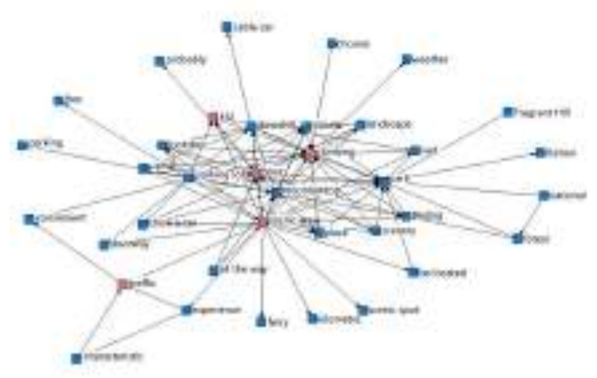

Figure 2. The semantic network of positive evaluations.

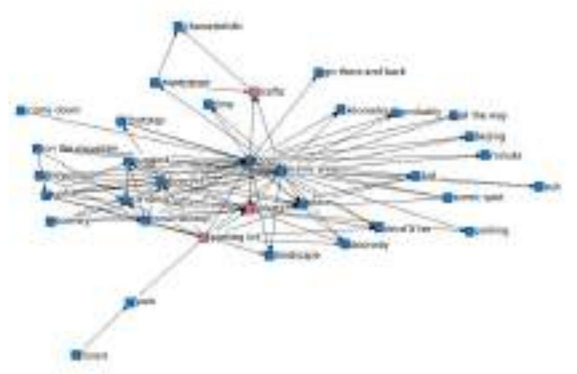

Figure 3. The semantic network of negative evaluations.

According to the semantic network analysis of textual data from people of different genders (Figures 4 and 5), male users mainly focused on mountain climbing, infrastructure, and traffic accessibility, and female users paid more attention to the scenic quality, scenic environment, convenient transportation, recreational activities, parent-child experiences, and infrastructure. It can be seen that women paid more attention to recreational experiences than men did.

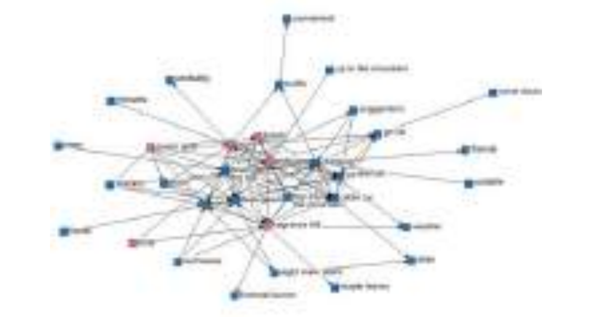

Figure 4. The semantic network of males' evaluations.

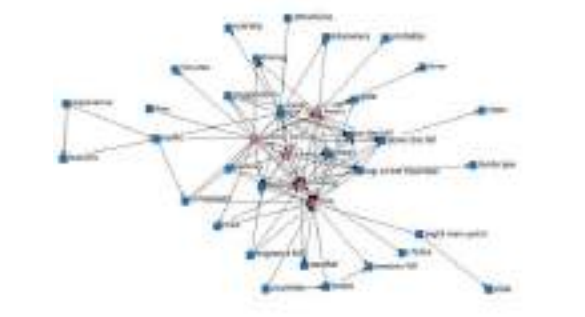

Figure 5. The semantic network of females' evaluations.

In a comprehensive IPA of tourists satisfaction in terms of recreation in mountain landscapes in Beijing (Figure 6), most of the indicators were concentrated in the first and second quadrants, indicating that tourists overall satisfaction with the mountain landscapes was high. The mountain landscapes were shown to have greater advantages in terms of natural landscapes, plant landscapes, outdoor recreational activities, parent-child experiences, and emotional experiences, but public service facilities, traffic accessibility, ticket cost, and park management services needed to be improved.

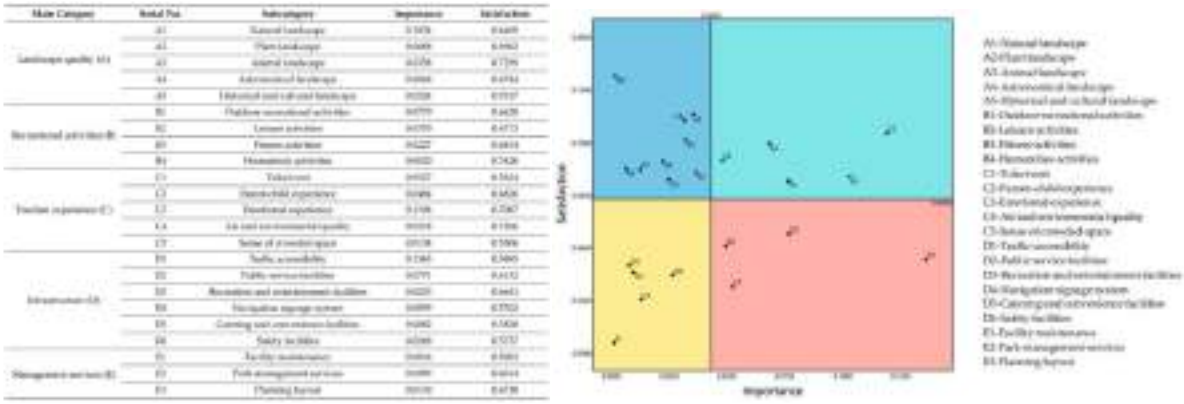

Figure 6. Comprehensive IPA of satisfaction in terms of recreation.

The IPA (Figure 7) of mountain landscapes in different mountain ranges showed that tourists were more satisfied with the overall recreation offered by the mountain landscapes in the Taihang Mountains than those offered by the Yan Mountains. Tourists loved the mountain landscapes in the Taihang Mountains in terms of plant landscapes and outdoor recreational activities, while the mountain landscapes in the Yan Mountains were more distinctive in terms of historical and cultural landscapes and leisure activities. In terms of traffic accessibility, public service facilities, ticket cost, and park management services, there was a need for further strengthening and improvement of the facilities. The plant landscapes and the outdoor recreational activities offered in the Yan Mountains had higher importance but a lower satisfaction rating than the average. Therefore, the mountain landscape in the Yan Mountains needs to be improved.

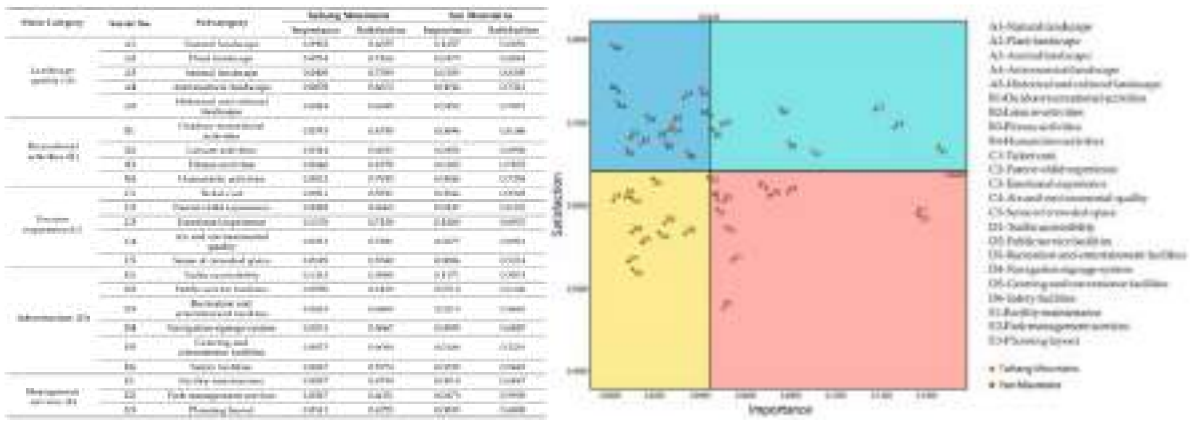

Figure 7. IPA of satisfaction with recreation in different mountain systems.

A comprehensive IPA of the experiences of tourists in the mountain landscapes in Beijing in terms of the five senses (Figure 8) showed that most of the indicators of the five senses were concentrated in the second and third quadrants, implying that tourists did not pay much attention to the overall sensory experience of the mountain landscapes, and the overall satisfaction of the tourists was high in terms of sight, smell, and touch, but low in terms of taste. Visual and olfactory landscape elements–such as visibility of plants, visibility of animals, landscape recognizability, and smell of air/water–in the first quadrant can continue to be developed; visual and taste elements–such as visibility of natural landscapes, visibility of roads, and food sales–in the fourth quadrant need to be improved and enhanced; and auditory and tactile landscape elements–such as the sounds of plants, sounds of animals, feel of sunlight, feel of water, and touch of the road–in the third quadrant need to be gradually improved.

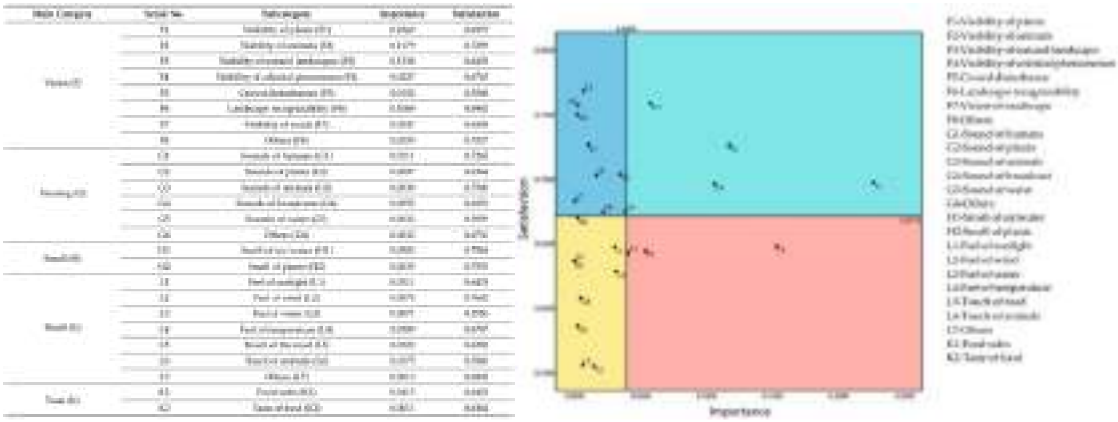

Figure 8. Integrated IPA of the experience of the five senses.

For the landscapes of different mountain ranges, the IPA (Figure 9) showed that, similarly to the conclusion regarding tourists satisfaction with recreation, tourists satisfaction with the mountain landscapes in terms of the five senses was higher for the Taihang Mountains than for the Yan Mountains. The Taihang Mountains were characterized by the visibility of plants, the visibility of animals, landscape recognizability, the smell of air/water, and other visual and olfactory landscape elements that were highly valued, while the tourists in the Yan Mountains attached more importance to the visibility of natural landscapes, landscape recognizability, the visibility of roads, smell of air/water, and the feel of temperature, as well as other visual, olfactory, and tactile landscape elements. That is, tourists in both mountain landscapes attached more importance to visual and olfactory sensory feelings. In terms of sensory elements in urgent need of key improvement, for the Taihang Mountains, more attention should be paid to improving the visibility of natural landscapes, the visibility of roads, and food sales, and for the Yan Mountains, more attention should be paid to the visibility of plants, the visibility of animals, and food sales. Thus, it is clear that both need to improve the sensory experiences of vision and taste.

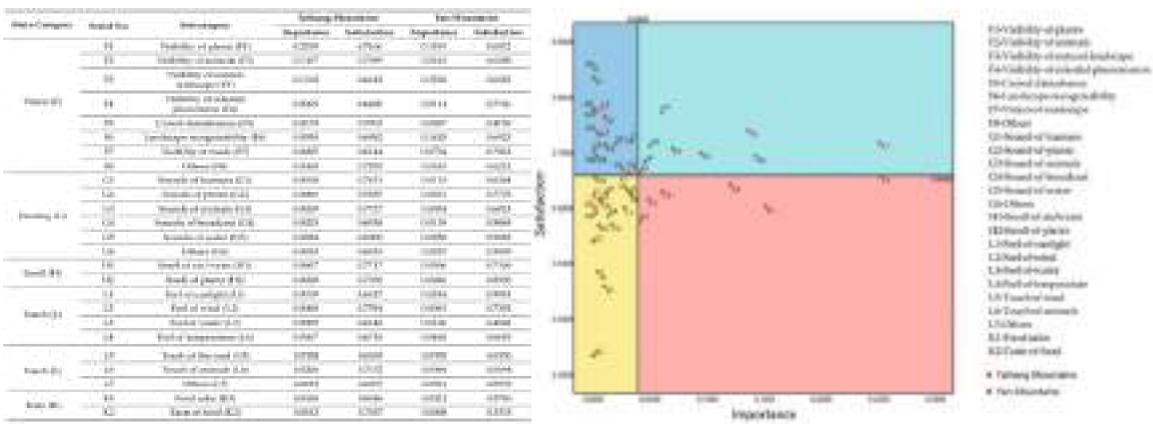

Figure 9. IPA of the experiences of different mountain systems in terms of the five senses.

4. Conclusion

This study investigated the demographic characteristics and landscape preferences of tourists visiting the mountain landscapes in Beijing by classifying photos based on the associated text uploaded by users to social media. In this study, more tourists in mountain landscapes chose a self-driving mode of transportation, which was closely related to the geographical locations of the mountains in the urban countryside. In terms of travel mode, they preferred to travel with friends, classmates, or family members. Regarding landscape preferences, geographical landscapes, buildings, and facilities were the most preferred, followed by biological landscapes and water landscapes; the interest in tourist purchases was the lowest. Tourists landscape preferences were related to their gender, transportation mode, and travel mode. Men’s perception of landscapes was more direct, and they were more inclined toward geographical landscapes and biological landscapes, while women were more emotional, preferring to record the beautiful scenery and personal activities during the trip. The influence of different transportation modes on landscape preferences is not obvious, and the difference is small. Tourists who traveled with friends and classmates preferred astronomical phenomena, climatic landscapes, and tourist shopping. Compared to other sources, the three sources selected in this paper are more representative and provide more images with evaluative significance. The images presented in guides and blogs tend to be more illustrative. For the purpose of studying tourist destination imagery, prescriptive, evaluative, and normative components are valuable conceptualizations. The present study employs both quantitative and qualitative methods of analysis in a quasi-empirical manner. Using this hybrid approach, factual results based on sample data can be developed alongside interpretive results intended to enhance conceptual understanding. As a result of this study, important scientific and practical implications are generated in terms of theoretical frameworks, techniques, and insights, providing a theoretical basis for the key points and developmental directions of the construction and improvement of mountain landscapes.

A comparative evaluation of Beijing’s mountain landscapes based on social media data can provide comprehensive information on the advantages of mountain landscapes, thus promoting their development and the construction of a forest city. Accommodation facilities, however, remain an important tourist resource that should be considered. An analysis of tourists landscape preferences can help the government and managers of scenic spots manage, plan, and promote tourism in a more targeted manner. The analysis of tourists’ evaluations can help managers grasp the current situation, advantages, and disadvantages of scenic spots and decide quickly and intuitively on a developmental direction. These data are of great significance for the planning, design, construction, development, and management of different mountain landscapes and can help the government and managers analyze the advantages of local landscape resources, make up for the shortcomings, improve the service level, and environmentally improve the park and landscape quality according to the aesthetic preferences of different tourist groups, making Beijing’s mountain landscapes more attractive for sightseeing and enhancing their competitive advantage in the future.

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Revealing Scene Preferences for Recreation Based on Social Media Data

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Abstract

In the process of rapid urbanization, the use of parks after the epidemic has become a new issue that needs to be explored urgently, which can provide a reliable basis for the implementation of the policy. Social media data can inform decision-making in response to rapid changes in the demands and preferences of green space. Taking Chaoyang Park in Beijing as an example, this paper studied the scene preferences for recreation based on Rednote social media data. We have developed a method to combine image and textural data through topic analysis and image coding. Through the random forest, the contribution of different landscape elements to the selection of activity scenes was discussed. Landscape appreciation and picnicking are the most popular recreation behaviors. In the selection of activity scenes, people prefer scenes with kinds of landscape elements, such as mixed scenes of grass, water bodies, and built area. This study uses social media data to identify changes in public demand for green space, allowing for timely adjustments to green space strategies in high-density cities, particularly after the epidemic.

Keywords: Outdoor recreation behaviors, social media data, city park, urban green space;

1. Introduction

The frequency and quantity of visits to green space in parks by citizens have increased during the pandemic, resulting in a shift in usage patterns. Understanding the connection between newly emerging outdoor recreation and green space in parks is essential for human well-being (Geng et al., 2024). Previous research on park use and construction focused on assessing park quality and fairness (Liu & Xiao, 2020). Few researchers concentrated on specific landscape preferences that corresponded with various activities (Yang et al., 2023). To meet public expectations for parks after the pandemic and align with current park management, it is necessary to study the new patterns of recreation and landscape preference from the user perspective. However, qualitative approaches such as interviews and questionnaires have limitations regarding location and time (Talal, Santelmann, & Tilt, 2021). Social media data, with its abundance of information and accessibility, can compensate for the shortcomings of traditional data and offer rich study opportunities (Tarashkar, Hami, & Namin, 2020). Combining text and visual data from social media provides a comprehensive view of green space usage, reflecting varied information. However, merging text and image data for analysis is challenging due to discrepancies between the two data sets (Chen et al., 2024).

To address the aforementioned research gaps, we investigated new green space usage patterns by combining textual and visual data from LittleRedBook (LRB) social media. We use Chaoyang Park, Beijing's most popular urban park, as a case study to gauge public landscape preference between different activities, thereby supporting the construction of parks.

2. Material and Method

Case study

Chaoyang Park in Beijing was the focus of our investigation. With a total planned area of 288.7 hectares, including 68.2 hectares of water and 87% designated as green space, Chaoyang Park is the largest urban park in Beijing. Additionally, Chaoyang Park is the most popular park on social media, providing a wealth of data to support research.

Research framework

The study was conducted in three parts. First, we collected social media data from the LRB platform. The LRB application's programming interface (API) was used to gather data about outdoor activities in Chaoyang Park using keywords. Through this process, we created corresponding text and image databases. Second, we processed text and image data separately. Thematic analysis was used to extract textual information and identify activity categories. We referred to the leisure experience classification by Olafsson and Anton and adapted it to the specific characteristics of Chaoyang Park to categorize leisure behaviors into seven categories. For image data, grounded theory was applied to identify and extract landscape elements and scenes. The image information was converted into text through three-level coding, resulting in ten landscape categories. Finally, we combined the text and image information for each item to determine public landscape preferences for different outdoor activities. Using the random forest algorithm, we calculated the contributions of landscape elements and scenes to various activity categories.

3. Findings and Discussion

Finally, we collected a total of 436 notes and 2,564 pictures of outdoor activities in Beijing's parks from February to September 2023. From these notes, we identified 736 activity entries and 1,551 valid pictures.

Characteristics of social media text data

We identified 736 activity entries through text information (Figure 1). In terms of the number of activities, the most popular activity is picnicking (182), accounting for 24.73% of all samples. This is followed by landscape appreciation (163). Gathering activities are the least popular (30). Regarding the number of pictures, landscape appreciation is the category with the most pictures, followed by picnicking (340), feeling of nature (288), and camping (248). The monthly distribution shows that most activities increased significantly in May and June.

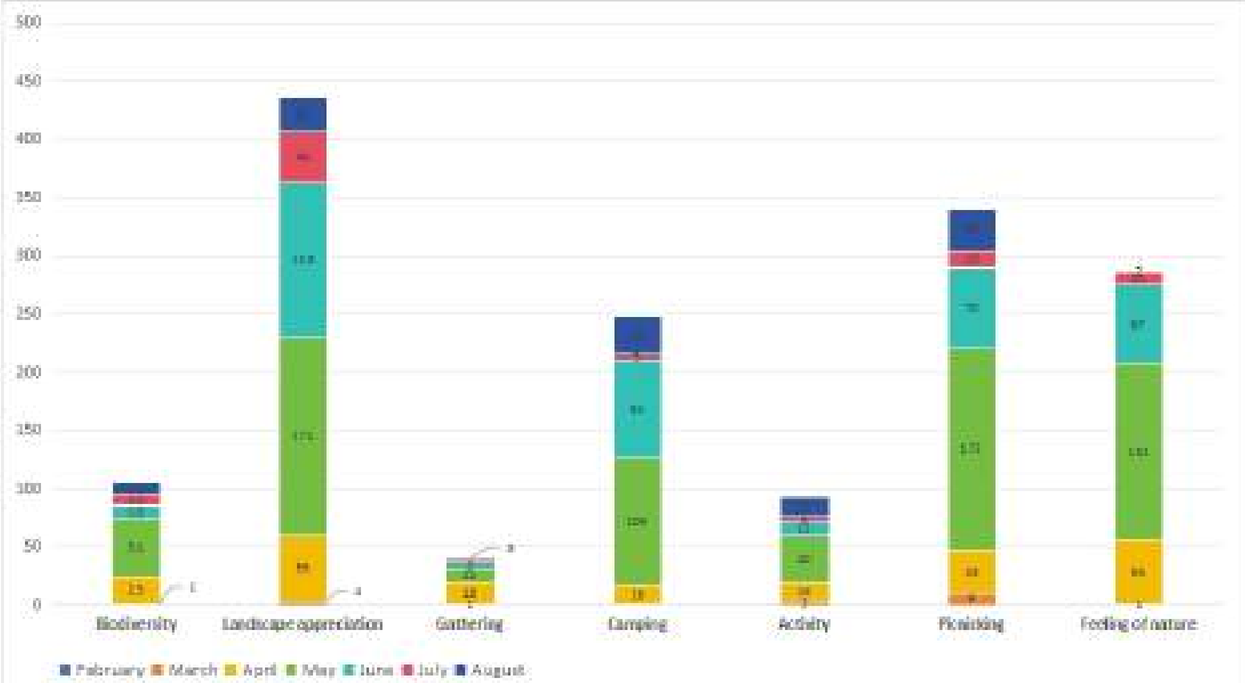

Figure 1. Typology and numbers of recreation behaviors.

Characteristics of social media image data

We identified the distribution of landscape elements and scenes in 1,551 valid photos through image analysis. According to the statistical results, forests (34.68%) are the most common landscape element, followed by lawns (25.08%) and water (16.77%). Bare land is the least common, accounting for only 0.34%. Regarding landscape scenes, mixed scenes are the most common (33.02%), followed by forests (25.27%) and lawns (20.24%). Pavement is the least common scene type, making up just 0.27%.

Landscape preferences for different behaviors

Overall, in the identification of activity elements, the forest element has the most significant influence across all recreational behaviors, followed by lawn, while bare land has the smallest proportion. Notably, in biodiversity activity, the "bushes and flowers" element is particularly prominent. The water element is most prevalent in picnicking activities and least prevalent in gathering activities (Figure 2).

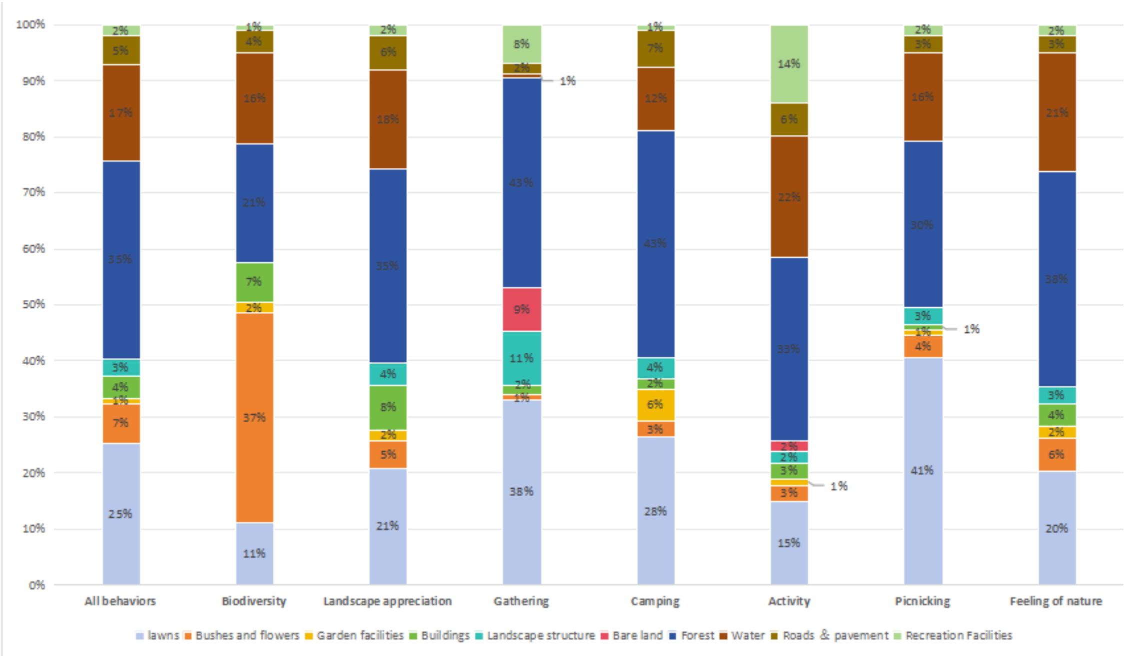

Figure 2. Typology and numbers of landscape elements.

In the association between recreational behaviors and landscape scenes, it is evident that different activities tend to prefer mixed scenes with rich landscape elements, such as combinations of lawns, water, and built elements. Additionally, people generally prefer natural element landscapes like forests and lawns. Specifically, in diversity activities, bushes and flowers scenes are the most common, followed by water, forests, and mixed scenes. In landscape appreciation activities, mixed scenes are the most preferred, followed by forests, water, and lawns (Figure 3).

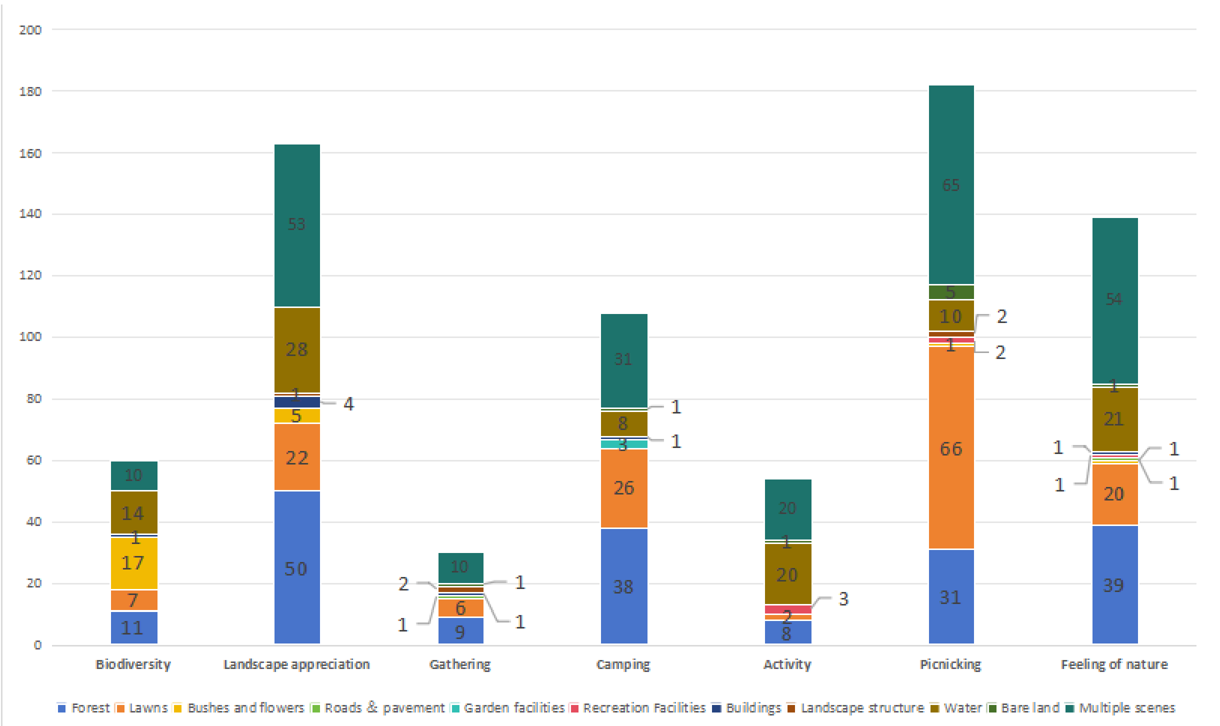

Figure 3. Typology and numbers of landscape elements.

The meaning and the limitations of the study

In this study, our approach facilitates the in-depth mining of social media information. Unlike previous studies that used either pictures or text alone, we integrated image and text data in the same dimension through image coding, effectively combining the two data types. This study also complements existing research on landscape preferences by exploring differences in preferences for various activities, opening new possibilities for park studies.

The results indicate that leisure activities prefer rich natural landscapes with minimal artificial intervention, where the most artificial elements are activity facilities provided by the venue. The landscape scene needed for different activity types varies significantly. This finding suggests that park green space management should create differentiated landscapes tailored to specific activities to meet public expectations for green spaces. Such differentiation can improve the utilization rate of park space and prevent the conflict between management and actual use.

However, the research has certain limitations. The manual process of image coding, while collecting extensive information, is time-consuming and requires further refinement.

4. Conclusion

We conducted a study to investigate patterns of public recreation behavior in urban parks by integrating social media data from text and images. The results revealed the distribution of various recreational outdoor activities in Chaoyang Park. Additionally, the study examines the contributions of different landscape elements to various types of activities, highlighting differences in landscape preferences among these activities. Significant differences in activity frequency were observed, with picnicking being the most popular leisure activity, followed by landscape appreciation and feeling of nature.

Integrating social media text and image data proves effective in exploring people's landscape preferences during leisure activities, thereby enhancing the potential for park research. This study offers a comprehensive understanding of recreational behavior in parks from the public's perspective, aiding managers in understanding post-pandemic changes in public behaviors. It also helps reconcile the conflict between public accessibility and the actual utilization of green spaces, ultimately aiming to maximize public health and well-being.

Note

Some sections of this article, along with subsequent research, are currently under review in Landscape Architecture Frontiers.

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Visual Landscape Management Strategies and Mountain Protection

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Abstract

China has an extensive past, a vast land, and diverse natural environments. Man and nature have, over time, co-created varied regional landscapes with varying building practices and regional cultures. Nonetheless, rapid urbanization has devastated both the national and regional landscapes. The agricultural system and countryside dominate current regional landscape research. These landscapes have no solid connection to urbanization. However, The regional mountain landscape encompasses numerous aspects of the regional landscape system and has tight ties to urban spatial form. This study investigates methods for restoring this link in the face of urbanization. This research takes visual space as the entry point because visual space is the medium through which individuals can most easily perceive the city and is also an essential link in urban analysis. Therefore, exploring the mountain landscape's visual characteristics is of great significance.

This research proposes a visual analysis method for comprehensively analyzing urban visual characteristics to establish visual management strategies for mountainous city regional development. This type of visual analysis employs multiple digital technologies and multi-scaled studies. The proposed method could quantify visible urban spaces, thus assisting in decision-making. This study utilizes GIS, LiDAR, and other digital technologies to examine urban mountain visual landscapes objectively. Quantitative analysis uses multidimensional digital models with multiple dimensions, including 2D and 3D urban models. The proposed method can quantify the optical properties of large, medium, and micro-scale urban environments, thereby revealing their inherent visual patterns. Develop an algorithm for visibility analysis with LiDAR point clouds and solid vector models. The hybrid model-based visibility method evaluates the visual impact of urban vegetation. The case of Fragrant Hills, Beijing, is selected for further investigation. The proposed method was conducted in this case to analyze the visual properties of Fragrant Hills and the urban open spaces visible in the Fragrant Hills. This research will integrate Beijing's existing planning, apply GIS and LiDAR to the visual landscape mapping of Beijing Fragrant Hills, test the practical effect of Beijing's mountain landscape protection, and ultimately optimize strategies.

Keywords: Landscape architecture, regional landscape, visual landscape, cultural heritage, digital landscape

1. Introduction

China's long and diverse history is reflected in its extensive natural environments and the regional landscapes formed by the interaction between man and nature. However, rapid urbanization over recent decades has disrupted these traditional landscapes, particularly in areas where agricultural and rural settings have predominated in scholarly research (Chen & Wei, 2008). Urban development has gradually decoupled the natural mountain landscapes—once integral to regional identity—from the urban spatial form. In metropolitan areas such as Beijing, where significant cultural and natural resources are at stake, the protection of mountain landscapes like Fragrant Hills has become a strategic priority.

Urban visual space, as the primary medium through which individuals perceive their surroundings, is critical in evaluating and managing urban aesthetics (He & Hu, 2022). The visual quality of urban landscapes not only influences the lived experience of residents but also reflects the underlying cultural heritage and ecological sustainability of a region. Recent advances in Geographic Information Systems (GIS) and Light Detection and Ranging (LiDAR) technologies provide novel opportunities to quantify and analyze visual characteristics of complex urban environments (Llobera, 2003). This study proposes a comprehensive visual analysis methodology that integrates these digital tools with multi-scaled modeling techniques to assess the visual impact of urban vegetation and built structures, using Fragrant Hills in Beijing as a case study.

2. Material and Method

This research employs a multidimensional approach that integrates GIS, LiDAR, and digital modeling techniques to analyze urban mountain visual landscapes quantitatively. The methodology is structured into several phases:

2.1. Digital Data Acquisition and Modeling

A combination of GIS datasets, digital elevation models (DEMs), and high-resolution LiDAR point clouds is used to construct both 2D and 3D representations of the study area. The hybrid point cloud–solid vector model is developed to capture detailed spatial information necessary for accurate visibility analysis. LiDAR data, organized into different levels of detail (LoD), compensates for the limitations of traditional 2D or 2.5D models (Ruiz, 1997; Zhao et al., 2020).

2.2. Visibility Analysis Algorithm

The core of the analysis is based on a raster data model, where the urban space is divided into a pixel matrix that stores elevation and visual information. The visibility analysis is conducted using a custom algorithm that combines LiDAR point clouds with solid vector models to compute line-of-sight from multiple observation points. This hybrid model evaluates not only the built environment but also the visual impacts of urban vegetation, a factor often neglected in previous studies (Saeidi et al., 2019).

2.3. Quantitative Visual Indices

Two categories of visual indices are defined to characterize urban visual spaces:

Scalar Visual Indices: These indices describe horizontal visual characteristics such as visual exposure, which is calculated using line-of-sight analysis to determine the proportion of a target visible from an observer's standpoint (Fisher, 1991, 1992; Westervelt, 2004).

Vector Visual Indices: These indices capture the geometric and perceptual aspects of the urban skyline, including measures of spatial openness and perceived saliency. Visual openness is defined as the proportion of sky visible within a given field of view, which serves as an indicator of spatial quality and psychological comfort (Christopherson & Guertin, 1996; Lake et al., 1998).

2.4. Case Study: Fragrant Hills, Beijing

The Fragrant Hills area in Beijing is selected as the empirical case for testing the proposed methodology. LiDAR point cloud data and GIS-based mapping are applied to generate a detailed visual landscape model. The analysis examines various visual indices at multiple scales, thereby providing quantitative results that inform urban planning and mountain protection strategies.

3. Findings and Discussion

3.1. Multi-Scale Assessment of Visual Characteristics

By analyzing the Fragrant Hills region at large, medium, and micro scales, the study revealed how changes in terrain, vegetation, and building density impact the overall visibility patterns. On a large scale, the method demonstrated apparent variations in skyline profiles when observing the city from key viewpoints near Fragrant Hills. The vector visual indices—particularly skyline contour and visual openness—highlighted how increasing building height restricts mountain views, thus emphasizing the need for stringent height control within specific corridors (He & Hu, 2022).

At the medium scale, the hybrid model facilitated a detailed examination of visibility around significant transportation arteries and open spaces. Results showed that the interplay between tree canopies and mid-rise structures creates both pockets of visual enclosure and open vista points, which can be strategically managed to preserve key sight lines of mountain peaks. Remarkably, the LiDAR-based vegetation data identified canopy volumes that significantly occluded views of ridgelines. These findings underscore the role of precise vegetation management in balancing ecological value and scenic quality (Ruiz, 1997).

At the micro-scale, the proposed visibility algorithm helped quantify visual quality in pedestrian zones, parks, and residential areas that interface directly with the mountainous backdrop. Evaluations of scalar indices (such as visual exposure) revealed that slight variations in elevation or building setbacks could dramatically shift the percentage of mountain views accessible at street level. These fine-grained insights can inform micro-level urban design interventions, including street tree placement, building setback adjustments, and public space orientation.

3.2. Visual Impact of Urban Vegetation

One of the innovative aspects of this study was assessing urban vegetation's impact on visibility. Existing research on urban visual space often focuses on buildings or other infrastructure while overlooking the substantial effect of green cover (Saeidi et al., 2019; Zhao et al., 2020). By integrating LiDAR point clouds into a hybrid 2D–3D model, this research calculated how the canopy structure occludes or reveals sight lines to Fragrant Hills.

The findings indicate that different tree species (and thus canopy shapes) exert varying degrees of visual obstruction. Taller tree species, such as mature coniferous stands near key pathways, were found to obscure 10% to 15% more of the mountainous skyline than shorter ornamental trees. This quantitative result reinforces the importance of using suitable plant species and targeted pruning to maintain crucial mountain views—an essential strategy for balancing ecological and visual objectives.

3.3. Integration with Existing Urban Plans and Height Control Guidelines

Beijing's existing urban plans include guidelines for controlling building heights and maintaining strategic view corridors (Chen & Wei, 2008; He & Hu, 2022). The GIS and LiDAR analyses provide robust, empirical data that can be mapped directly onto these frameworks. By overlaying the visibility metrics onto current zoning maps, planners can refine existing regulations by pinpointing the specific parcels where height restrictions need to be upheld or even intensified.

Moreover, this integrated approach clarifies the real-world implications of plan implementation. For instance, some areas designated for moderate building heights were found to severely impact mountain views due to topographic factors not fully accounted for in the original plan. Identifying these discrepancies can guide more nuanced policy amendments that better protect iconic natural features like Fragrant Hills.

3.4. Socio-Cultural Dimensions and Public Engagement

The analysis also carries socio-cultural significance. Many residents value the connection to Beijing's historical and natural landmarks, and urban development that diminishes these views could elicit adverse public reactions. Providing a quantitative basis for decision-making enables more transparent discussions with local communities. Public input sessions, aided by visual simulations rendered from LiDAR data, can foster consensus around trade-offs between development density and mountain view preservation (Chen & Wei, 2008).

3.5. Limitations and Future Directions

While the proposed methodology successfully quantifies urban visual properties, several limitations remain. First, the accuracy of LiDAR-derived models depends heavily on the resolution and recency of the data. Rapid urban changes may require frequent re-surveys to keep visibility analyses current. Second, the hybrid algorithm focuses on static visual assessments, whereas dynamic factors—such as seasonal changes in foliage density and variations in daily lighting conditions—are not fully integrated. Future research could explore integrating real-time sensor data and incorporating temporal variations to provide an even more comprehensive picture.

Furthermore, although this study centers on mountainous urban landscapes, the methods may be adapted for coastal or riverine cities with similarly unique topographies. Comparative studies across different cities and landscapes could yield broader theoretical insights and help refine best practices in visual management strategies worldwide.

4. Conclusion

This study has developed and tested a novel, multidimensional methodology for the quantitative analysis of urban visual landscapes, with a special focus on mountain protection in rapidly urbanizing contexts. By combining GIS, LiDAR, and advanced digital modeling techniques, the research demonstrates that it is possible to objectively measure and manage the visual characteristics of urban environments in ways that account for both built infrastructure and natural elements like vegetation.

In the case of Fragrant Hills in Beijing, the methodology has shown how topography, buildings, and vegetation collectively shape public views of significant natural landmarks. The findings confirm that strategic vegetation management, building height controls, and public engagement are crucial to preserving cultural and environmental heritage in the face of ongoing urban expansion. The detailed visibility metrics generated—ranging from scalar measures of exposure to vector analyses of skyline composition—can be readily integrated into existing urban plans, offering a robust empirical foundation for regulatory decision-making.

In sum, the practical implications of this work are substantial. Beyond guiding local planners in Beijing, the approach serves as a template for other cities aiming to reconcile urban growth with landscape protection. Methodologically, the study provides an adaptable framework that future researchers can refine by integrating real-time data, temporal variability, and multi-criteria decision models. As such, these findings underscore the importance of high-quality digital tools and community-centered policy in shaping resilient, visually engaging urban spaces that preserve their essential connection to natural and cultural heritage.

Note

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Generating Parks from Satellite: A Fully Automated Al Design Workflow

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Abstract

The development of AI-driven generative design is progressing rapidly, but two main research gaps exist: 1) most studies focus on the relationship between design elements and neglect external site information, and 2) GANs and other traditional generative algorithms produce low-resolution, detail-lacking results. To address these issues, this study integrates GANs with Stable Diffusion, a multimodal large-scale image pre-training model, to create a full-process park generative design method. The method involves three steps: 1) Building a high-precision remote sensing object extraction system for automatic extraction of urban environmental data; 2) Using GANs to create a park design generation system based on external environment data, enabling rapid generation of design schemes from this data; 3) Employing Stable Diffusion to optimize the design plan, adding details and increasing the resolution by 64 times. This approach allows for a fully automated design process without human intervention.The research results show that: 1) The relationship between the inside and outside of the site will affect the algorithm generation results. 2) Compared with traditional GAN algorithms, Stable diffusion significantly improve the information richness of the generated results.

Keywords: Landscape architecture, generative design, generative adversarial networks, digital landscape.

1. Introduction

Urban green spaces, especially parks, are essential for livability, sustainability, and urban services. Traditional park design relies on professional experience, leading to inefficiency and limited options. The introduction of Generative Adversarial Networks (GANs) in 2014 by Goodfellow et al. (2020) has improved the creative potential of park design by enabling rapid generation of diverse designs and supporting early-stage design adjustments, benefiting urban planning.

Park design is a complex and technical task, divided into two main categories: solving design problems based on site constraints and expressing designs in standard drawings. In the first category,Chen et al. (2023) developed an automatic GAN-based design system for small and medium-sized parks. However, most research ignores the impact of external environmental factors, which are crucial for park design. In the second category, Zhou & Liu, (2021) achieved rapid land use classification generation, but the results still lack precision for final scheme presentation.

Deep learning methods, such as convolutional neural networks, are widely used for environmental feature extraction, but their application to park external environment data is underexplored. This paper proposes a GAN-based design system focused on the "external environment-layout-scheme" framework to address these gaps. The system operates in two stages: first, generating layouts with practical constraints, then enhancing them using stable diffusion technology for improved visual results. Key contributions include: (1) Creating a "remote sensing-layout-scheme" dataset for park design; (2) using GANs to incorporate external environment elements and generate optimized layouts; (3) Enhancing design visuals with stable diffusion technology; (4) comparing learning modes to showcase the system's effectiveness in generating high-quality layouts.

2. Relevant Work

2.1 GAN-based generative design research

Generative adversarial network (GAN) was proposed by Ian Goodfellow in 2014 (Goodfellow et al., 2020),and consists of two components: a generator and a discriminator. TThe generator aims to create samples that pass the discriminator's review, while the discriminator distinguishes synthetic samples from real ones. GAN's image generation capability has surpassed previous deep learning models, making it increasingly popular for design generation in human environments (Zhao et al., 2022). GAN was initially applied to interior space layout generation in architecture, with Huang and Zheng using pix2pix for generating architectural drawings and interior layouts, establishing the main research paradigm in this field. Over time, this method has been extended to architecture and urban planning for automatic layout generation (Huang et al., 2018) used pix2pix to identify and generate architectural drawings, explored the layout of interior space plan, and established the main research paradigm in this field. at the same time, It has also been used for fast rendering of urban planning designs (Ye et al., 2022).

In outdoor space design, particularly urban green spaces, the complexity and flexibility of the layouts pose challenges for rapid scheme generation. Current research on park green space generative design is mostly limited to site layout planning (Chen et al., 2023). For example, Liu et al. (2022) guided the generation of garden layouts, and Chen et al. (2023) used pix2pix and CycleGAN to generate park spatial layouts and render color plans. However, research on residential green space generative design is almost nonexistent.

In summary, GAN's application in urban green space park design is limited. The generative design methods for park green spaces still follow those used in architecture and urban planning, with optimization done through trial and error based on site internal element layouts. This approach has not yet considered other external factors that could influence the generation process.

2.2 Generative design based on constraint control

Constraint-based scheme layout generation was first applied to small-scale indoor space design. Initially, the constraints were limited to the inside of the red line. Zheng (Huang et al., 2018) et al. aused CGAN technology to incorporate architectural interior design constraints, such as room types and axes, improving the reliability of generated results. Huang & Zheng, 2018 refined this approach using Pix2PixHD, adding annotations for room types and details like doors and windows, making the layouts clearer and more logical. Wang et al. (2021) introduced the bi-RRT algorithm to simulate indoor pedestrian trajectories as constraints, designing indoor layouts based on these trajectories. They further developed ActFloor-GAN, a deep learning framework that uses human activity maps to guide floor plan generation.

As research in outdoor design evolved, attempts were made to use external environment data as constraints for scheme generation. (Lin, 2020) applied Pix2Pix to generate primary school campus layouts with the design red line and urban roads as constraints. Urban road constraints provided semantic design information, improving the rationality of the generated layouts. Liu et al. (2021) developed a two-step method for university campus layout generation: first generating functional zoning based on the external environment, then generating architectural layouts based on the zoning. Fedorova (2021) used GANs to generate designs based on the surrounding urban environment.

Constraint-based layout generation has been applied to medium-scale outdoor design, with potential for urban green space generative design. However, research using the external environment as a constraint is limited, and extracting complex environmental elements as constraints remains a challenge for urban green space design.

3. Methodology

This study proposes a park layout generation system based on the external environment, designed to quickly generate park layouts and color plans, offering design inspiration. The experimental framework includes four steps (Figure.1): (1) dataset creation; (2) extraction of urban remote sensing objects; (3) generation of park design schemes based on the external environment; (4) detail optimization of the design scheme.

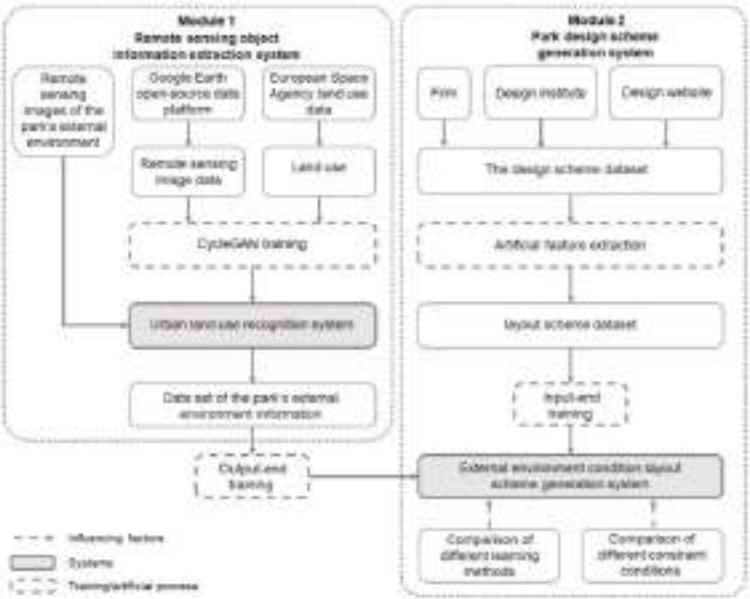

Figure. 1. Methodology for automated park design schemes generation based on external environment condition.

3.1 Dataset

3.1.1 Remote sensing data

This data consists of remote sensing images and land use information from five equally-sized blocks in Beijing, sourced from Google Earth and ESA global land use data. Ultimately, 1000 remote sensing and land use images were used for training the object extraction system.

3.1.2 Park data

This study focuses on medium and small-sized parks, including community parks (1-10 hectares) and small comprehensive parks (over 10 hectares). It uses park external environment remote sensing images and layout schemes. To avoid deep learning algorithm failures due to complex outdoor space data, high-quality data samples were selected based on four criteria: (1) strong regularity, (2) minimal special design conditions, (3) clear functional zones, and (4) slight land elevation differences. A total of 137 parks were selected as training samples, with 6 test samples representing various functional zones and common layout patterns. The park plans were divided into six categories: green land, water, road, paving, buildings, and plants, with water bodies and buildings extracted separately as site information.

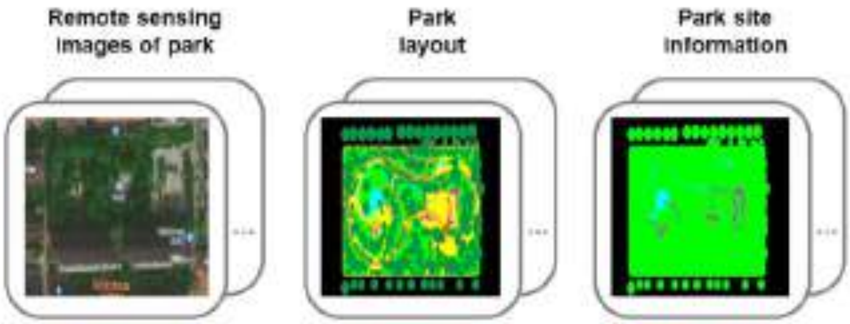

Figure 2. Display of three types of park data.

3.2 Park design scheme generation based on external environment

This generation process consists of two parts: (1) generating the park layout scheme color block diagram from external environment information, and (2) generating the park design scheme from the layout scheme color block diagram. The original GAN model focuses on regular spatial design and does not address complex layout generation well. To improve this, Chen et al. proposed LandscapeGAN, based on pix2pix and CycleGAN, for automated park green space design. However, layout generation based on external environment constraints is similar to image completion tasks, rather than style transfer tasks typically performed by GAN models. Therefore, this study improves on LandscapeGAN.

3.3 Detail optimization of design scheme

The previous process generates the design scheme from external environment conditions. However, issues like unclear edges and noise in the design scheme make it difficult to present as a final result. Therefore, this study introduces the AIGC algorithm model based on Stable Diffusion to refine the design details.

4. Experiment

First, we extract park external environment conditions using remote sensing images, train the Cycle GAN algorithm, and test to obtain the park external environment information (see Fig. 3).

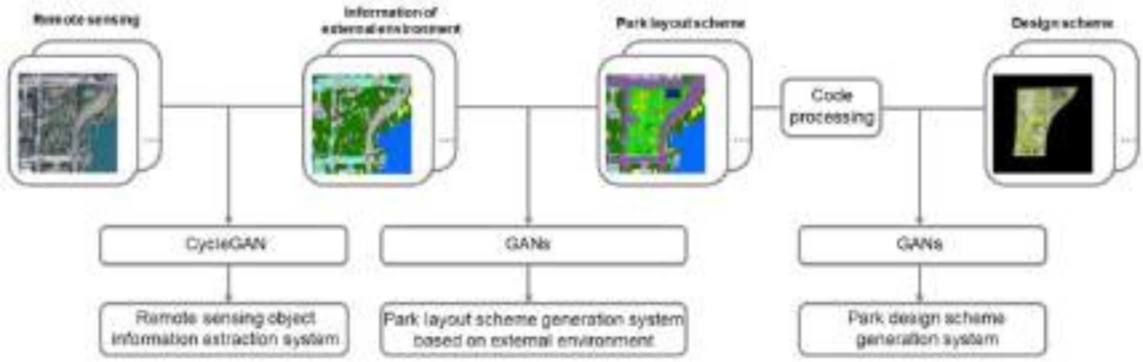

Figure 3. The overall workflow of training and predicting.

Next, we use the training data "external environment information-park layout" and "park layout-design scheme," training through Pix2Pix and CycleGAN networks to construct a park layout generation system and a park design scheme system based on the external environment.

Finally, we input the CycleGAN-generated design plan into Stable Diffusion for optimization. Based on pre-experiment results, the larger the proportion of the plan in the image, the better the optimization effect. Therefore, we enlarge the design scheme in the data image using PS and add concise descriptive words like "urban park, top view." Stable Diffusion does not require algorithm training and can directly generate results by inputting data.

5. Result and Discussion

5.1 Generation results of park layout scheme and design scheme

Based on the park data set, the design layout and scheme generation systems were trained in turn. The following figure shows the park layout scheme and design scheme trained and generated by CycleGAN.

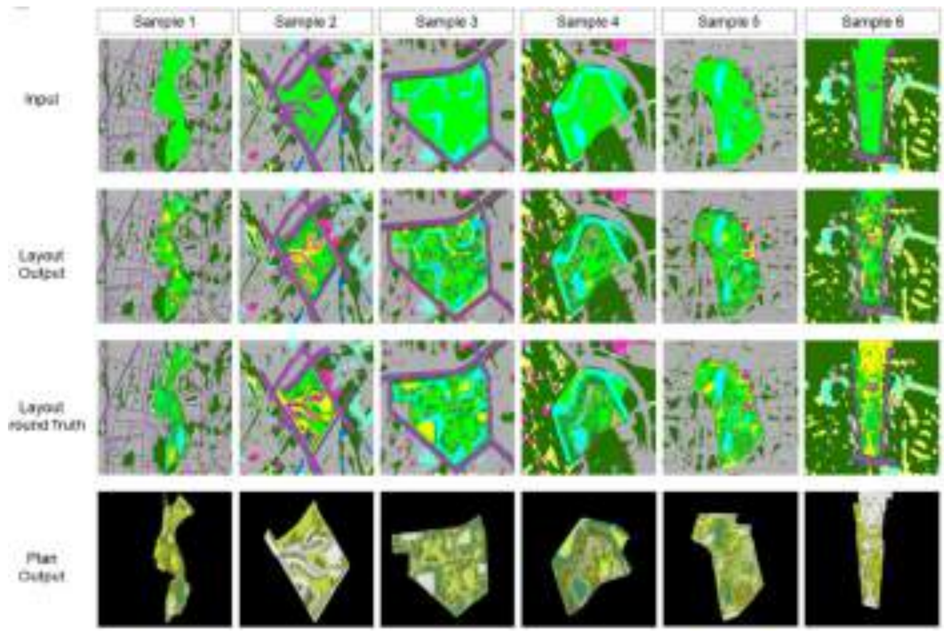

Figure 4. Examples of park layouts and design plans generated by CycleGAN under the constraints of external environment.

In general, the CycleGAN algorithm is capable of summarizing the characteristics of various design elements to some extent. It establishes connections between structures, roads, paving, and other landscape elements, and reconstructs them according to the given environmental conditions.

5.2 Generation result evaluation

We selected 50 diverse park layout cases as test samples to assess the applicability and accuracy of the trained network across various scenarios. It also compared the effects of layout generation under different learning methods and constraints, as well as the impact of training data quality on the generated design schemes.

(1) The influence of the learning method on the layout scheme generation effect

Currently, pix2pix or CycleGAN are mainly used as the training algorithms for automatic generation research in the field of planning and design; Liu et al., 2022; Zhou & Liu, 2021; Ye et al., 2022 and others have used them. However, few studies compare these algorithms' application scenarios. This section compares supervised learning with Pix2Pix and unsupervised learning with CycleGAN, evaluating the generation effects of each.

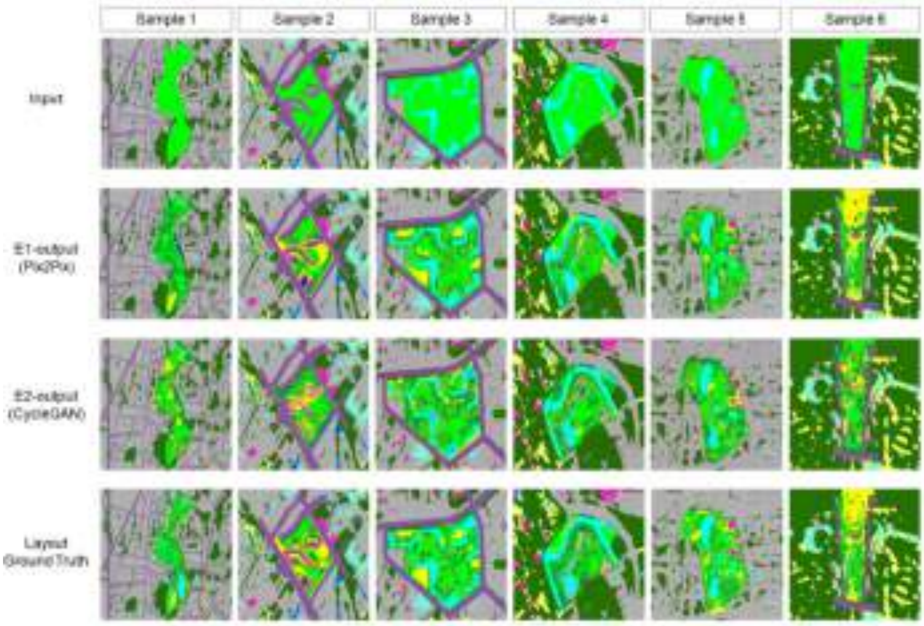

Figure 5. Comparison of park layouts generated by different algorithms under the constraints of external environment.

Both algorithms have distinct advantages and limitations in park layout generation. Pix2Pix performs better with small sample training and closely restores the training data, but the generation results lack stylistic consistency. CycleGAN, on the other hand, offers stable style generation, is more innovative, and is better suited for landscape designs with no standardized answers. The primary drawbacks of both algorithms are low clarity and insufficient data, leading to repetitive or noisy results. Based on this analysis, CycleGAN outperforms Pix2Pix in terms of stability, accuracy, and potential for generative design.

(2) The influence of constraint conditions on the layout scheme generation effect

Comparison of park layout generation results based on different constraints. The following summarizes the findings:

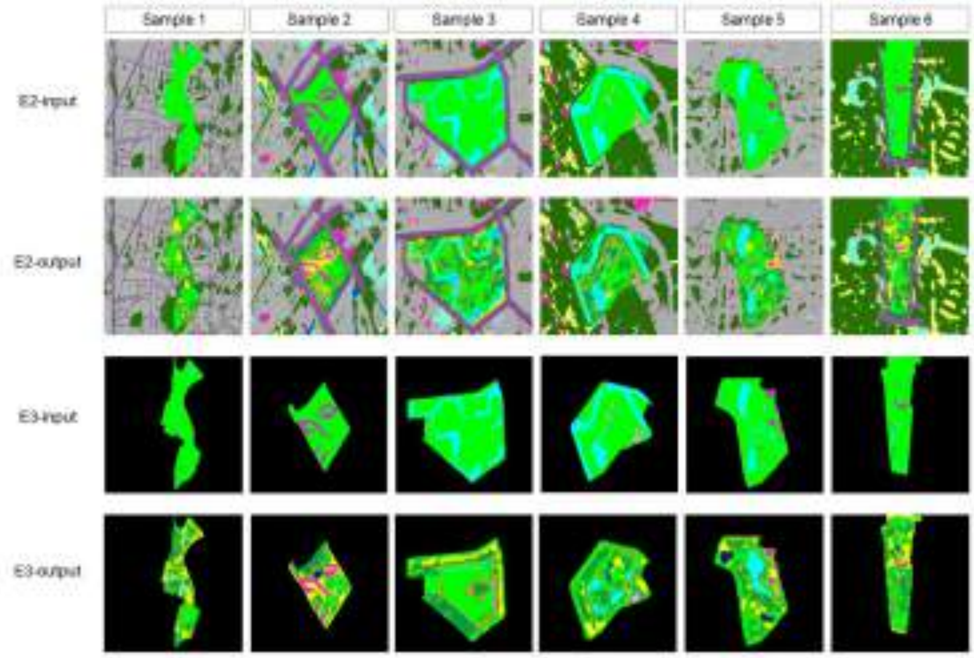

Figure 6. Comparison of park layout generation results based on different constraints.

a. Road system: Both experiments generated a park road system that runs through the entire park. Other design elements were well integrated, and each paving node was connected by the park road, offering a diverse and rich spatial experience.

b. Spatial relationship: The test results formed a diversified and harmonious space. By using environmental data as a constraint, the algorithm flexibly incorporated various landscape elements, considering the external environment's impact on park design, making the generated layout more aligned with an actual park's spatial structure.

c. Design element understanding: CycleGAN effectively identified and summarized the features of various design elements, establishing connections between structures, roads, pavings, and other landscape features.

5.3 Park design scheme optimization stage

This part of the experiment aims to use the Stable Diffusion model to generate park design schemes, complete the details of the park design schemes generated by CycleGAN.

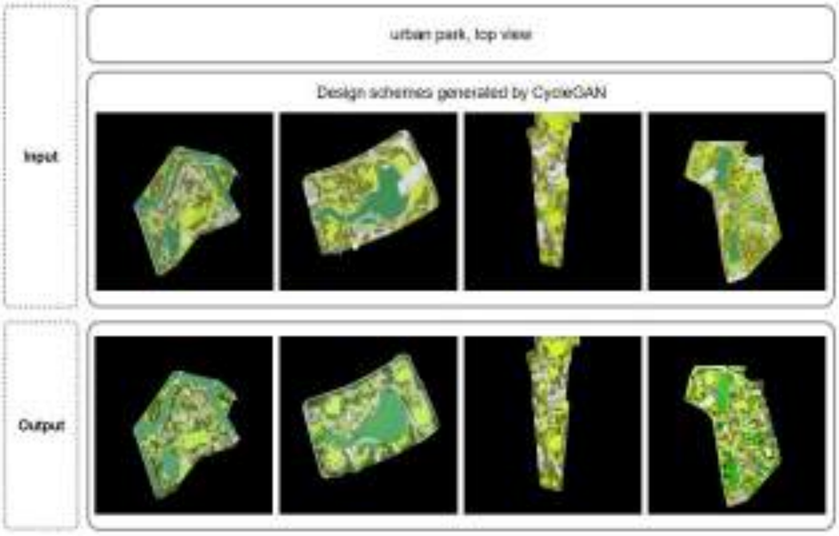

Figure 7. The generation result of inputting text information and park plans generated by CycleGAN in Stable Diffusion

In this experiment, the generated results of Stable Diffusion include rich and diverse site details. They can generate activity sites and vegetation with different contents (Sample 4), and building shadows (Sample 1, 2, 3), and the generated design elements can correspond to the input data individually.

Compared with the layout scheme, the input data of this round of experiments added the color (Sample 1) and texture (Sample 2) of each design element, equivalent to supplementing the corresponding semantic information for each color block. Stable Diffusion algorithm can add more design element details based on clear semantic information. It shows that CycleGAN can obtain the primary design element features and design rules of the park through the landscape-specific data set, which is exactly what Stable Diffusion lacks.

Figure 8. Stable Diffusion optimizes the details of design plans.

6. Conclusion

Traditional park design involves balancing various constraints and manually transferring information across software platforms. With the rise of digital technologies, algorithm optimization, and data resources, Generative Adversarial Networks (GANs) are increasingly being used for automated landscape design. However, challenges remain in applying GANs effectively in landscape planning. This study proposes a method to enhance the logic and scientific basis of generative design, offering a park design system based on the "external environment - layout - scheme" framework to support designers, particularly in the early design stages. The main issues in generative design are addressed across three aspects:

(1) Constraining Generative Design: GAN-based design often involves minimal designer input, with complex algorithms that are difficult to constrain. This study integrates environmental data into the process, improving the scientific validity and interpretability of designs.

(2) Feasibility of Automatic Park Layout Design: Evaluating algorithm-generated layouts from a landscape architecture perspective, the study finds that CycleGAN produces more stable results than pix2pix. Incorporating external environment data as constraints enhances the algorithm's flexibility, allowing for better integration of design elements and producing more realistic park layouts.

(3) Optimizing Generative Design Drawings: The study explores optimizing park designs generated by algorithms using Stable Diffusion, addressing issues with small sample training. It also compares park plan generation results with different input data, revealing the limitations of Stable Diffusion and the need for specialized professional datasets in park generative design.

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Additionally, This paper is based on research content that has been submitted to the *Cities* journal and is currently under its second round of revisions. To avoid any issues of duplicate publication, I would like to clarify this prior submission. I hope that the inclusion of this paper in the IFLA proceedings will be helpful and will not affect its potential publication in *Cities*.

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The Thriving Digital Platform-based Food Delivery Sector in Informal Settlements in China

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Abstract

This article focuses on the transformation of villages-in-the-city under the influence of the platform-based food delivery sector and discusses the support dimensions of villages-in-the-city for this emerging entrepreneurial ecosystem. As a unique type of informal settlement in Chinese cities, villages-in-the-city evolved from historically rural areas engulfed by urban expansion through the self-help building of villagers. With the popularisation of food delivery platforms in recent years, a thriving platform-based food delivery sector has developed in some villages-in-the-city, which operates through a network mediated by platforms consisting of numerous small individual restaurants, gig delivery workers and other supportive sectors in the villages. Using Shipai Village in Guangzhou as a case study, this article describes its spatio-temporal restructuring and supportive socio-spatial conditions for the food delivery sector based on site-based note writing, participant observation and semi-structured interviews. Shipai Village shows a spatial restructuring of fragmentation, use extension and trans-spatial connections, and a temporal restructuring of changing rhythms. We submit that the village's empowering infrastructure, flexible devolved governance, and inclusive socio-cultural environment constitute vital support for the food delivery sector.

Keywords: Village-in-the-city, informality, food delivery, digital platform

1. Introduction

Village-in-the-city (hereafter ViCs) are urban residential areas in China characterised by informal features (Wang et al., 2009; Wu, 2016; Zhang, 2011). As a distinctive urban phenomenon, ViCs evolved from former rural villages that were engulfed by urban expansion, most notably in the rapidly urbanising Pearl River Delta metropolitan region (Li, 2002; Wang et al., 2009). Under the dual state-collective land system, the remaining land of these villages, after expropriation, maintained collective ownership, distinguishing it from the surrounding state-owned land managed by urban authorities (Tian, 2008). This institutional grey area, which circumvented formal regulatory frameworks, enabled villagers to capitalise on rapid urban development by constructing or extending multi-storey housing on their housing plots, ultimately forming high-density neighbourhoods comprised of five to eight-storey apartments (Hao et al., 2013; Y. Liu et al., 2010; Wang et al., 2009). Since the 1990s, these villages have provided affordable rental housing for the influx of domestic migrant workers and accommodated a diverse informal economy, with the resulting rental income becoming a crucial supplement to the original villagers' livelihoods (Lin et al., 2011; Wu, 2016; Zhan, 2018).

The speculative construction, extremely crowded environment, and prevalence of non-compliant activities in ViCs initially sparked social controversy (Li, 2002). However, over the past two decades, prejudiced criticism has gradually been superseded by a systemic understanding of the ViC phenomenon. Existing literature conceptualises ViCs as migrant enclaves formed in the post-1978 reform era (Douglass et al., 2012; He, 2013), an innovative spatial typology generated by the market-oriented transition paralleling factory dormitories (Roberts, 2012), and a spillover of the dormitory exploitation system (Su et al., 2023). Traditional research perspectives focus on institutional interventions as the decisive factor in ViCs' qualitative change. Academic discussions on ViC transformation have primarily focused on historical analysis (Hao et al., 2013; Wang et al., 2009), redevelopment and governance (Li et al., 2021; Lin et al., 2012, 2015; Lin & De Meulder, 2012; Liu & Wong, 2018).

This article questions the static understanding of ViCs and provides evidence of their ongoing transformation through digitally enhanced production practices. The study examines a ViC that has developed a thriving food delivery sector and related entrepreneurial ecosystems through digital platforms. Their most distinctive feature is the concentration of numerous small individual restaurants, gig delivery workers, supportive shops and service providers, with food delivery activities primarily mediated by digital platforms. In the Chinese context, these villages are termed Waimai Cun (food-delivery villages) or "Takeaway Factories" (Zhao et al., 2024). As their names imply, these ViCs are known for catering to the city.

This article aims to reveal how spatial utilisation and organisation of ViCs have transformed to accommodate the flourishing platform-based food delivery sector and preliminarily explore why ViCs could foster this novel entrepreneurial ecosystem.

2. Material and Method

This study selects a representative case of a food-delivery village, Shipai Village (Figure 1), located less than three kilometres east of Guangzhou's new administrative and financial centre, the Zhujiang New Town. It covers an area of 0.31 square kilometres with more than 300 streets, winding alleys, and handshake buildings, forming a dense urban complex with nearly 100,000 residents, predominantly migrants, of which 27,000 are engaged in the courier and food delivery sectors (Tianhe Publishing, 2023; Xu et al., 2023). Within Shipai Village, the maze-like streets are lined with small restaurants where neon signs glow throughout the night. An endless stream of scooter riders engage in picking up and delivering food. At peak times, this village can generate up to 600 orders per minute, supplying meals to surrounding commercial and residential areas (Xu et al., 2023).

The data for the empirical study were collected during three intensive fieldwork in Shipai Village between 2023 and 2024. These investigations were supplemented by information from newspaper articles, government reports, village records and documentary films. The study employed site-based notetaking, spatial mapping, participatory observation and semi-structured interviews. The 15 respondents include operators of restaurants, delivery riders, nail salon employees, ordinary tenants, local villagers, and village committee staff members.

Figure 1. A view of Shipai Village from a high vantage point (photo by the author)

3. Findings and Discussion

3.1 Spatio-temporal restructuring of shipai village under the ınfluence of platform-based food delivery

The catering sector is prevalent in many ViCs and has long been an integral part of their informal economy (Wang et al., 2009). Traditionally, it comprised street-facing family-operated restaurants, primarily serving nearby residents with dine-in and takeaway services with marginal and small-scale delivery activities. Restaurants in Shipai Village often have very compact spatial configurations due to the constraints of the small building size and the limitation on their expansion over multiple floors. Their width and depth usually span one to two structural bays, each measuring 10 to 20 square metres. Nevertheless, operators endeavour to arrange the dining area, albeit adjacent to stoves and kitchenware, accommodating only three to five people.

In recent years, food delivery platforms, such as Meituan and Ele, which integrate services including online ordering, payment, and delivery services, have had a transformative impact on the catering sector. This development has altered the spatial dynamics of Shipai Villag's catering sector, transforming it from serving a small locality into part of the city's vast network of distributed kitchens. By enabling receiving orders from a broader neighbouring area, these platforms have expanded the customer volume and type for restaurants in Shipai Village, supported the integration of their distributed operations, and enhanced their marketing and production capabilities. This has consequently led to a differentiation in operational models, forming new restaurant typologies ranging from hybrid dine-in/delivery restaurants to delivery-only outlets. The former is commonly found among existing Shipai Village restaurants with integrated platform operations, while the latter is exemplified by cloud kitchens (John, 2021; Shapiro, 2023), which primarily serve the platform-based food delivery market.

Spatial Restructuring

- Fragmentation

Delivery-dependent catering consumption significantly reduces the reliance on restaurants' specific locations and dining spaces. For cloud kitchens and delivery-oriented hybrid restaurants, only the most fundamental cooking facilities must be maintained, thus requiring less operational space. This has led to spatial fragmentation in Shipai Village, one form of which is the split of areas involving the subdivision of larger spaces intended for one restaurant. In some cases, village landlords partition the space for separate rental, while in others, different operators lease it in partnership and then make space transformation. Another form of fragmentation is the dual use of space, primarily involving diversified operations within a shared space, such as parallel production in several production zones and a single location being registered as multiple restaurants on platforms.

- Use extension

Within Shipai Village, the shrinking in dine-in and the popularity of delivery have freed restaurants from reliance on location factors such as traffic flow and accessibility. The requirement for the site has been reduced to just being accessible to riders, facilitating the development of new spaces for the catering sector. This is evidenced by the spread of catering business led by cloud kitchens from the village's main streets to side streets and alleys, with more buildings' first floors being utilised. In addition, as cloud kitchens pursue low rental costs yet are insensitive to space conditions (John, 2021), this has prompted the development of more corner spaces and temporary structures. Examples include the construction of modular cubicles targeting cloud kitchens on vacant lots, a project driven by the authorised management entity representing the village collective.

The use extension also manifests in the widening of existing restaurants. Hybrid restaurants that maintain their original dine-in capacity while adding food delivery services require additional kitchen facilities such as cooking tables, stoves, microwaves, and stock of disposable utensils, as well as new digital equipment for processing platform orders and shelves for temporarily storing packaged food for rider pick-ups. This extension not only involves layout changes but also compels operators to allocate more space for production activities. Some hybrid restaurants have even appropriate public streets as dining areas to utilise all their interior space as a kitchen.

- Trans-spatial connection

The platform transcends geographical constraints through instant data streams, refined process control, and dynamic resource allocation, fostering a real-time, highly interactive collaborative network among restaurants, riders, and consumers. Through this process, Shipai Village transitions from the secondary position (Shannon et al., 2014) in urban development to being deeply embedded into a larger economic system, with narrow streets and small restaurants potentially serving as a key micro-node in this digitalised trans-spatial network. To support every order, the infrastructure within and outside of Shipai Village, including transportation networks, communication systems and other spatial resources, is dynamically reconfigured and efficiently connected under the coordination of the digital platform.

Temporal Restructuring

- Change of Rhythm

Most traditional ViC restaurants are family-operated and have a loose order processing flow. They often adjust production flexibly without fixed linear operation directives based on available staffing, prepared ingredients, and customised requests. In terms of daily operation, these restaurants also have a certain degree of autonomy. For example, their operating hours often depend on the day's business dynamics and the operators' schedules.

However, the situation has changed in hybrid restaurants and cloud kitchens. Based on big data analytics and predictive modelling, platforms impose several time checkpoints on the order process, including times of order acceptance, preparation, packing, rider arrival, pick-up, and delivery. This precise regulation more strictly constrains operation times and compresses order intervals, accelerating and rationalising the food production and delivery process.

Food delivery platforms also dominate the daily rhythm of these restaurants. Concerning daily operating hours, platforms require restaurants to set specific opening and closing times and ensure service provision during this period. At the same time, online orders generated through platforms at random times have eliminated the traditional off-peak hours for dine-in service. In order to capture the nighttime market, some cloud kitchens have shifted entirely to nighttime operations. In the most extreme cases, restaurants shift workers to achieve 24/7 service.

3.2 Three dimensions of shipai village's support for the platform-based food delivery sector

Empowering Infrastructure

From the perspective of the material basis of space supporting the food delivery sector, Shipai Village offers critical infrastructural conditions. First, it provides the digital infrastructure essential for the penetration of digital platforms. Despite being often described as a relatively underdeveloped informal settlement, the case of Shipai Village demonstrates a robust foundation for digital practices. The well-established facilities of China's three major telecommunications ensure Internet access capability across private and public spaces, and almost all restaurants offer free Wi-Fi networks. Nearly every street hosts shops selling affordable digital devices and repair services, supporting the proliferation of smartphone and digital platform terminals within the village. These establishments often double as agencies for setting up internet service plans, serving as crucial intermediaries in the digital infrastructure.

Secondly, the road and public space infrastructure of Shipai Village underpins the intensive delivery activities. Its fine-grained spatial configuration, featuring a dense and unrestricted road network, creates a highly porous urban area. This sharply contrasts with gated communities and large commercial complexes, enabling riders to navigate flexibly without parking their scooters. The decentralised public spaces connected by streets, though modest in scale, serve as essential spatial references for riders and function as sites for encounter, interaction and rest. Although these infrastructures are not formally planned, they have accumulated basic material conditions through gradual development, such as paved ground, drainage and lighting systems, address coding and routine maintenance.

Flexible Devolved Governance

Unlike urbanised areas directly governed by city authorities, administrative affairs in ViCs are commonly outsourced to village collective organisations, the model of which is characterised by devolvement and a thicker autonomy (Zhan, 2018). This distinctive arrangement originates from the dual system of land management and household registration established in the 1950s. Under this system, urban land is state-owned, while rural land is owned and managed by the collective organisation comprised of village members with agricultural household registration (Tian, 2008). In Shipai Village, the village collective organisation took shape during the era of rural socialist collectivisation, integrating governance practices rooted in premodern clan systems dominated by four major family lineages. In the 1990s, it evolved into a shareholding company owned by village members (Shipai Village Committee, 2003). The village collective organisation operating as a shareholding company not only oversees collective land development and asset management, but also retains key community governance and political functions, leading the public security, villager mobilisation, and registration of the migrant population.

This governance model has profoundly influenced the built environment of Shipai Village by compromising with villagers' autonomous development initiatives (Liu et al., 2012). It has resulted in one of the most striking high-density neighbourhoods adjacent to the CBD, offering a unique developmental stage distinct from surrounding urban areas. Although nearly all buildings were designed to maximise affordable residential units, as the village developed, increasing ground-floor units have been converted into retail, catering, and entertainment spaces, leading to a shift towards mixed-use structures. The functional transformation is often informal and provisional and sometimes does not comply with city construction standards and regulations, yet it is widely tolerated within the village.

Opening a small-scale restaurant in Shipai Village usually requires little more than obtaining the necessary licences, negotiating with landlords, installing ventilation systems to mitigate environmental impacts, and paying a modest extra sanitation fee. While licensing requirements theoretically restrict catering businesses from being registered in residential buildings, Shipai Village appears to be an exception. Many landlords advertise their properties with the promise of facilitating "Two Licences" (business licence and food business licence), and advertisements for intermediary services are easy to find, despite the presence of a branch office of the administration for market regulation less than 200 metres from the village.

Inclusive Socio-cultural Environment

The inclusivity is first manifested in Shipai Village's capacity to accommodate the vast influx of migrant workers on which the platform-based food delivery sector depends. By offering a convenient location and low rents, the village significantly reduces the cost of living for rural migrant workers, small entrepreneurs, and transitional workers. This is achieved through the village's inclusion of informal economies, providing essential spaces for street vendors, food stalls, repair shops, and hair salons. These small-scale businesses collectively create a functional, mutually satisfying, affordable living environment. Furthermore, the village's just-enough infrastructure, relaxed governance, and low capital requirements lower the threshold for entrepreneurship, making it easier for migrant workers to leap from being employed to starting a business and further integrating into the city.

As a convergence point of migrant and local cultures, Shipai Village has developed a multicultural character. The migrant workers we encountered in our fieldwork included individuals from nearby cities in Guangdong, neighbouring provinces such as Hunan and Fujian, and distant northern provinces such as Shandong, Jilin, and Heilongjiang. People from different regional backgrounds have brought diverse dialects, cuisines, and lifestyles to the village, most notably the proliferation of hometown restaurants catering to varied tastes. While competition among these catering businesses is intense, it is accompanied by cultural exchange and mutual learning. Interviews with restaurant operators frequently highlighted the importance of agglomeration in attracting customers and fostering a sense of mutual respect and solidarity among migrant communities, further strengthening recognition among peers.

In contrast to the direct participation of migrant workers, the villagers of Shipai play a more behind-the-scenes role in the food delivery sector. While often characterised as speculative rentier landlords with significantly higher economic status than migrants (He et al., 2010), it is undeniable that the villager landlords contribute to balancing urban resource distribution by maintaining a low-cost community. Moreover, shared agricultural experiences enable them to better understand the needs and habits of rural migrant workers. This cultural empathy translates into a tolerant and open-minded approach to new production practices, such as cloud kitchens, diminishing the hegemonic nature of villager landlords. Additionally, villagers respond to collective initiatives to enhance their properties, such as affixing signage and installing electronic locks. The ever-improving address signage systems have proven important for food delivery riders, serving as key navigational references.

4. Conclusion

This article focuses on the thriving platform-based food delivery sector in ViCs, representing a spontaneous digital practice emerging in informal settlements. The case of Shipai Village demonstrates the spatio-temporal restructuring in adapting to this sector, including spatial fragmentation, the extension of spatial use, the increase in trans-spatial connections, and the change of rhythm. We submit that the village's empowering infrastructure, flexible devolved governance, and inclusive socio-cultural environment have provided vital support for the emergence of this new entrepreneurial ecosystem. The study provides a case for global research on informal settlement, illustrating the openness of digital practices in the production sphere to informality and the potential for urban popular economies to enhance their capabilities using digital technologies.

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Traditional Tools, Virtual Realities: Sustainable Landscape Design Exhibit in Brazil

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Abstract

This research explores the integration of Extended Reality (XR) technologies into urban landscape design, focusing on the "Cultural Corridor" project in Fortaleza, Brazil. The project aims to revitalize a major avenue using nature-based solutions to create a pedestrian-friendly extension of cultural institutions like theaters, museums, and universities. A museum-style exhibition at the Museum of Art of the Federal University of Ceará (MAUC) showcased the project through physical models, banners, mosaics, maps, videos, and interactive XR experiences. Over two months, stakeholders and the public engaged with the project, promoting transparency and inclusivity. Findings reveal that while XR enhances stakeholder negotiations and project comprehension, physical tools remain essential due to XR's hardware limitations. The study underscores XR's potential to foster more inclusive and resilient urban solutions while balancing traditional and digital methods.

Keywords: Urban Landscape Design, Extended Reality, Nature-Based Solutions, Stakeholder Engagement

1. Introduction

The Creative Cultural Corridor project emerges in a context where urban centers face increasing challenges related to sustainability, resilience, and inclusivity. Cities like Fortaleza, Brazil's fourth most populated city, with 2.5 million people living in it (IBGE, 2022), with rich cultural and historical heritages, require innovative solutions to address rapid urbanization and its environmental, social, and economic impacts. Sustainable Development Goals (SDGs) provide a comprehensive framework for integrating these dimensions into urban planning practices.

Figure 1. Project's location (Authors, 2024)

Historically, the proposed axis for the Creative Cultural Corridor (*Av. da Universidade*) has played a pivotal role in Fortaleza's development, serving as a vital vector of expansion (Costa, 2014). Over decades, it has fostered the establishment of key buildings, roads, public spaces, and transportation systems, symbolizing the city’s progress in architecture and urbanism. As a repository of both tangible and intangible heritage, the axis represents a valuable cultural asset for Ceará (Diário do Nordeste, 2014).

The integration of Extended Reality (XR) technologies into urban planning processes opens up innovative possibilities for engaging stakeholders and visualizing large-scale urban transformations. As discussed by Orladn et al. (2001) and Adrienne & Nora (2024), XR allows planners, designers, and the public to experience and interact with proposed changes in a virtual environment before they are implemented. This immersive technology offers a powerful tool for communicating complex concepts, testing design ideas, and facilitating more informed decision-making by all involved parties. By providing a more accessible and interactive way to explore urban spaces, XR enhances collaboration and fosters a deeper understanding of the potential impacts of planning decisions.

This project stands out by combining historical preservation with new technologies and participatory governance mechanisms. It proposes a novel model for urban regeneration that integrates non-structural solutions, such as tactical urbanism, with structural measures like rain gardens and sustainable drainage systems. Furthermore, its focus on equity—emphasizing racial and gender equality—alongside the promotion of sociobiodiversity and bioeconomy, underscores its originality and relevance.

Figure 2. Project’s 10 premisses (Authors, 2025)

The main objective of the Creative Cultural Corridor is to transform a historically significant urban axis into a pedestrian-friendly, culturally vibrant environment while addressing climate challenges and fostering inclusivity. By implementing XR within a participatory framework, the project contributes to advancing sustainable urban paradigms, offering a replicable model.

Figure 3. Project's street section (Authors, 2024)

2. Material and Method

To create the exhibition, a working group was formed, consisting of undergraduate and graduate students, as well as professionals from various fields, with a primary focus on architects and urban planners. This interdisciplinary team collaborated to develop the project, drawing on their diverse expertise to ensure a comprehensive and multifaceted approach to the exhibition. The exhibition was held at the Museum of Art of the Federal University of Ceará (MAUC), located in Fortaleza, Brazil. The exhibition showcased a variety of objects and products, including physical graphic pieces such as models, banners, mosaics, and maps, as well as digital components like project videos. Additionally, interactive experiences were offered through VR immersion and motion-capture interactions, providing visitors with an engaging and immersive exploration of the project's concepts and goals.

Figure 4. Picture of the exhibition (Authors, 2024)

The scale models served as tangible representations of the project's proposed transformations. Crafted with precision through laser cutters, they were intended to allow visitors to visualize the spatial layout of the corridor, including key urban interventions such as pedestrian zones, green areas, and cultural landmarks. By interacting with these models, visitors could better understand the physical dimensions of the project and its integration into the existing urban fabric.

Figure 5. Picture of scale models in the exhibition (Authors, 2024)

The banners provided detailed narratives and visual summaries of the project. They featured diagrams, timelines, and annotated illustrations that highlighted the main phases of the proposal, the sustainable development goals it aligned with, and the specific challenges addressed. Positioned strategically throughout the exhibition, the banners offered visitors a structured journey through the project's overarching vision and key objectives.

By blending visual artistry with voices from the community, the mosaics not only celebrated the identity of the region but also served as a platform for dialogue. Visitors were invited to reflect on the area's past, present, and future while engaging with the lived experiences and aspirations of those most closely connected to it. This fusion of visual and textual elements underscored the importance of participatory approaches in shaping the project's narrative and design solutions.

The maps displayed geographic and urban data related to the corridor and its surrounding neighborhoods. They included overlays of historical maps, current land use, and proposed changes, enabling visitors to grasp the project's scale and spatial impact. Interactive map features, such as touch-enabled overlays, allowed for deeper engagement, enabling users to explore specific data layers in detail.

Figure 6. Picture of visitors in the exhibition (Authors, 2024)

The digital components of the exhibition included professionally produced videos that narrated the project's story. These videos combined animations, interviews, and drone footage to provide a dynamic overview of the corridor's current state and the proposed transformations. By blending technical information with storytelling, the videos catered to both technical audiences and the general public.

The immersive experiences offered through VR immersion and motion-capture interactions allowed visitors to step into a simulated version of the Creative Cultural Corridor. Oculus 2 headsets were used, connected via cable to a computer running real-time renders processed through the Enscape program. This setup enabled users to be transported into a digitally recreated environment, where they could explore proposed changes firsthand. Walking through redesigned streets, they could interact with elements such as nature-based solutions, experiencing the potential impact of these transformations. Motion-capture technology further enhanced the experience, allowing visitors to use their own movements to engage with the virtual environment. This hands-on interaction fostered a deeper and more tangible understanding of the project's innovations, making it accessible and engaging for all users, regardless of their technical expertise.

However, a limitation of the VR experience was that students were required to assist visitors throughout their interactions. At all times, there needed to be staff on hand to help with the setup, navigation, and troubleshooting of the VR headsets. This reliance on continuous support highlighted a logistical challenge and underscored the need for adequate resources to ensure smooth and independent engagement with the technology.

These components had the intention of making the exhibition accessible, engaging, and informative, ensuring that visitors of all backgrounds could connect with the project's vision and goals.

Figure 7. Picture of visitors in the exhibition (upper image) and of the virtual experience (bottom image) (Authors, 2024)

3. Findings and Discussion

The success of the Creative Cultural Corridor project can be attributed to its innovative approach to engaging a diverse array of stakeholders transparently while fostering meaningful integration with the local population. The two-month exhibition at the Museum of Art of the

Federal University of Ceará (MAUC) demonstrated the capacity of the project to reach individuals across various age groups, genders, and socio-economic backgrounds. This inclusivity was a critical achievement for an initiative of this scale, as it ensured broad public understanding and support for proposed urban transformations.

One of the standout features of the project was its accessibility. By incorporating multiple modes of interaction—ranging from physical graphic elements like models, banners, and mosaics to digital components like project videos and immersive VR experiences—the exhibition provided meaningful engagement opportunities for all visitors. Even those who were unable or unwilling to participate in the XR experiences could still interact with other elements of the exhibition, ensuring no visitor was excluded from the broader narrative of the project.

Despite its strengths, the use of XR technologies presented certain limitations. Hardware requirements, such as the need for virtual reality goggles (Oculus 2 connected to real-time renders via the Enscape program), posed logistical challenges. These devices required significant technical setup and continuous support from trained students to assist visitors during their VR experiences. This dependency highlighted the practical barriers to widespread XR adoption, including the need for dedicated personnel and resources. Additionally, the reliance on such hardware underscored the continued importance of physical graphic elements, which remained vital for conveying project details in an accessible and tangible manner.

Nevertheless, the XR experiences played a pivotal role in the project's success by fostering dynamic interactions and enabling stakeholders to visualize and navigate proposed changes in real-time. This immersive capability proved invaluable in facilitating informed negotiations among stakeholders, particularly by bridging the gap between technical experts and non-specialist participants. As a result, the project exemplified how innovative technologies, when thoughtfully integrated with traditional tools, can contribute to more inclusive, transparent, and resilient solutions to the pressing urban challenges of today.

4. Conclusion

In conclusion, the Creative Cultural Corridor project demonstrates the potential of interdisciplinary approaches, participatory design, and innovative technologies like XR in addressing urban challenges while fostering inclusivity and resilience. By integrating physical graphic elements, digital media, and immersive experiences, the project bridged the gap between traditional and modern tools, ensuring accessibility and engagement for a diverse audience. The exhibition at MAUC served as a platform for transparent dialogue among stakeholders, enabling meaningful discussions and fostering a shared vision for the corridor's transformation.

While XR technologies provided valuable tools for visualization and negotiation, their limitations, particularly regarding hardware accessibility, highlighted the continued importance of complementary methods, such as models, mosaics, and maps. These elements played a crucial role in ensuring the project's reach and inclusivity, accommodating varying preferences and technological access levels.

Ultimately, the project underscores the value of integrating community voices, cultural heritage, and sustainable development principles to create urban interventions that are socially equitable and environmentally responsible. It serves as a model for future initiatives, emphasizing the need for collaboration, adaptability, and innovation in tackling the complexities of urban transformation. Through this comprehensive approach, the Creative Cultural Corridor not only reimagines the city's public spaces but also inspires a broader conversation on the role of design in shaping sustainable and inclusive urban futures.

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PROJECTING THE PROCESS

From Assessment to Improvement: An Approach of Landscape Performance Analysis

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Abstract

In the context of high-quality development, research on landscape performance needs to explore its potential for utilization based on objective evaluation and develop precise analytical techniques. This study takes pedestrian blocks as a case example and focuses on the relationship between spatial composition and landscape performance. We establish a technical approach for analyzing landscape performance that integrates landscape spatial information translation, landscape performance index measurement, and threshold assessment, and collect 45 samples and obtain their indicator. Furthermore, the mechanism between each indicator and landscape performance is explored by using multivariate statistical analysis. Subsequently, the threshold intervals for each indicator are analyzed to identify the ideal range to form criteria for judging the landscape performance. By setting weights and assigning grades, the landscape performance benefit is comprehensively measured and mapped. Finally, based on the spatial clustering characteristics of each indicator and the assessment result of landscape performance benefit, the priority of the indicator and the key areas for renewal are clarified. This study provides a set of workflow for objectively assessing the landscape performance, and has important practical significance for optimizing landscape space and improving landscape performance benefits assessment efficiency and accuracy.

Keywords: Landscape performance, quantitative assessment approach, evidence-based benefit enhancement design

1. Introduction

Landscape performance (LP) analysis is essential in creating livable, equitable, and resilient landscapes (Barnes, 2024). Current research emphasizes the measurement of benefits in built projects. The landscape performance series (LPS), proposed by the Landscape Architecture Foundation (LAF), measures sustainable benefits across three dimensions: environmental, social, and economic performance benefits. This framework has developed a comprehensive set of indicators, benefit measurement tools, and workflows. Additionally, the LAF-funded Case Study Investigation (CSI) Program has generated numerous empirical cases for LPS (Yang, 2020). However, the potential of large sample databases remains underexplored, and the relationships among various indicators for the benefit outcomes are not yet clear (Yang & Lin, 2020). Therefore, a targeted performance assessment system and an evidence-based improvement approach need to be established.

İn this paper, we propose a landscape performance analysis approach designed to address three key questions:

(1) How can a scientific and reasonable performance indicator system be constructed? In particular, can various benefit dimensions complement one another?

(2) How should the judgment standard for LP be established? Specifically, does a higher benefit in LP equate to better performance?

(3) How can performance measurement results guide design practice at the spatial level?

2. Material and Method

Aiming at enhancing LP, this research utilizes pedestrian blocks as a case study, focusing on the scientific identification and assessment of LP. Guided by LP and evidence-based design theories, we establish a systematic approach to LP analysis that includes landscape spatial information translation, LP index matrix measurement, and LP threshold assessment for key issues (Figure 1).

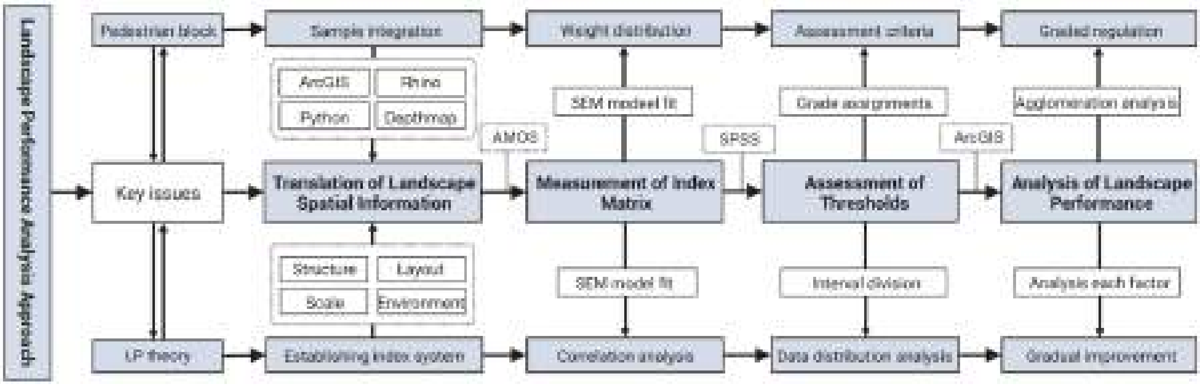

Figure 1. Technical roadmap of pedestrian block landscape performance analysis

2.1 Translation of landscape spatial ınformation

The quantitative translation of landscape spatial information is a fundamental step for scientifically analyzing composition patterns and assessing LP. This process involves establishing a factor system and formulating translation algorithms.

First, we develop an observation indicator system for pedestrian blocks based on classical theories and significant advancements from the past decade. We categorize the factors associated with LP into four key dimensions: spatial structure, spatial layout, block scale, and landscape environment (Shen & Karimi, 2016; Ewing & Handy, 2009). In this framework, streets provide the structural skeleton of pedestrian blocks, with their spatial relationships influencing accessibility and vitality. The spatial layout represents the fundamental texture of the block, formed by the arrangement and combination of tangible factors within the block and intangible external spatial factors. Block scale serves as a physical characteristic that shapes spatial morphology and reflects users' intuitive perception of three-dimensional space. Additionally, the landscape environment emphasizes the aesthetic qualities of public spaces and the creation of a sense of place, acting as a catalyst for improving and rehabilitating underperforming areas while enhancing the overall quality of the block's environment.

Subsequently, we select 45 representative pedestrian block cases in China. Using Depthmap, Grasshopper, and Python, we set algorithms for each factor to facilitate data translation (Figure 2). ArcGIS serves as our primary operating platform for integrating, overlaying, and statistically analyzing the spatial components of the pedestrian blocks. SPSS is utilized for data analysis to examine the mechanisms of LP and conduct quantitative assessments.

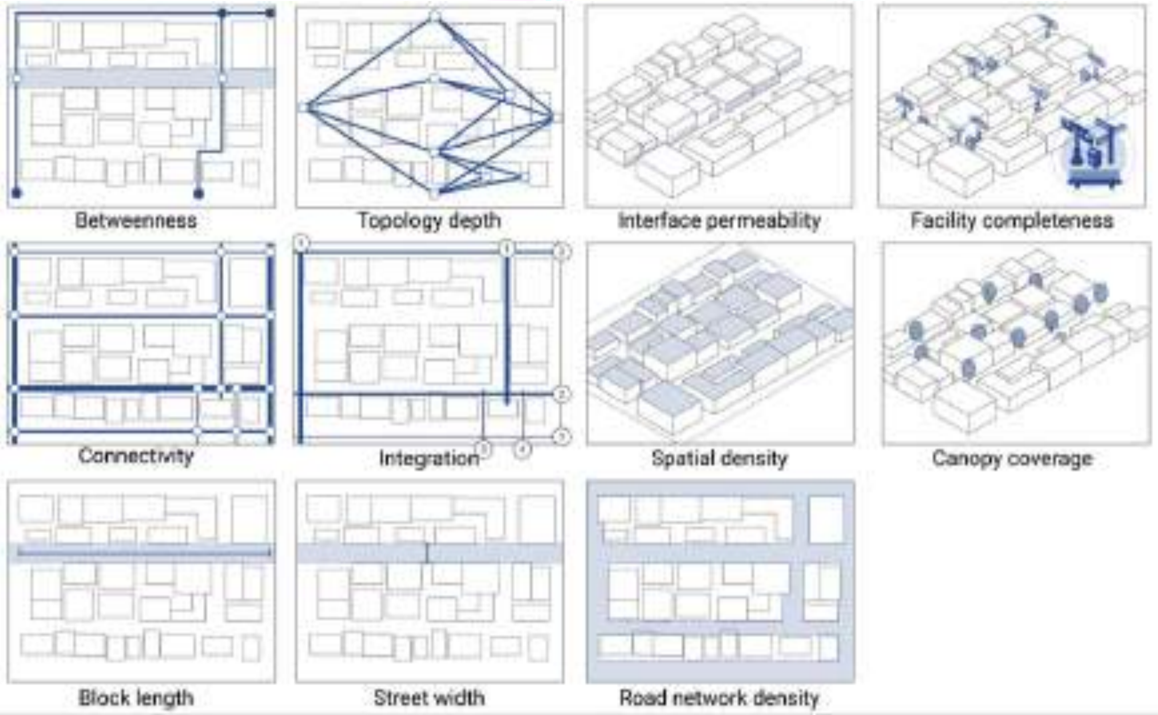

Figure 2. Landscape performance indicator system for pedestrian blocks

2.2 Measurement of landscape performance ındex matrix

To analyze the mechanisms associated with LP in pedestrian blocks, we employ the Structural Equation Model (SEM) due to the complexity of interactions among numerous factors and the high dimensionality of the data (Moustaki, 2004).

The core logic of SEM is to transform the causal relationships between variables into a mathematical matrix, allowing for the calculation of the fitness between the theoretical model and empirical data, thereby validating the reliability of the theoretical model (Sharafatmandrad, 2020). A key advantage of SEM is its capability to address unobservable variables within urban spaces, facilitating the batch processing of variable systems and enabling comprehensive evaluations of multi-factor datasets. This is particularly useful for assessing landscape resource allocation and informing landscape renewal decision-making, thereby providing essential prerequisites for scientifically verifying and analyzing LP.

Measuring the LP index matrix through SEM involves several steps: establishing path relationships, conducting model fit tests, and normalizing factor loadings. By interpreting the index matrix, we can identify the key factors influencing the LP of pedestrian blocks.

2.3 Assessment of landscape performance thresholds

Establishing effective evaluation criteria for LP that accurately reflect the outcomes of spatial configurations poses a significant challenge in translating performance assessment into practical applications. The threshold analysis method leverages the distribution patterns of observed data as the basis for interval division. By flexibly defining these thresholds based on the specific conditions of various research subjects, this method enables a more scientific analysis of LP that aligns with real-world contexts.

Based on the probability distribution of each factor's data, we categorize the dataset into five distinct interval levels. Values are assigned to these intervals, decreasing from the center towards the edges. When evaluating the performance of new research samples, values are allocated according to the corresponding interval of the measurement data.

By integrating the LP index matrix with the level intervals of each factor, we obtain a comprehensive result for LP through weighted aggregation. This enables the quantitative identification and measurement geographical positioning of components within pedestrian blocks. Furthermore, it is possible to analyze factors individually based on the patterns of data composition and the mechanisms of factor association. This approach identifies key areas for renewal, optimization strategies, and design interventions aimed at enhancing overall performance.

3. Findings and Discussion

3.1 Results of landscape performance ındex matrix and threshold ınterval analysis

Following a reliability assessment of the dataset, we utilized AMOS software to construct and analyze the structural equation model (SEM). This process generated standardized path coefficients, resulting in a landscape performance ındex matrix for the pedestrian block. A coefficient closer to 1 indicates a stronger positive association of that factor with LP, while a value closer to -1 signifies a greater negative impact. The SEM model fit results (Figure 3) reveal that the LP is influenced by 4 dimensions and 11 factors. Notably, spatial structure (0.938) and block scale (0.767) emerged as the primary dimensions affecting LP. The spatial density (-0.703), vegetation coverage (-0.384), and road network density (-0.609) were negatively associated with spatial layout and block scale.

By using the percentile points of the dataset as critical values for interval boundaries, we defined five ordinal grade levels and assigned corresponding scores. The specific distribution of values for each factor, along with the results of the threshold interval division, is illustrated in Figure 4. A score of 3 represents the critical threshold for LP conversion; higher scores indicate stronger performance for that factor.

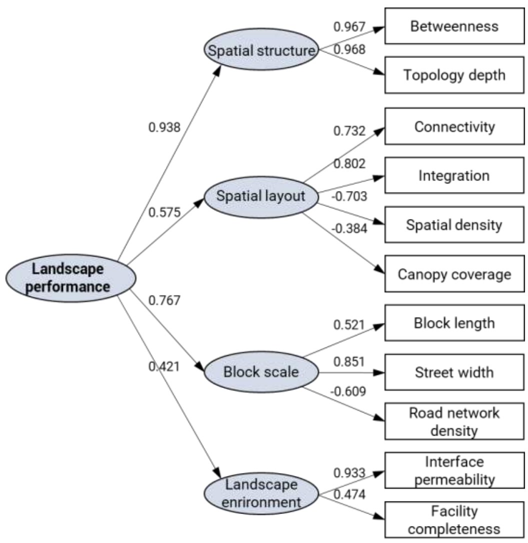

Figure 3. Path coefficient diagram of pedestrian block landscape performance model

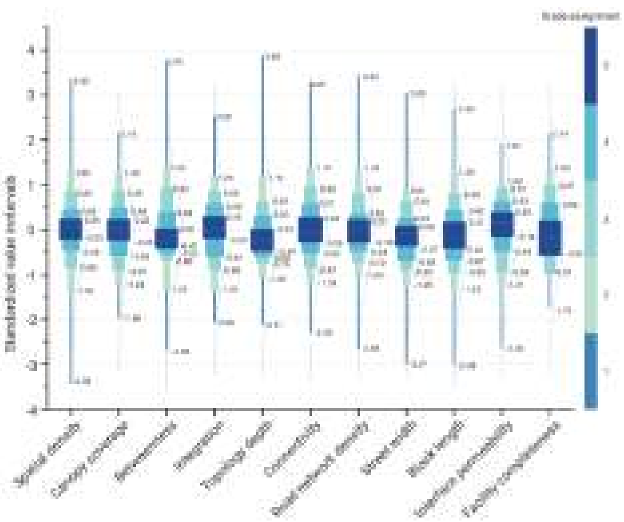

Figure 4. Standardized value intervals for each observed factor

3.2 Results of landscape performance in pedestrian blocks

After thoroughly understanding the mechanisms and data patterns influencing LP, we conducted a detailed analysis of the contributing factors in a specific case study. Using the

Nanjing Confucius Temple pedestrian block as our example, we gathered data on various factors and input this information into the ArcGIS platform. Each factor's data was categorized and assigned values through threshold interval analysis.

The path coefficients obtained from the structural equation modeling (SEM) fitting were then used as weights for an overlay analysis, resulting in a comprehensive measurement of LP, which we geographically displayed across different levels.

Building on this, we analyzed the spatial clustering characteristics of the performance assessment results. Areas with low values were identified as inefficient spaces that required improvement (Figure 5). Within the study area, LP showed a significant uneven distribution, with higher performance observed along roads connecting major entrances and the main streets of the central area. In contrast, low-performance areas were primarily clustered around Jinling Road, Xishichang and Dongshichang, Daqianfu Alley, and the eastern section of Jiankang Road.

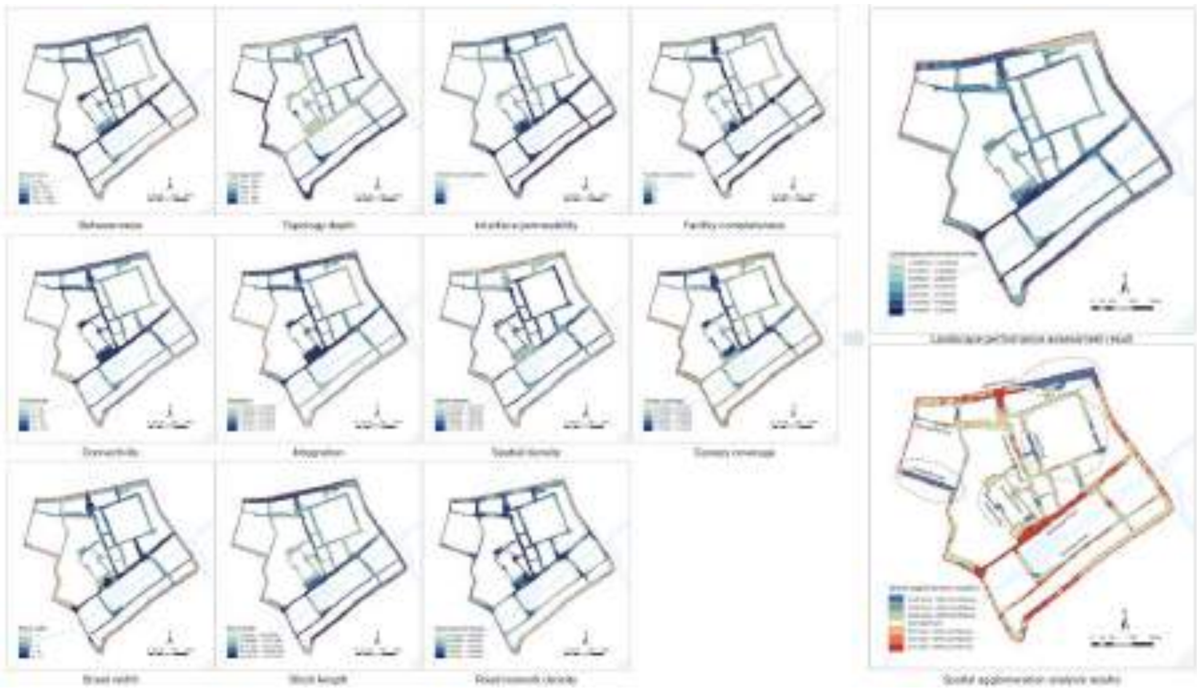

Figure 5. Landscape performance overlay analysis for an individual sample

Next, we constructed a key segment factor update judgment matrix, with "performance rating" on the horizontal axis and the path coefficients from SEM fitting on the vertical axis (Figure 6). By analyzing the different quadrants in which each indicator falls, we identified the key driving factors and potential weaknesses in each segment of the Confucius Temple pedestrian block, establishing a priority order for landscape environmental governance (Li, 2020). The results indicate that key areas for focused improvement are high-correlation factors, low-performance clustering, and low-factor clustering.

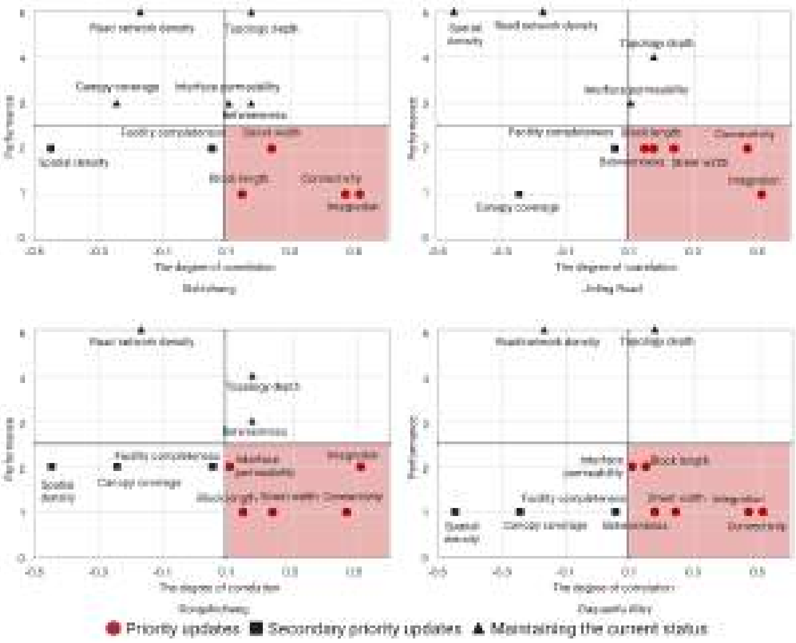

Figure 6. Update judgment matrix for key segments of Confucius Temple pedestrian block

4. Discussion

Based on our findings, we propose several enhancement strategies to achieve evidence-based improvements.

4.1 Macroeconomic regulation based on correlation patterns

The LP index matrix enables us to identify key factors that should be prioritized during the renewal of pedestrian blocks. The order of updates should be determined by the degree of interrelationship among these factors. In addition, the threshold interval obtained from the distribution pattern of each factor data is set as the optimal value range. By comparing the measurement data of each factor with these thresholds, we can further clarify the optimization directions for each factor.

In the context of pedestrian blocks, it is important to understand the complex interdependencies among individual factors such as spatial density, road network density, and canopy coverage, which are negatively correlated with LP. This indicates that when implementing landscape renewal designs, one should not focus solely on increasing positively correlated factors in isolation to improve LP. Instead, it is essential to maintain key influencing factors within their optimal value ranges while also considering the ratios and combinations of various factors within the pedestrian space.

Additionally, identifying these patterns requires extensive data collection. Therefore, it is crucial to continually improve the construction of the database, gradually refining it to establish performance assessment standards and enhancement strategies that can serve as benchmarks for the industry.

4.2 Targeted strategies based on spatial aggregation features

Given the spatial aggregation characteristics of various factors, targeted policy measures should be developed to promote regional transformation and renewal through a bottom-up micro-intervention approach, beginning at specific points and expanding outward.

For areas exhibiting both high correlation and performance, as well as those with low correlation but high performance, it is crucial to maintain their existing advantages. These spaces can serve as catalysts for enhancing the performance of surrounding areas. Conversely, in spaces where both correlation and performance are low, adjustments should be made according to the thresholds of each factor to address baseline deficiencies. We recommend establishing a list of localized enhancement strategies to facilitate evidence-based improvements for individual spaces (Zhao, 2018).

Additionally, the transition methods between each transformation unit and the surrounding spaces should be carefully considered to ensure a seamless connection in terms of circulation, functionality, and form. By applying simple updating design techniques to a multitude of micro-transformation spaces, an overall enhancement of LP in pedestrian blocks can be realized.

4.3 Creating scenes to enhance landscape performance

The spatial structure, layout, and scale are essential components of landscape space. However, improving overall LP within existing spaces poses significant challenges, particularly due to limitations associated with demolition and construction during the renewal process. Our research highlights the connection between interface permeability and the completeness of facilities within the landscape environment. As a result, optimizing the landscape environment—especially the street-facing buildings—becomes a crucial strategy for enhancing LP and creating a vibrant commercial atmosphere.

In building-dominated pedestrian blocks, these factors influence street spaces' openness and visual orientation, thereby affecting pedestrians' path choices. Moreover, in high-traffic alleys and nodes, strategically arranging outdoor furniture and landscape facilities can stimulate more activities, improving both functionality and a sense of place within the pedestrian block.

5. Conclusion

In the context of stock-based, refined, and quality-oriented development in urban renewal, exploring digital methods for LP and scientifically guiding evidence-based enhancements of landscape spaces are critical issues in contemporary research and practice. Transitioning from performance assessment to improvement requires exploring the correlational mechanisms of LP, allowing for an objective evaluation of the current state of spatial development.

This study takes pedestrian streets as a case example and proposes a technical approach for analyzing LP. It integrates landscape spatial information translation, index matrix measurement, threshold interval analysis, and empirical research. The empirical results demonstrate that this approach distills the advantageous characteristics of classic cases through large sample data, achieving a quantitative description and scientific analysis of the correlation patterns of LP from four dimensions: spatial structure, spatial layout, block scale, and landscape environment. Our study provides a technical methodology for LP analysis, moving from experience-based qualitative research to data-driven quantitative assessments. This approach offers evidence-based justification for spatial enhancement designs and holds significant potential for application in urban renewal.

This study also has limitations that require further refinement. In constructing the factor system, future analysis should expand from purely physical space to include the associative effects among functional attributes, individual perceptions, and group behaviors. This broader approach will yield a more comprehensive understanding of landscape space's composition and relational mechanisms. Additionally, further research could focus on comparative analyses of LP across different types of spaces and their temporal evolution, revealing deeper insights into the developmental trajectory of landscape spaces. As the theoretical framework and technical approaches continue to improve, relevant research methods should be further validated through practices. This will facilitate the transition from theory to practice, allowing for stable assessments of LP and the development of precise policy-making models.

Acknowledgments

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Urban Riverside Green Space Cultural Ecosystem Services from Online Commentary

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Abstract

Urban riverside green spaces hold significant ecosystem service value, particularly in cultural services (CES). This study aims to evaluate these services in detail to better address the public's basic cultural needs. Using the riverside green space of the Hutuo River in Shijiazhuang City, Hebei Province, as a case study, a CES perception evaluation method tailored to urban riverside green spaces is proposed. Social media data from the site are utilized to extract effective information from user-generated comments, linking it with venue-specific data. The evaluation results are spatially mapped onto specific landscape features, and spatial autocorrelation analysis is applied to identify priority renovation areas. The findings reveal:Areas with high CES comprehensive value are primarily located in the Hutuo Flower Sea and Hutuo Ecological Island.Four categories of zones are identified:High-service, high-usage hotspots;Low-service, low-usage cold zones;High-service, low-usage renovation zones;Low-service, high-usage improvement zones. The study expands CES evaluation by incorporating social media text data as a novel source. The integration of word frequency analysis and text segmentation techniques enhances the accuracy of CES evaluations by more effectively linking social media content with landscape features. This method provides valuable guidance for the renovation and improvement of urban riverside green spaces.

Keywords: Ecosystem cultural services, urban riverside green spaces, social media, landscape perception evaluation, word frequency analysis, spatial mapping

1. Introduction

Urban green spaces are an important component of urban natural ecosystems, offering various ecological benefits such as regulating climate, purifying the environment, and maintaining biodiversity. They can also provide spiritual and cultural services for humanity (Dong et al., 2014; Sylla et al., 2020; Yang et al., 2022; Zhu et al., 2023). Cultural ecosystem services (CES) are key indicators in ecosystem research, used to evaluate perceptions and preferences of green spaces. CES evaluations of urban riverside green spaces help assess urban residents' attitudes toward green spaces and enhance understanding of users' perceptions of these spaces (Ostoić et al., 2017).

Social media comment text data contains a wealth of tourist experience information, such as landscape photos (Ghermandi et al., 2020; Figueroa-Alfaro et al., 2017), sightseeing experiences (Dai et al., 2019; Zhang et al., 2022), and emotional expressions, offering researchers opportunities to better understand public perceptions of green spaces. However, CES research based on social media comment text data faces three main shortcomings: (1)The research scale is limited. Due to the accuracy constraints of online comment data placement, researchers find it challenging to conduct detailed evaluations of specific attractions or landscape features within parks. (2)A significant portion of social media comment text data lacks geographic spatial information. (3)CES evaluation results have yet to be effectively linked with actual tourist activities, making it difficult to provide precise guidance for planning and renovation of venues.

China's large-scale participatory social media platforms provide advantages, such as extensive data volumes and reflections of authentic user sightseeing experiences (Kim et al., 2019). Their comment information offers a highly potential source of perception and evaluation data for urban riverside green spaces. Additionally, the perception and evaluation of CES based on social media data have diverse correlations with the actual usage of venues. In-depth exploration of the spatial relationship between the two can yield more scientific and practical recommendations for venue optimization across different spatial patterns (Schirpke et al., 2018; Vaz et al., 2020).

This study uses participatory social media comment text data as the primary data source. First, high-frequency location-specific vocabulary is identified through word frequency analysis and text segmentation techniques, and a "scenic spot land use" graded location dictionary is constructed. Second, using the location dictionary, comment data is linked to specific venue spaces, with CES serving as the evaluation index to assess cultural service perceptions of urban riverside green spaces. Finally, by analyzing the spatial autocorrelation between the comprehensive value of CES and venue utilization, targeted recommendations are provided for planning and renovation of various areas within the venue. This method enables evaluations of specific landscape spaces without geographic coordinate data and provides a robust foundation for optimizing and renovating urban riverside green spaces.

2. Material and Method

2.1 Overview of the study area

This study selected the riverside green space along the urban section of the Hutuo River in Shijiazhuang City, Hebei Province, as the research object (Figure 1). The research section spans 42 km in length and encompasses a water body area of 2,925.58 hectares, situated near the main urban area of Zhengding County, Shijiazhuang City. The spatial landscape features are diverse, including wetlands, islands, flower fields, and other plant-based landscapes.

Figure 1. Distribution of scenic spots in the study area

2.2 Research Methods

This study constructs a landscape information dictionary database, associates comment data with spatial sites, and conducts CES perception evaluations. The research process is divided into the following six steps (Figure 2):

(1) Using Python web crawlers to obtain text data and usage trajectory data from social media comments on the site. Perform word frequency analysis on the text data, identify high-frequency vocabulary related to the site, and construct a location information dictionary.

(2) Extract scenic spot information and land use data from segmented social media comment texts based on the location information dictionary.

(3) Construct a CES indicator system and create a venue CES dictionary based on word frequency analysis, extracting CES evaluation information from the segmented comment texts.

(4) Encode scenic spot and land use information, associate the comment texts with site spatial data, and conduct CES spatial perception mapping.

(5) Calculate the kernel density of trajectory data to represent usage intensity within specific areas of the site.

(6) Use spatial autocorrelation methods to explore the relationship between the comprehensive value of CES and venue utilization, and propose suggestions for venue renovation design.

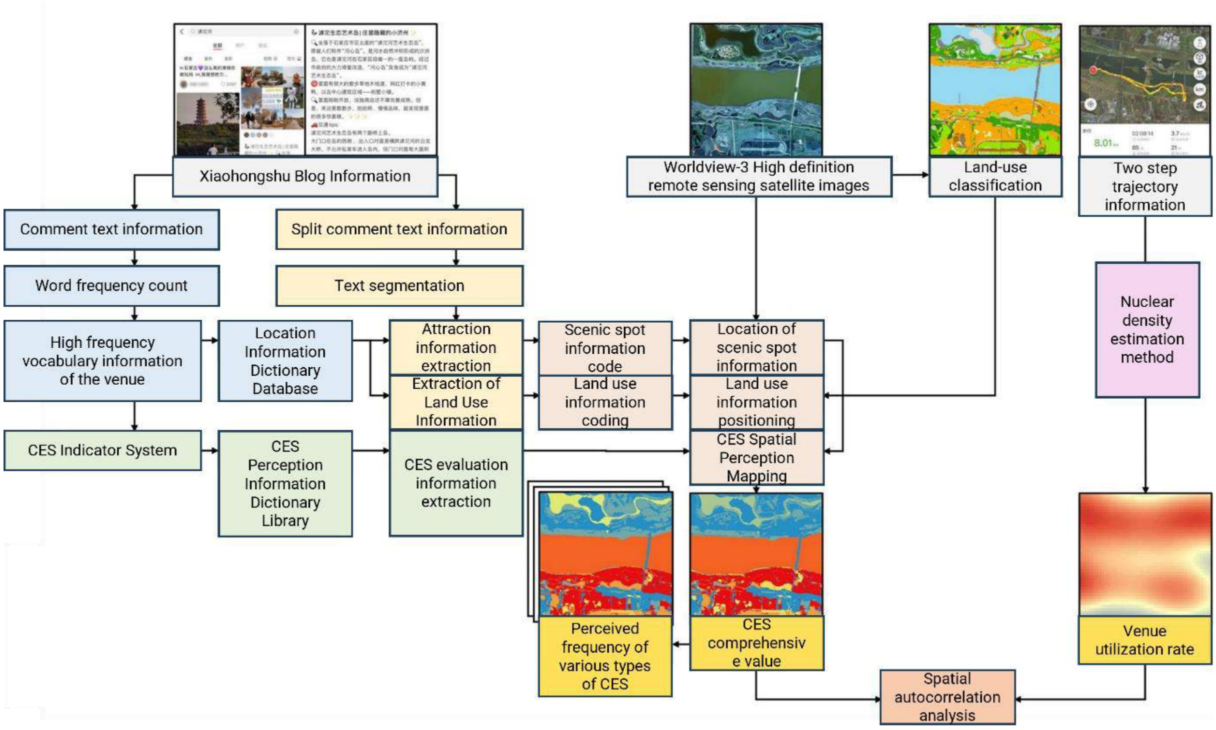

Figure 2. Technical route

This study evaluates the content of social media comment texts and uses a "scenic spot–land use" linkage approach for data spatial positioning and CES perception analysis. Python's third-party library jieba is employed to conduct word frequency analysis on preprocessed text. The analysis identifies key information vocabulary, which is then used to establish a research site dictionary. Based on high-frequency keywords, landscape-related terms are selected to summarize the scenic spots, land use types, and CES perception information mentioned in the research site. Two dictionaries—one for scenic spots and one for land use—were created, totaling 101 words. The CES perception information dictionary includes 317 words.

For CES classification, the study refers to the frameworks provided by the Millennium Ecosystem Assessment (MA), The Economics of Ecosystems and Biodiversity (TEEB), and the Common International Classification of Ecosystem Services (CICES). Combined with CES segmentation results, six CES types were selected: Tourism and recreation, Science education, Spiritual satisfaction, Aesthetic experience, Social relations, and Cultural heritage (Costanza et al., 1997; Kumar et al., 2012; Jónsson et al., 2016; Haines-Young et al., 2018).

Using land use information derived from WorldView-3 remote sensing images and maps enhanced with scenic spot data as the base map, the map is encoded using the "scenic spot–land use" method based on the location information dictionary. Cultural service types extracted from the corresponding comments are matched with the location codes. The formula for calculating the perceived frequency of each CES type is as follows:

$$F_j = \frac{n_j}{n}$$

In the formula: F_j represents the perceived frequency of the j-th type of CES at the venue. n_j denotes the number of word segments mentioning the j-th type of CES. n is the total number of text word segments related to the venue.

The evaluation data for site utilization in this study was derived from trajectory data captured by the official website of the Two Step Road Outdoor Network. By identifying hotspot areas of event distribution and applying distance decay to measure changes in time density (Cai et al., 2012), the study used the kernel density of trajectory data at different locations to represent the level of usage in specific areas of the site. Additionally, the intensity of visitor activity was analyzed based on the clustering degree of their travel trajectories (Okabe et al.,2009). Geoda software was employed to conduct Local Indicators of Spatial Association (LISA) clustering analysis, exploring the relationship between the comprehensive value of CES and site utilization.

3. Findings and Discussion

3.1 Perception of cultural services in urban riverside green space ecosystems

3.1.1 Spatial distribution of the comprehensive value of ecosystem cultural services

The comprehensive value evaluation of cultural services in the site ecosystem (Figure 3) reveals a highly clustered distribution of areas with higher values, predominantly located near water bodies and coastal sites. The hotspots within the research area are primarily concentrated in the Art Ecological Island, Hutuo Wetland, Fountain Square, Hutuo Flower Sea, and surrounding areas. Among these, Hutuo Flower Sea exhibits the highest intensity, with a comprehensive CES value of 217. The ground cover, forest land, and shrubs within this area receive significant attention. Hutuo Ecological Island follows with a comprehensive CES value of 72, where the island's land cover scenery contributes to higher overall CES benefits.

3.1.2 Spatial distribution of perceived frequency of cultural services across ecosystem types

The spatial distribution of perceived frequency for the six CES types within the venue is depicted in Figure 4. Sightseeing, recreation, and aesthetic experience services are predominantly concentrated in Hutuo Wetland and the surrounding waters. Educational science popularization and spiritual satisfaction services are primarily focused around water and wetland areas (Lin et al., 2022). Social relationship services are notably distributed near water bodies and popular venues such as Hutuo Flower Sea and Hutuo Ecological Island. Cultural heritage services are commonly observed at locations including Hutuo Flower Sea, Fountain Square, Shengli Street, the characteristic locomotives and their nearby waters, as well as Mingxi Lake Park.

3.2 Spatial distribution of utilization of urban riverside green spaces

Site utilization was evaluated using the kernel density estimation method (Figure 5). Areas with high-intensity usage are predominantly concentrated along the middle and eastern coasts of the site, including Hutuo Ecological Island, Hutuo Wetland, Hutuo Flower Sea, and Mingxi Lake Park. These locations demonstrate a high frequency of visitors and significant vitality. In contrast, sites such as Diecui Mountain Park, Olympic Sports Park, and Xingye Park exhibit lower levels of construction and correspondingly lower site utilization.

Figure 3. Technical route

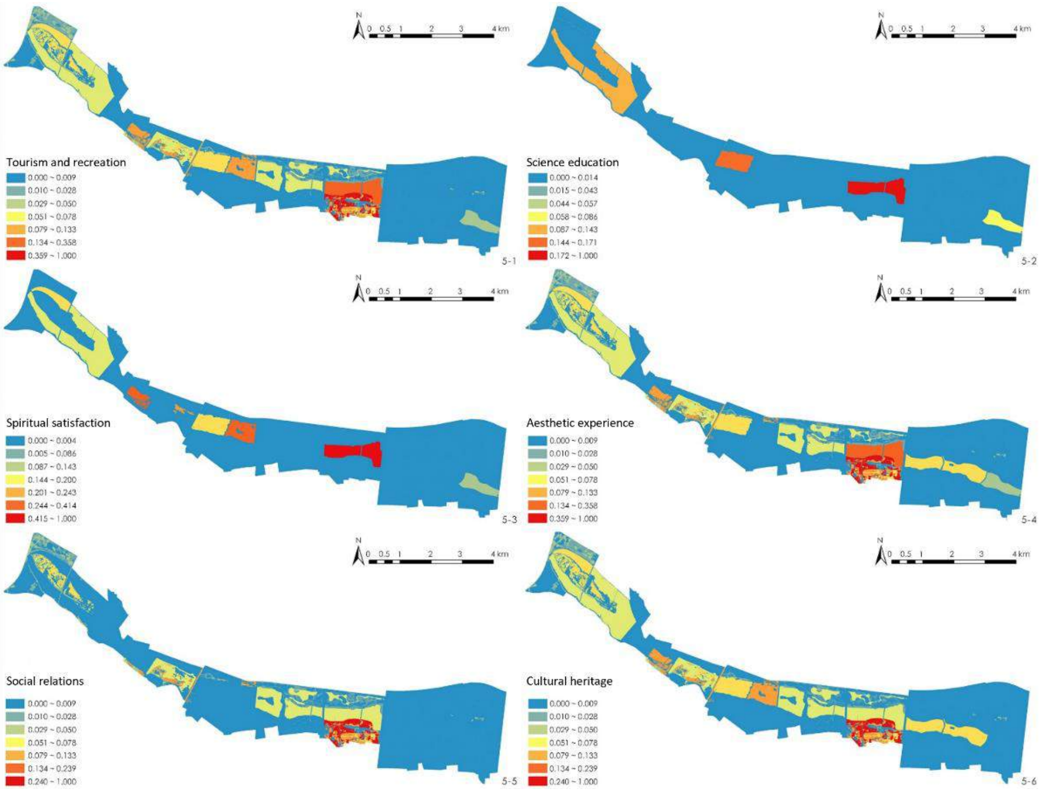

Figure 4. The spatial distribution of CES value of various types of riverside green space in urban section of Hutuo River

3.3 Spatial autocorrelation analysis of cultural services and site utilization in urban riverside green space ecosystems

The local bivariate Local Moran's I for the research site is greater than 0, with a P-value of less than 0.001 and a Z-score of 22.625, indicating a significant correlation between the comprehensive CES value and site utilization (Liu et al., 2019). The LISA clustering map (Figure 6) ($P < 0.050$) highlights the spatial correlation characteristics between the CES comprehensive value and venue utilization in the study area.

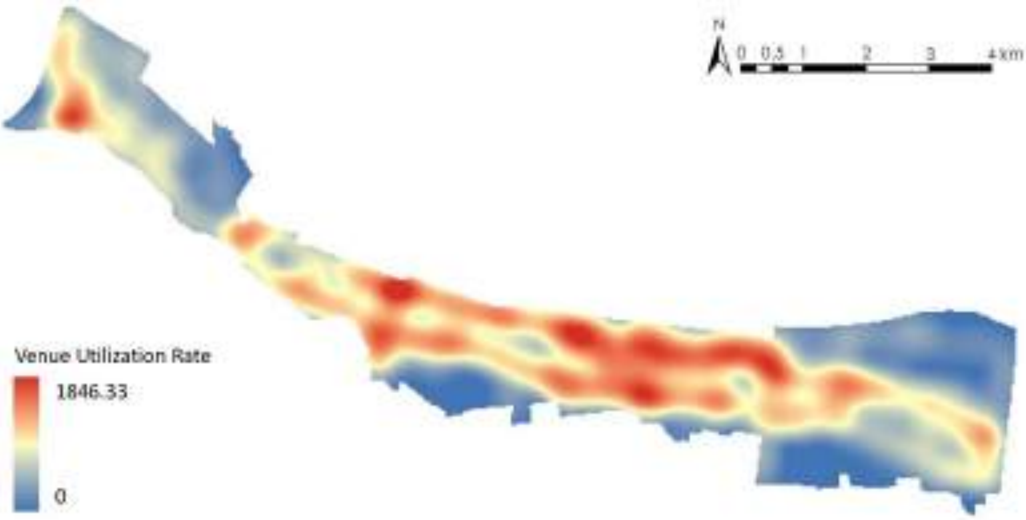

Figure 5. Spatial distribution of usage degree of riverside green space in urban section of Hutuo River

The high-high aggregation areas are mainly concentrated in the Hutuo Wetland, the western part of Hutuo Ecological Island, and the vicinity of Hutuo Flower Sea, demonstrating both high comprehensive CES values and high utilization rates, thus reflecting significant recreational value (Anselin et al., 1995). Conversely, low-low aggregation areas are primarily found in locations such as Diecui Mountain Park, Xingye Park, and Olympic Sports Park, where CES levels and venue utilization rates are both low. High-low aggregation areas are observed mainly in the waters north of Hutuo Ecological Island, while low-high aggregation areas are concentrated near the site's water regions and along both sides of the riverbanks.

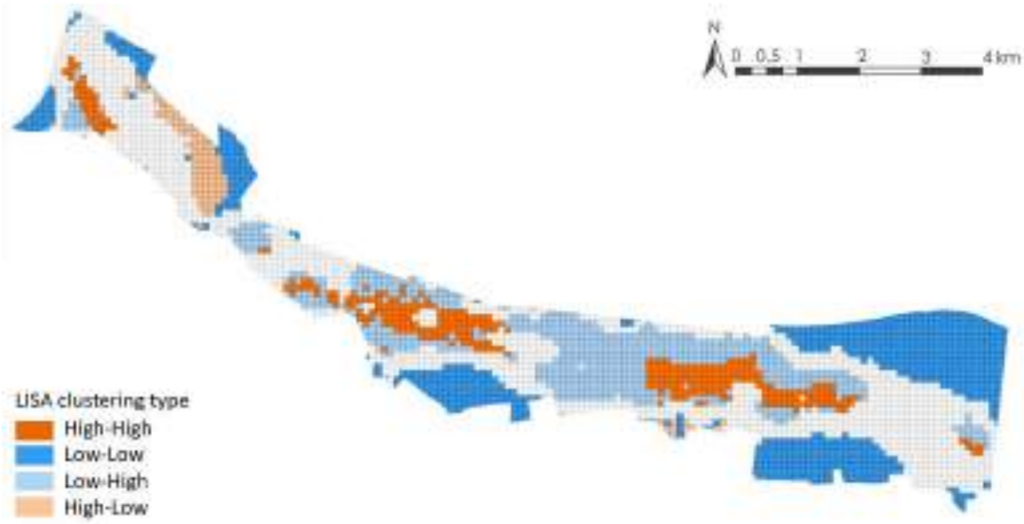

Figure 6. LISA cluster analysis of CES comprehensive value and venue usage

4. Conclusion

4.1 Advantages of perceiving ecosystem cultural services based on social media text data

In recent years, CES evaluation using social media data has emerged as a prominent research area globally. However, due to limitations in geographic positioning data accuracy and available data volume, most studies have focused on large-scale green spaces or urban park clusters, with limited attention to open urban riverside green spaces. This study introduces a CES spatial perception mapping method that does not require geographic spatial data from social media. The visualization effectively captures user evaluations of open riverside green spaces, broadening the data sources for CES perception and addressing the gap in evaluation data for these spaces. It also provides a new approach for researchers to collect public opinions more comprehensively.

The method demonstrates broad applicability and highlights the uniqueness of specific sites. In practical applications, it is not constrained by site type or data completeness, offering new perspectives for researching and managing riverside green spaces. Moreover, the customized "one site, one dictionary library" data processing approach fully leverages the unique characteristics of research areas, enabling comprehensive and multi-dimensional park descriptions. This tailored approach provides park managers with a customized tool to enhance management strategies, plans, and decision-making. By deeply understanding park features and collecting extensive data, managers can develop more precise and effective management strategies.

4.2 Bivariate spatial autocorrelation analysis to guide planning and transformation

The spatial aggregation types of CES comprehensive value and site utilization reveal the distinct characteristics of sites within the study area, offering valuable insights for planning and renovation.

(1) High-High Aggregation Areas: These sites exhibit high cultural service levels and utilization rates, marking them as high-quality hotspots. Maintaining their current status and ensuring sustainable operation should be the priority.

(2) Low-Low Aggregation Areas: These cold spots have low cultural service levels and usage rates, often due to underdeveloped infrastructure and insufficient services. Renovation efforts should prioritize updating these sites and enhancing supporting facilities.

(3) High-Low Aggregation Areas: These venues have high cultural service levels but low utilization rates, often related to social hot topics. Their low usage highlights incomplete construction, suggesting the need for improvements in accessibility and public space openness.

(4) Low-High Aggregation Areas: These sites have high usage rates but low cultural service levels, requiring improvements in their cultural offerings and public visibility. Emphasis should be placed on constructing distinctive landscapes and enhancing tour guide systems.

This study developed a method for evaluating CES without geographic location data, enabling the visualization of cultural service levels and the identification of distinct planning and renovation zones. This approach offers a viable solution for evaluating urban riverside green spaces lacking geographic location data and expands the data sources available for cultural service perception evaluations. The method effectively reflects visitors' perceptions, provides refined evaluation positioning, and identifies the supply of various cultural services. Additionally, it can be applied to other riverside green spaces to assess service levels, analyze the supply-demand relationship between tourists and green spaces, and inform targeted renovation suggestions for decision-makers. Future studies should consider integrating multi-source social media data with traditional methods such as participatory mapping to include diverse demographic groups, thereby enhancing the CES evaluation framework.

Prior Publication

Li Haoran, Liu Zhe, Li Xiaoxi&Zheng Xi (2023). Cultural Service Evaluation of Urban Riverside Green Space Ecosystem Based on Social Media Text Landscape Architecture (08), 80-88

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Construction of ROS of River Beach IGS in Mountain City

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Abstract

As a special type of informal green space (IGS) with important recreational value in mountain city, which has become a popular recreational destination in recent years. In order to explore the rational utilization of river beach IGSs, it is necessary to identify and classify them from the perspective of recreation opportunity. First, this research discusses the definition and characteristics of rive beach IGS in mountain city. Next, through field investigation, questionnaire investigation and factor analysis, this research identifies four types of recreation environments, including natural experience type, daily life type, humanistic characteristic type and urban tourism type. Finally, construct the recreation opportunity spectrum of river beach IGS in the range of two rivers and four banks in Chongqing, and puts forward feasible suggestions for the planning, construction and management of river beach IGS in mountain city from the perspective of improving recreation experience. This research is of important reference significance for improving the blue and green space system of mountain city dominated by formal green space and supplemented by IGS, and also expands the application scope of IGS and the research on ROS.

Keywords: Landscape architecture, informal green space (IGS), recreation opportunity spectrum, river beach, Chongqing

1. Introduction

Informal green space (IGS) refers to green space in the built environment that is not formally categorized by managers or landowners (Rupprecht et al., 2014; Rupprecht & Byrne, 2014), and is a low-cost "patch" of urban green infrastructure (Liu et al., 2023). Due to the multi-dimensional spatial form and restricted construction conditions of mountain cities, IGSs are widely present, and some of them have significant open potential and value. Therefore, the effective utilization of IGSs is an important way to explore the open and shared blue-green spaces in mountain city.

As a special type of IGS with important recreational value in mountain city, river beach is one of the main space carriers for residents to carry out waterfront activities and enhance the characteristic recreational experience of mountain city, which has become a popular recreational destination in recent years. However, most of the existing studies on IGS paid less attention to the recreational attributes of river beaches.

This study takes the two rivers and four banks in Chongqing as an example, aiming to clarify the definition and scope of the river beach IGS in mountain city. By adopting comprehensive methods of on-site investigation, questionnaire survey, and factor analysis, this study explores the construction of the recreational opportunity spectrum of the river beach IGS, focusing on the following three issues: 1) How to classify the river beach IGS in mountain city from the perspectives of the recreational environment, recreational behavior, and recreational experience? 2) How do the environmental characteristics of each type of river beach support recreational activities and recreational experiences? 3) How to propose strategies for optimizing the recreation environment of the river beach from the perspective of enhancing the recreational experience?

2. Material and Method

2.1 Definition and characteristics of river beach IGS in mountain city

The undulating terrain of mountain cities creates diverse habitats, and the blue-green space has more distinctive vertical characteristics compared to plain cities, which creates a large number of IGSs that are difficult to identify by hard indicators, such as greening rate. IGS in mountain city is characterized by three points: 1) fragmented distribution and clustering (Zheng, 2021), due to the fragmented topography, many spatial units are not effectively related to each other, but are closely integrated with landscape habitats; 2) three-dimensional greening is of various types and covers a large area, such as steep slopes and ramparts (Liu & Xiang, 2022); 3) three-dimensional greening is usually compounded with other types of IGS, such as IGSs under elevated riverside bridges, which can be simultaneously characterized by three-dimensional greening, abandoned plots and waterfront greenspace.

River beach IGS is a special type of IGS with typical regional value in mountain city, which is defined as a non-construction land below the urban river management line, submerged and exposed to the water in specific seasons, open for public use or with open potential (Chongqing Jiangbei District Urban Management Bureau, 2023), and we focus on the river beach IGS with recreational value (Figure 1).

Figure 1. Schematic diagram of river beach structure in mountain city

River beach IGS combines natural and cultural characteristics in mountain city. Natural characteristics include seasonal flooding, abundant marginal habitats (Rupprecht et al., 2015) and topography undulating waterfront, while the humanistic characteristics include no construction, close connection with man-made facilities and control ambiguity leading to bottom-up spontaneity (Liu, 2020). Among them, the periodic rise and fall of water levels in river beaches caused by seasonal precipitation, artificial regulation, and climate change, is the basis for the identification of river beach IGS in mountain city.

However, river beach IGS has generated many usage problems due to its informal nature, such as some river beaches being overcrowded while others are rarely visited. In order to explore the rational utilization of river beach IGSs, it is necessary to identify and classify them from the perspective of recreation.

2.2 Research area

Chongqing is a typical mountain city in China, and the two rivers and four banks in Chongqing refer to the four riverbanks of the Yangtze River and Jialing River, with distinct canyon-type geomorphological features. The water level is both affected by the storage of the Three Gorges Reservoir and flood seasons (Chongqing Planning and Natural Resources Bureau, 2019), leading to large areas of river beach being exposed during low water periods, with a large number of spontaneous recreational activities. Based on the field research, satellite maps during low-water period and relevant policy documents, we selected typical river beach IGSs within the recent upgrade scope of the two rivers and four banks of Chongqing, i.e., the area of Ciqikou, Danzishi and Yuqiuhao, as the research area (Figure 2).

However, river beach IGS is difficult to be accurately localized due to its large number, wide distribution, and scale elasticity (Qian et al., 2022), etc. We attempted to divide river beaches with continuous morphology and similar characteristics into 20 spatial units, with a total length of the shoreline of about 45.7 km. These spatial units traverse the multicultural and densely populated central urban area of Chongqing, encompassing the river-beach interface where recreational resources and recreational behaviors are most concentrated, which is of great value for studying the recreational resources of river beach IGS in mountain city.

Figure 2. Distribution spatial units of river beach IGS

2.3 Research method

Recreation opportunity spectrum (ROS) is an effective management framework for coordinating recreation resources with recreation demands (Lin et al., 2019), emphasizing that recreational opportunities should match the experiences that recreationists expect to receive. Utilizing ROS to study recreational resources of river beach IGS in mountain city can help managers to establish an inventory of recreational opportunities across administrative boundaries (Cai, 2006); and help recreationists to have intuitive and fair opportunities for place selection to meet the diverse recreational demands of high-density people in urban areas.

First, in order to apply ROS to the study of recreation environment of river beach IGS in mountain city, on the basis of existing research (Chen, 2015; Lin et al., 2019; Wu, 2020), we initially constructed a recreational opportunity indicator system based on qualitative analysis.

Second, conduct research on each spatial unit while recording the types and intensities of activities of the recreationists to determine the degree of intervention of the urban interface on the river beach. To verify the reliability of the 35 selected environmental variables from the perspective of recreationists, we designed a questionnaire based on the initially constructed recreational opportunity indicator system. From April to October 2023, a total of 402 questionnaires were randomly distributed at various river beaches, with 391 valid responses, resulting in an effective response rate of 97%. The questionnaire used a five-point Likert scale, requiring respondents to rate the importance of 35 environmental variables on a scale of 1 (completely irrelevant) to 5 (very important). Subsequently, we processed and analyzed the collected scoring data using SPSS 27.0.

Next, we conducted descriptive statistical analysis of the mean and standard deviation for the 35 environmental variables after assignment, and ranked the importance of the variables based on their mean values. To reduce the interference between variables, factor analysis was used to reduce the dimensionality of the variable information. The 9 principal component factors obtained from the above analysis are the environmental factors that most influence the recreational experience of the river beach IGS in Chongqing from the perspective of recreationists.

Finally, 9 factors were named by analyzing the meanings of the environmental variables corresponding to each factor and their combinations, and these factors constituted the recreation opportunity index system of river beach IGS in the two rivers and four banks of Chongqing based on the subjective importance evaluation of recreationists (Table 1).

Table 1. Recreation opportunity index system of river beach IGS in the two rivers and four banks of Chongqing (Zhang et al., 2016)

Level 1	Level 2	Level 3
Management Environment (M)	Experience maintenance level (Z1)	Accessible surrounding recreation facilities (MF1)
		Walking accessibility (MT3)
		Maintenance of public facilities (MC2)
		Accessible water and cleaning Facilities (MF2)
		Regular garbage removal (MC1)
		Guide mark (MG2)
Physical Environment (F)	Regional humanistic experience (Z2a)	Accessible business service facilities (MF3)
		Cultural experience value (FH1)
		Accessible tourist attractions (MF4)
	Temporary facility supply (Z2b)	Temporary night lighting (FF2)
		Temporary trash can (FF1)
Social Environment (S)	Relationship with popular tourist destinations (Z3)	Optimal node usage (SI3)
		Degree of crowding (SI1)
		Visible characteristic tourist landscape (FV1)

Level 1	Level 2	Level 3
Physical Environment (F)	Regional nature experience (Z4)	Plant growth status (FN6)
		Animal abundance (FN5)
		Visible natural views of the city (FV3)
		Microclimatic amenity (FN7)
		Revetment aesthetic feeling (FN4)
Management Environment (M)	Safety and Educational Value (Z5)	Safety warning message (MS1)
		Public security administration patrol (MS2)
		Environmental information display (MG1)
Physical Environment (F)	Difficulty level of activities (Z6)	Ease of walking (FN3)
		Degree of relief (FN2)
Social Environment (S)	Diversity of activities (Z7)	Suitable population type (SI2)
		Full-time nature of the activity (SE1)
		Activity richness (SE2)
Management Environment (M)	Vehicular accessibility (Z8)	Private car accessibility (MT2)
		Public transport accessibility (MT1)
Physical Environment (F)	Aesthetic of artificial landscape (Z9)	Visible artificial landscape of the city (FV2)

3. Findings and Discussion

3.1 Classification of recreation environment

Based on the evaluation of the importance of different environmental factors by recreational users, combined with the comprehensive analysis of the recreation environment, recreation behavior and recreation experience of each spatial unit, we divide the recreation environment of river beach IGSs into four types: natural experience type, daily life type, humanistic characteristic type and urban tourism type. At the urban interface, the disturbance of these four types of recreation environments on river beach IGS changes from low to high, forming a continuous sequence of recreation opportunities.

3.2 Characterization of each type of recreation environment

Environmental factors reflect the characteristics of the recreation environment. By analyzing the mean values of the factors, the horizontal comparison can be made to derive the distribution pattern of the subjective importance of various environmental factors among different types of recreational environments. Combined with the results of the previous field research, the characteristics of each environment type of river beach can be summarized.

3.2.1 Natural experience type

The natural experience type of river beach has the lowest degree of intervention from the development and construction of the urban interface, retaining the wild state of green spaces to the greatest extent, with the highest vegetation coverage, the richest biodiversity, and outstanding natural aesthetic value and ecological regulation capacity. And the number of service facilities around the river beach is low, with a small number of managers patrolling the area. Compared with other types, recreationists in the natural experience type attach the most importance to the "regional nature experience", and do not have a high demand for other environmental factors.

3.2.2 Daily life type

The transition zone between the daily life type of river beach and the city interface has been developed to a certain extent, serving as a medium for the intersection of the urban interface and the river beach. The daily life type of river beach have fewer tourists, mainly providing nearby water-accessible places for residents, with few managers patrolling. Recreationists place relative importance on "difficulty level of activities", and demand for other factors is only slightly higher than that of the nature-experience type, which proves that recreationists believe that this type of river beach should meet the needs of convenient and comfortable daily activities.

3.2.3 Humanistic characteristic type

The humanistic characteristic type of river beach is highly influenced by the development and construction of the urban interface, and the form of the formal green space bordering the river beach is close to that of the daily life type. Some local culture enthusiasts gather at the humanistic characteristic type of river beach for a long time, attracting some local tourists who come specifically to experience the unique culture. Recreationists place a higher value on "regional humanistic experience" and "internal facilities provision", considering the distinctive culture in this type of river beach the most appealing, while also having higher requirements for the convenience of lighting and sanitation facilities.

3.2.4 Urban tourism type

The urban tourism type of river beach is most affected by the development and construction of the urban interface, with relatively complete supporting facilities in surrounding areas, frequent management and maintenance, and convenient transportation.In addition to "regional natural experience", recreationists attach great importance to all other environmental factors, proving that the public has the highest expectations for the comprehensive recreation environment of urban tourism type of river beach. In cases of excessive tourist density, attention can be focused on visible tourist attractions and rich recreational activities.

If the density of tourists is too high, the natural resources of the riverbank itself can be neglected, and the focus can be placed on the visible tourist sites and rich recreational activities.

3.3 Construction of the recreation opportunity spectrum and recreation opportunity map

In this study, the relationship between the recreational environment, recreational activities and recreational experience of river beach IGS is comprehensively considered, and the recreation opportunity spectrum (Table 2) of two rivers and four banks in Chongqing based on 4 environmental types and 10 environmental factors are derived.

Table 2. Recreation opportunity spectrum of river beach IGS in the two rivers and four banks of Chongqing (Zhang & Tang, 2017)

Types of Recreation Environment	**Spatial Unit**	**Evaluation of the Importance of Environmental Factors by Visitors**										**Suitable Type of Recreation Activity**		**Main Recreational Experience**
		Experience Maintenance Level	Humanistic Experience in Mountain City	Provision of Temporary Facilities	Relationship with Popular Tourist Destinations	Natural Experience in Mountain City	Safety and Education	Activity Difficulty	Activity Diversity	Accessibility of Vehicular Traffic	Beauty of Artificial Landscape in Mountain City	Universal Activity	Characteristic Activity	
Natural Experience Type	05/14/15/16/17	+++	+	+	+	+++	++	+	+	++	+	Walking, chatting, picnic camping, photography, chess and cards, playing in the water and dredging sand, shopping at the market, fishing, paddle board, pet walking, volunteer activities, etc	Enjoy natural scenery, natural cognition, meditation	Immerse in the natural wild interest, release the pressure of life, enhance the relationship between friends and relatives
Daily Life Type	02/03/06/07/09/18	++	++	++	+	++	++	+++	++	++	+		Exercise, meditation, reading and learning, family activities, daily cooling, outdoor simple meals	Daily recreation, outdoor exercise, enhance the relationship between friends and relatives, solitude
Humanistic Characteristic Type	04/08/19 /20	+++	+++	+++	++	++	+	++	++	++	+++		Enjoy the cultural scenery, diving, swimming, outdoor dining	Immersive experience mountain city characteristics and cultural customs, into the local atmosphere
Urban Tourism Type	01/10/11/12/13	+++	+++	+++	+++	+	+++	+++	+++	+++	+++		City sightseeing, performances and screenings, group building games, boat Tours	Enjoy the landmark tourist destination of mountain city and feel the lively Jiangtan culture

"+, ++, +++" respectively indicates that the importance of individual environmental factors is "low, medium, and high".

3.4 Optimization strategy for river beach IGS based on the spectrum of recreational opportunities

Based on the recreation opportunity spectrum of river beach IGS in the range of two rivers and four banks in Chongqing, which is constructed from the perspective of recreational experience, this research proposes optimization strategies to improve the quality of the recreation environment of river beach from both the overall and classified dimensions (Table 3). Due to the special land use of river beach, it is impossible to excessively construct the internal physical environment of river beach, so the optimization of river beach should focus on the management and maintenance of river beach and the planning and design of surrounding urban interface.

Table 3. Optimization strategy based on recreation opportunity spectrum of river beach IGS (Monz et al., 2010; Zhou, 2022)

Primary classification	Secondary Classification	Description
Overall	Overall Planning of Recreation Opportunities	identify available recreation resources
		locate recreation needs of the public and match the existing beach environment
		publicize the spectrum of recreational opportunities
		expand the provision of regional recreation opportunities
	Coordination of Peripheral Supporting Construction	serial urban vertical transportation system
		optimize the river-beach parallel traffic system
		set up recreation facilities and forms according to local conditions
		control visual effects of city interface
	Construction of a Complete Recreation Management System	fully investigate the recreation impact degree of the recreation use area
		establish multi-dimensional rules and regulations
		apply management measures differently according to actual recreation conditions
		delimit permitted business areas
		enhance the recognition of the navigation system
Classified River Beach	Natural Experience Type	develop reasonable ecological environment protection and restoration strategies
		control visitor density and low-impact education
	Daily Life Type	improve the walking accessibility
		improve the attractiveness of artificial space
	Humanistic Characteristic Type	excavate the cultural connotation of the site
		improve the supporting recreational facilities in the interface between the river beach and the city
	Urban Tourism Type	set up temporary facilities
		improve the quality of night view
		strengthen public security management and environmental sanitation
		promote the efficient traffic dispersal during peak hours of night recreation

4. Conclusion

This research discusses the definition and characteristics of river beach IGS in mountain city, identifies four types of recreation environments, including natural experience type, daily life type, humanistic characteristic type and urban tourism type, constructs the recreation opportunity spectrum of river beach IGS in Chongqing, and puts forward feasible suggestions for the planning, construction and management of river beach IGS in mountain city and surrounding areas from the perspective of improving recreation experience. This research is of important reference significance for improving the blue and green space system of mountain city dominated by formal green space and supplemented by IGS, and also expands the application scope of IGS and the research on recreation opportunity spectrum.

As an exploratory study on the identification of types of river beach IGS in mountain city, this study still has many limitations, such as the preliminary construction of index system is not accurate enough, and the collected questionnaire samples are small, resulting in errors, etc. It is expected that in the future, through the long-term monitoring of the use of river beach and the collection of more sample data, we will elucidate the coupling relationship between the ecological and recreational functions of river beach, as well as the interactive influence mechanism of the recreational environment, demand, behavior, and experience.

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Research Progress on Ecosystem Carbon Sink Assessment Methods and Application Based on Multi-source Data Fusion

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Abstract

Ecosystem carbon sink accounting is an important research field related to global climate change and ecological balance. With the rapid deployment of hardware and software in smart cities in recent years, technologies such as the Internet of Things, multi-source data analysis, and artificial intelligence pre-trained large models have provided many new technical methods in this field. This study systematically summarizes the technical system of carbon sink assessment in the context of intelligence from the perspective of multi-source data: firstly, the carbon sink accounting methods are summarized based on different data types and classified into vegetation data, meteorological data, land cover data, building material data, etc.; secondly, the applicability of different accounting methods in four different ecosystems is discussed by identifying the characteristics of each accounting method; finally, we summarize the current status and drawbacks of the research on carbon sink accounting methods based on multi-source data fusion, and propose the future development direction in order to contribute to China's dual carbon target and global sustainable development.

Keywords: Multi-source data; carbon sink accounting; ecosystem; methodology evaluation

1. Introduction

Recent advancements in smart city infrastructure have significantly increased multi-source data, providing diverse angles for studying human settlements. This data includes IoT perception, remote sensing, site data, and big data from public networks, forming a comprehensive network for research. With the growing emphasis on "carbon neutrality," multi-source data fusion is improving carbon monitoring and accounting methods. Unlike traditional field-based approaches, multi-source data fusion allows for a more accurate, cross-scale system that accounts for carbon storage, sinks, and sources (Tian, 2022; Qian, 2022; Yang, 2022). Various data types, such as vegetation, meteorological, and soil data, are used in carbon sink accounting, with each method suited to specific contexts. This paper summarizes current multi-source data-based accounting methods, their ecosystem applicability, and research trends to help develop a more robust carbon sink accounting system.

2. Ecosystem Carbon Sink Accounting Method Based on Multi-Source Data

Multi-source data refers to datasets derived from various origins, categorized into different types, and encompass various applications suitable for various data processing tasks (Luo, 2023). Common data used in carbon sink accounting include but are not limited to, vegetation data, meteorological data, remote sensing data, and soil cover data. This section classifies the common methods for carbon sink accounting based on data sources (Table 1).

Table 1. Common carbon sink accounting methods based on data sources

Carbon sink accounting methods			**Data required**	**Features**	**Application scenarios**
Carbon sink accounting method based on vegetation data	Sample site survey method	Biomass method (including average biomass method, biomass growth model, etc.)	Biomass, vegetation area, average carbon content of various organs of trees, etc	Biomass as the core of carbon sink calculation, the method is relatively basic	Forest ecosystem Urban ecosystems
		Accumulation method (including basic biological factor conversion method, biological factor continuous function method, etc.)	Forest stock, vegetation area, etc	Taking stock volume as the core of carbon sink calculation, the method is relatively mature.	Forest ecosystem Urban ecosystems
		Biological inventory method	Biomass, stock, trunk density, etc	Carbon sinks are accounted for by estimating dynamic changes in the carbon cycle based on the relationship between biomass and stock	Forest ecosystems
	Assimilation quantifier		onomer vegetation data (transpiration rate, net photosynthetic rate, intercellular carbon dioxide concentration, stomatal conductance, etc.)	Carbon sinks are calculated using environmental factors, but the results are full of inconclusive results	Forest ecosystems
	Leaf area-photosynt	hetic rate method	Monomer vegetation data (leaf area, photosynthetic rate, etc.)	The error of carbon sink data obtained by simply multiplying the green space area with the corresponding parameters are large	Forest ecosystem
Carbon sink accounting method based on remote sensing data	Remote Sensing	monitoring method	Optical remote sensing data, microwave radar data and Lidar data	Advanced and closely integrated with cutting-edge technologies (artificial intelligence, deep learning, etc.)	Grassland ecosystem Agroecosystems Forest ecosystems Urban
Carbon sink accounting method based on meteorological	Micrometeorological method	Vorticity method	Wind speed and CO2 concentration, etc	Measure the flow difference to calculate carbon sequestration	Grassland ecosystems Agricultural ecosystems Forest

Dataset	Vorticity covariance method		Co2 concentration and vertical wind speed	Calculate CO2 flux using the covariance of CO2 concentration and vertical wind speed	Agroecosystems Grassland ecosystems Urban
	Vortex accumulation method		The vertical component size of the speed samples the air	Random sampling	Forest ecosystems
	Relaxation vortex accumulation method		The size of the vertical component of the wind speed samples the air	Time sampling to improve accuracy and reliability	Forest ecosystem
	Box Method		Co2 concentration	Carbon dioxide 2 Set up an enclosed gas tank	Forest ecosystem Grassland ecosystem
Methods of carbon sink accounting based on soil data	Soil Type method		Soil profile information, organic carbon content, and bulk density	Soil Profile Information	Agroecosystems Urban ecosystems
	Life zone method		Soil data Soil type, soil carbon density and distribution area	Classification before data collection before calculation	Agroecosystems Urban ecosystems
	GIS estimation Method		Multi-source soil database	Use the spatial analysis function of GIS	Grassland ecosystems Agroecosystems
Carbon sink accounting method based on multi- source integrated data	Model Method	Biomass modeling	Vegetation data	Power function model was used for modeling.	Forest ecosystem
		Other models	Vegetation data, soil data, climate data, surface data, etc	Easy to operate, easy to obtain parameters, fast measurement speed, any scale	Forest ecosystem Grassland ecosystem Agricultural ecosystem
	Model estimation Method		Environmental variables, climate variables, and soil attribute data	The relationship between independent variables such as environmental variables and dependent variables such as soil carbon storage was constructed through mathematical models	Forest ecosystem Grassland ecosystem
	Net primary productivity method	CASA Model	Total organic matter synthesized in the process of photosynthesis, organic matter consumed by the plant's own respiration, light energy utilization, etc	Ecosystem process models capable of describing changes in carbon and nitrogen fluxes and water in terrestrial ecosystems over time	Forest ecosystems Agroecosystems
		BEPS model	Meteorological data, soil data, land use type data, leaf area	Large area of plant NPP is analyzed to calculate carbon sink	Forest ecosystems

			index, etc		Agroecosystems
Methods of carbon sink accounting based on artificial materials	Carbon sink accounting method for construction activities		Cement dosage, chemical data	Calculation of carbon produced during construction	Urban Ecosystems
	Industrial activities carbon urban ecosystem sinks accounting method		Chemical data, carbon sequestration	Alkaline solid waste from industrial processes sequesters carbon	Urban Ecosystems
	Carbon sink accounting method for industrial and mining activities		Chemical data, carbon sequestration amount	Calculate carbon sinks with tailing related data	Urban Ecosystems
	Urban buildings carbon sink accounting method		Remote sensing data, chemical data	Classification of building types	Urban Ecosystems

3. Application of Carbon Sink Accounting in Different Ecosystems

Ecosystems comprise organisms and their environment, interacting in a relatively stable dynamic equilibrium. Ecosystems are generally divided into two categories: natural and artificial. Natural ecosystems include terrestrial ecosystems like forests, grasslands, and deserts and aquatic ecosystems like marine, freshwater, and wetland systems. Artificial ecosystems consist of farmland and urban areas. The concept of a carbon sink has expanded beyond forests to include other ecosystems such as grasslands, deserts, wetlands, oceans, soil, and buildings. The main contributors to carbon sequestration are vegetation and soil. Terrestrial ecosystems account for about one-third of the global carbon sink, which is crucial in mitigating climate change. Forests are the largest carbon sink within terrestrial ecosystems, followed by grasslands and farmland ecosystems. Urban ecosystems, however, contribute significantly to global carbon emissions, negatively affecting climate change.

3.1 Forest ecosystem

With their complex structure and rich biodiversity, forests store the largest carbon pool among ecosystems. Vegetation in forests accounts for 80% of the global terrestrial carbon sink, while soil contributes 40%. Trees absorb CO_2 through photosynthesis, forming a large plant carbon pool, while decaying leaves store carbon in the soil, creating a substantial soil carbon pool. Research has shown that since 1980, forest expansion has been the primary driver of increased land carbon sink in China. However, deforestation, such as in the southeastern Amazon, has turned some forests from carbon sinks into carbon sources, exacerbating climate warming. This highlights the importance of forests in carbon sequestration and the need to measure forest carbon sinks to address global carbon emissions. Forest carbon sink estimation primarily relies on carbon stocks, using methods like sample plot inventories and remote sensing techniques. Only micrometeorological methods can directly measure carbon sinks.

3.1.1 Sample plot survey method

The biomass and stock methods are widely used in sample plot surveys to estimate the carbon sink of forest ecosystems. The biomass method has evolved from using average biomass estimates to more advanced, non-destructive techniques like the biomass relative growth model. For example, this method was used to estimate biomass in the rainforests of Hainan Island. More recent studies have used models like those developed in Zhejiang Province to estimate forest biomass. Although the biomass method is efficient and accurate, it can introduce errors due to atypical sample selection and incomplete data, especially from underground biomass. It is labor-intensive, making it suitable for small, uniform forest areas. Remote sensing has become a popular alternative to overcome these limitations and allows for large-scale, rapid carbon sink measurements. The stock method estimates carbon storage by converting the biomass of trees into carbon storage, often using biomass conversion factors. For example, the IPCC and continuous function methods have been used to calculate carbon stocks in various regions. The stock method is faster than the biomass method but still overlooks factors such as soil respiration and underground biomass, leading to incomplete carbon sink calculations.

3.1.2 Remote sensing monitoring method

Remote sensing is increasingly used for large-scale forest carbon storage estimation. Different data sources, such as optical remote sensing, and microwave radar, are applied to estimate biomass. Optical remote sensing, the earliest method, is commonly used for large-scale biomass estimation through regression analysis or neural network methods. For instance, multiple regression analysis has been used to estimate biomass in desert shrublands. Neural networks offer higher efficiency and precision compared to traditional regression methods. Ding (Ding et al.,2021) conducted a comparative analysis of the artificial neural network method, support vector machine, random forest, and multiple regression method for estimating tree biomass in Le Lin Plantation, Fujian Province, using optical remote sensing data. They concluded that the random forest-remote sensing data method is more accurate. Microwave radar is less affected by weather and cloud cover, making it ideal for regions with frequent cloud cover. The carbon sink measurement can be either direct, by establishing regression models based on backscatter values, or indirect, using structural data to establish biomass regression models. LiDAR, which can penetrate the forest canopy, provides data to estimate biomass and carbon storage. However, LiDAR is costly and prone to data loss and noise interference.

3.1.3 Micrometeorological method

Micrometeorological methods directly measure carbon sink changes. The eddy correlation method, which calculates carbon flux by measuring turbulent airflow, is commonly used. This method has high precision and can monitor carbon storage over long periods, reflecting dynamic changes. However, it requires advanced instruments and long experimental periods. The box method measures carbon flux by observing changes in carbon dioxide concentration. This simpler method is suitable for small-scale studies. For example, Li Hongqin (Li et al.,2014) used the static box-type method to determine the carbon flux of the ecosystem of the alpine golden plum shrub, and proved that this method had high accuracy after comparing the vortex correlation method. Sun (Sun et al.,2019) also used the static box-type method to calculate the carbon flux of the Horqin sandy grassland ecosystem. However, the box method is more susceptible to errors caused by human and external factors.

3.2 Agroecosystems

With nearly 1.4 billion hectares of arable land globally, agroecosystems are vital carbon sources and sinks, second only to forests and grasslands in China. Agricultural production is the second largest source of greenhouse gas emissions, accounting for approximately 19-29% of global carbon emissions. These emissions stem from crop and soil emissions, using fertilizers, burning agricultural fuels and residues, and other agricultural activities. Conversely, crops sequester carbon through photosynthesis, and agricultural soils can enhance carbon storage through proper management (Zheng et al., 2011). Agroecosystem carbon sinks can be divided into agricultural carbon sinks and agricultural soil carbon sinks based on crop and soil contributions.

3.2.1 Agricultural carbon sink

The agricultural carbon sink refers to the amount of carbon absorbed during the growth cycle of crops, calculated using the net primary productivity method. The principle of this method is photosynthesis of vegetation, usually combined with other data indicators at the crop physiological level, to measure carbon storage for major crops. For example, Li Mingqi (Li et al., 2018) used this method to determine the carbon absorption of different crops in Yunnan Province, thereby revealing the patterns of carbon footprint changes and influencing factors. The net primary productivity method is characterized by its accuracy in calculation, although there may be errors due to incomplete statistics, it is still widely used.

3.2.2 Accounting for agricultural soil carbon stocks

Soil carbon storage is typically calculated using methods based on soil data, such as the soil type method (Zha et al., 2020), model-based methods, and life zone methods (Mishra G. et al., 2019). Recent studies also employ micrometeorology and remote sensing techniques to measure agricultural soil carbon sinks. Zha Yinshui (Zha et al., 2020) used the soil type method to estimate soil carbon sinks in the Poyang Lake Ecological Economic Zone. The soil type method is straightforward with easily accessible data but may introduce significant errors in large-scale calculations due to spatial variability. Guo Hui (Guo et al., 2021) used micrometeorology to calculate carbon flux in cornfields under drip irrigation in Northwest China. It provides direct measurements with high accuracy, though it requires advanced technical conditions.

3.3 Grassland ecosystem

Grassland ecosystems cover one-fifth of the global terrestrial area and store about 25.40 Pg C, constituting approximately 10%-15% of the carbon in terrestrial ecosystems, second only to forests but surpassing agricultural ecosystems. Most of the carbon in grassland ecosystems is stored in underground soil, where organic matter decomposes slowly, making the carbon sink function relatively stable. However, research has shown that grasslands can also be a significant carbon source (Smith, 2014). Therefore, accurately estimating the carbon sink potential of grassland ecosystems is crucial for addressing future greenhouse gas emissions from grasslands and mitigating global warming. Historically, carbon sink estimates were based primarily on soil data, but technological advancements have expanded the methods to include modeling, remote sensing, micrometeorology, and soil classification methods.

3.3.1 Remote sensing detection method

Remote sensing in grassland ecosystems involves using satellite images to identify grassland types and areas. By analyzing reflectance data or vegetation indices, models can be created to estimate carbon sinks from the collected remote sensing data. Alternatively, remote sensing can estimate light energy utilization and net primary productivity and then calculate carbon sink values. However, terrain, climate, and other factors can influence remote sensing data, so optimization models are often employed to improve accuracy. Myrgiotis (Myrgiotis et al., 2021) combined model-based and remote sensing data to assess grassland carbon sink dynamics in the United Kingdom, introducing a "model + data" approach.

3.3.2 Micrometeorological method

Grassland carbon sinks are more susceptible to natural and human influences than in forests. Common techniques include vortex correlation, vorticity covariance, and the box method. For example, Fei Xuehai (Fei et al., 2017) used the vorticity covariance method to measure carbon sinks in savannas in southwest China. Gatti (Gatti et al., 2021) and Basso (Basso L S. et al., 2016) applied the box method for carbon flux measurements in the Amazon forest and methane flux calculations, respectively. Chang Jinfeng (Chang J. et al., 2017) used a micrometeorological model to calculate carbon sinks in European grasslands.

3.4 Urban ecosystems

Nearly 78% of the world's carbon emissions come from cities (Edenhofer O. et al., 2014), with China previously accounting for 85% (Cai et al., 2017). As urbanization accelerates, this proportion is expected to grow. Unlike natural ecosystems, urban ecosystems are composite, incorporating both natural and artificial components. These ecosystems include vegetation, water, soil, and human-made elements like minerals, steel slag, building materials, and waste, contributing to carbon sequestration. Nowak (Nowak et al., 2013) found that the carbon sink of urban vegetation accounts for 3.2% of national forest carbon sinks. And urban building materials in the U.S. have a similar carbon sink value (Li et al., 2021). In urban ecosystems, human activities and economic drivers contribute to spatial changes, making urban carbon sinks more dynamic and harder to quantify (Liu, 2021). Currently, the quantification of urban ecosystem carbon sinks is divided into two aspects: the natural carbon sink system and the artificial carbon sink system.

3.4.1 Quantification of carbon sink system

Urban ecosystems' natural carbon sinks include vegetation, soil, and water. Carbon sequestration in urban vegetation is studied using methods like plot inventory and micrometeorological approaches. The plot inventory method estimates carbon storage based on biomass, as seen in studies by Lin Wen (Lin et al., 2019) in Guangzhou and Zhong Qicheng (Zhong et al., 2019) in Shanghai. Micrometeorological methods, such as the eddy correlation technique, provide high accuracy but require specialized equipment, as demonstrated in Beijing's Olympic Forest Park by Chen Wenjing (Chen, 2013) and Haidian Park by Li Xia (Li et al., 2010).

Soil type, model and life zone methods can also be used to study soil carbon fixation capacity. For water carbon sink capacity quantification is mainly divided into three aspects: aquatic plants, water organic carbon and aquatic sediment carbon quantification method mainly adopt biomass method and box type method, water organic carbon data generally obtained through sampling, water sediment organic carbon carbon fixation ability method and soil, more soil type method or life belt method.

3.4.2 Quantification of the artificial carbon sink system

The quantitative research of artificial carbon sink in urban ecosystem is currently in its initial stage, most of the research is limited to the material itself, and is still rare on the urban spatial scale.The quantification of artificial carbon sink system mainly includes four ways: carbon sink calculation of construction activities (concrete), carbon sink calculation of industrial activities (alkaline solid waste), carbon sink calculation of industrial and mining activities (tailings) and carbon sink calculation of urban buildings, all of which are based on materials.

Concrete has been highlighted for its carbon sequestration potential, with studies by the American Portland Cement Association, Galan et al. (Galan et al., 2010), and Zhang Susxian (Zhang Suian & Sun Yongle, 2015). However, some argue that building materials may also be significant sources of greenhouse gases (Pei et al., 2018), suggesting a need for further research on artificial carbon sinks' long-term impact on urban carbon balance.

4. Summary and Future Outlook

Global warming caused by carbon emissions has become one of the most critical challenges for human survival and a global issue that urgently needs addressing. Developing various carbon sink measurement methods, understanding different ecosystems' carbon source and carbon sink functions, and employing accurate measurement techniques to estimate ecosystem carbon sinks are essential to achieving carbon neutrality and mitigating the global climate crisis. This paper reviews the commonly used carbon sink accounting methods based on different data types, discusses their application across four ecosystems, and presents the following conclusions.

4.1 Carbon sink measurement data

Carbon sink accounting relies on ground observation, remote sensing, and model simulation data. Ground data, including vegetation, climate, and soil information, is foundational but often sparse and inconsistent. Remote sensing and model simulations offer large-scale measurement capabilities. Traditional methods, like biomass measurement, require labor-intensive fieldwork, while soil-type methods are limited by scale and human influence. Data gaps and inconsistencies complicate carbon sink calculations, making long-term observation systems and data integration essential for accuracy. Remote sensing is increasingly used for large-scale measurements but faces weather and signal interference challenges. Combining remote sensing with ground-based observations through multi-source data fusion is crucial for improving accuracy. Accurate carbon sink measurement depends on integrating diverse data and ensuring systematic, long-term data collection.

4.2 Carbon sink measurement method

Various methods for carbon sink calculation have been developed, starting with the biomass method, which measures vegetation biomass through tree felling. Other approaches include micrometeorological, soil-type, and life-zone methods. Remote sensing and GIS-based techniques have become increasingly important, while AI integration further enhances accuracy by combining traditional data with remote sensing for large-scale, high-precision measurements.

However, traditional methods face technological limitations, inaccuracies, and static data, making it challenging to provide reliable long-term carbon sink data. Discrepancies in definitions, methods, and parameters also lead to inconsistent results.

Future research should focus on long-term data collection, refining models with comprehensive ground-based and remote sensing data, and accounting for seasonal, climatic, and human factors. Overcoming technical bottlenecks in advanced methods like AI and remote sensing will improve their applicability. A unified, authoritative measurement system should integrate diverse methods and factors to reduce errors and enhance accuracy.

4.3 Application of carbon sink calculation

Carbon sink research varies across ecosystems, with forests being the most studied, followed by grasslands and agriculture. Urban ecosystems are still in the early stages, while deserts and oceans remain underexplored with less-developed methods. Forest carbon sink measurement, mainly based on biomass, is the most established, with remote sensing and AI models refining the approach. However, comprehensive data collection remains a challenge, and future research will focus on integrating multi-source data and methods to optimize models.

In agroecosystems, carbon sinks primarily come from crops and soil, with challenges like incomplete data and spatial heterogeneity. Remote sensing and climate data can improve soil carbon sink accuracy. Grasslands, the second-largest carbon sink after forests, are increasingly becoming carbon sources due to human activities. Future research should explore the dynamic response of grasslands to climate change and human impacts.

In urban ecosystems, natural carbon sinks are like other ecosystems, but artificial carbon sinks, particularly from building materials, remain debated. Research should focus on quantifying urban carbon sinks on a larger scale, including roads and bridges. Methods for other ecosystems can be adapted by modifying data, models, and parameters. Future work should prioritize accuracy and comprehensiveness, ensuring that carbon sink accounting systems are applicable across ecosystems, supporting climate governance and global sustainable development.

In the future, as multi-source data applicable to carbon sink accounting becomes more accurate and abundant, the carbon sink accounting system will become more comprehensive and standardized. Carbon sink calculations for different ecosystems can be further refined according to climate, geography, seasons, etc., establishing a full-scale, wide-ranging, highly applicable, and efficient carbon sink accounting system that better serves climate governance and global sustainable development.

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BUILDING BRIDGES BREAKING BARRIERS

Integrating Music into Landscape Architecture Education: A Pedagogical Exploration for Enhanced Creativity

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Abstract

Landscape architecture design is a complex interplay of spatial creativity and aesthetic considerations. This research explores the integration of music into landscape architecture studio teaching, aiming to foster students' creativity and deepen their conceptual understanding of space. Drawing on interdisciplinary literature, this study examines music's role as a universal language in evoking emotions and inspiring design. Through empirical experiments involving music-guided drawing workshops, this research identifies significant benefits of incorporating music in design pedagogy. Findings reveal enhanced student engagement, improved imaginative capacity, and a deeper connection between auditory and spatial elements. This study contributes to developing innovative educational methodologies for landscape architecture and related design disciplines.

Keywords: Landscape architecture education, music integration, design creativity, interdisciplinary pedagogy

1. Introduction

Landscape architecture education is rooted in the interplay of technical skills, aesthetic sensibilities, and creative thinking. As global challenges demand innovative approaches to urban and environmental design, cultivating creativity among students is increasingly critical. Music, often described as “a universal language,” offers untapped potential to enrich the conceptualization of landscape spaces. Friedrich W.J. von Schelling’s portrayal of architecture as “frozen music” underscores the intrinsic connection between these disciplines, while Confucius highlighted music's essential role in cultural and emotional expression. Despite extensive exploration of music’s influence on architecture, its pedagogical application in landscape architecture remains underexplored. This study pioneers an interdisciplinary methodology, integrating music into landscape architecture studio teaching. By examining the effects of music on students’ creative processes, this research aims to uncover new pathways for fostering innovation in design education.

1.1 The intersection of music and spatial design

The relationship between music and spatial design has long been recognized in both Western and Eastern traditions. Plato regarded music as a moral force that shapes the soul, while Confucian philosophy emphasized its role in personal and societal harmony. In architectural theory, music’s rhythmic patterns and harmonic structures have been likened to the proportions and spatial arrangements of built environments. In the Eastern tradition, music's role extends beyond individual expression to include collective experiences, such as rituals and festivals, where spatial design and acoustics often converge. For instance, traditional Chinese gardens were designed to integrate soundscapes, utilizing water features and wind-activated elements to create harmonious auditory experiences that parallel the visual aesthetics of the space (Figure 1).

Figure 1. Left: Music composition monophony by Ying Li: My Loving Friend Jing Xin Zhai (Source: Author). Right: The central vista in Jingxin Zhai that presents the harmonious organization of architecture and landscape (Source:Author)

Recent studies highlight the parallels between musical composition and spatial design. Messervy and Abell (2007) described aesthetic spaces as embodying both physical and spiritual beauty, akin to the emotional resonance evoked by music. Scruton (1979) further articulated the "spatial music" of architecture, underscoring the shared language of rhythm, tone, and mood (Figure 2). Additionally, modern technological advances, such as sound-mapping tools and acoustic simulation software, have enabled designers to visualize and integrate auditory dimensions into their projects. For example, urban planners now use sound mapping to design spaces that mitigate noise pollution while enhancing desirable soundscapes, such as birdsong in parks or the subtle hum of water features in urban plazas. These applications bridge the gap between theoretical concepts and practical implementations, emphasizing the importance of auditory elements in spatial design.

Figure 2. Left: The beginning section of Franz Liszt's composition notes of The Fountains of the Villa d' Este (Liszt, 2009); Right: Hundred Fountains (Cento Fontane) in the Villa d'Este (Source: Author)

The relationship between music and architecture also finds expression in landmark architectural works. Structures like the Sydney Opera House and Berlin Philharmonie are designed to enhance acoustic performance while embodying visually striking forms that echo musical rhythms. The interplay of form and function in such spaces demonstrates how music and architecture can converge to create immersive experiences, enriching both the aesthetic and functional dimensions of a design.

1.2 Creativity in design education

Creativity is a cornerstone of effective design education, yet it remains challenging to cultivate. Traditional pedagogical methods often emphasize technical proficiency over imaginative exploration, which can stifle students' creative potential. Incorporating interdisciplinary tools, such as music, can address this gap. Studies in cognitive psychology suggest that music stimulates brain regions associated with imagination, emotional processing, and spatial reasoning, providing a fertile ground for creative development (Smith, 2009).

Music's ability to evoke emotions and inspire imagination is particularly relevant in the context of design education. Research has shown that listening to music can activate the brain's default mode network, which is associated with introspection and creative problem-solving. This connection suggests that music not only enhances emotional engagement but also facilitates the generation of novel ideas. For example, students exposed to music during design activities often report heightened focus and an increased ability to visualize abstract concepts. Moreover, music's influence on mood and focus can create conducive learning environments. For instance, slower tempos often promote relaxation and deeper reflection, whereas faster rhythms can energize and inspire action. These effects are not limited to individual experiences; group activities involving music can foster a collaborative atmosphere where students feel more connected and open to sharing ideas. Integrating such insights into educational strategies allows instructors to tailor studio environments to the diverse needs of students, fostering an inclusive and adaptive approach to creativity.

Case studies from design education further illustrate music's potential as a pedagogical tool. In one notable example, students participating in a music-inspired drawing workshop demonstrated greater diversity in their creative outputs compared to those who used conventional methods. The inclusion of music encouraged students to explore unconventional forms and narratives, resulting in designs that were both innovative and emotionally resonant. Similarly, workshops incorporating live musical performances have been shown to heighten students' sensory awareness, enabling them to translate auditory stimuli into visual and spatial representations more effectively.

Beyond the immediate impacts on creativity, music-integrated pedagogy has broader implications for the development of critical thinking and empathy in design students. Engaging with music's emotional and cultural dimensions encourages students to consider the experiential aspects of their designs, fostering a deeper understanding of how spaces can evoke specific feelings or cater to diverse user needs. This holistic approach aligns with contemporary trends in design education, which emphasize the importance of empathy-driven and user-centered design practices.

1.3 Music, future education and artificial intelligence

As technology continues to reshape education, the integration of music and artificial intelligence (AI) in design pedagogy offers unprecedented opportunities for innovation. AI-driven tools can analyze patterns in students' creative processes, offering personalized feedback to enhance their learning experiences. For example, algorithms trained on vast datasets of music and design could recommend specific musical pieces tailored to inspire particular design challenges, fostering targeted creativity.

Virtual reality (VR) and augmented reality (AR) technologies further expand the possibilities for integrating music into design education. Immersive VR soundscapes allow students to experience and manipulate spatial and auditory elements in real time, creating dynamic environments for experimentation. These tools enable educators to simulate real-world scenarios, such as urban soundscapes or the acoustics of architectural spaces, providing students with hands-on experiences that bridge theory and practice.

AI can also facilitate interdisciplinary collaboration by connecting design students with music professionals. Platforms powered by AI could match students' projects with composers or sound designers, encouraging cross-disciplinary exchanges that enrich both fields. Furthermore, machine learning models could analyze the emotional impact of students' designs, offering insights into how their work resonates with diverse audiences.

The integration of music, AI, and future education methodologies holds the potential to transform traditional design pedagogy. By combining the emotional depth of music with the analytical capabilities of AI, educators can create a more engaging, personalized, and effective learning experience. This approach not only prepares students to tackle complex design challenges but also equips them with the skills to navigate an increasingly interdisciplinary and technology-driven professional landscape.

In summary, the intersection of music and spatial design offers rich opportunities for innovation in design education. By leveraging music's capacity to inspire creativity, foster emotional engagement, and enhance collaborative dynamics, educators can cultivate a new generation of designers equipped to address complex challenges with imagination and sensitivity. The integration of music into landscape architecture pedagogy represents not just a methodological enhancement but a paradigm shift in how creativity is understood and nurtured in the design disciplines.

2. Methodology

This research employed an empirical approach to investigate the impact of music on creativity in landscape architecture education. The methodology consisted of the following components:

2.1 Participant selection

Thirty undergraduate students from Tianjin University's School of Architecture participated in the study. None had formal music training, ensuring that their responses were intuitive and unbiased. The participants represented a diverse range of skill levels and creative inclinations, allowing for a comprehensive analysis of music's effects across varied student profiles. This diversity provided insights into how music interacts with different learning styles and creative approaches, highlighting its universal applicability in design pedagogy.

2.2 Workshop design

A musical-drawing workshop was conducted over two sessions. Six musical pieces, varying in tempo and mood, were curated by a tutor with professional music expertise. The selection included classical compositions, contemporary instrumental tracks, and traditional folk melodies, providing a rich auditory palette for exploration. Each piece was chosen based on its ability to evoke distinct emotional and imaginative responses. Students were provided with A3 paper, a variety of drawing tools (including pencils, markers, and watercolors), and an open-ended prompt to express their interpretations of the music through sketches.

To ensure a dynamic and engaging experience, the workshop included an introductory session where students discussed their initial perceptions of music and design. This discussion aimed to prime their awareness of how auditory stimuli could influence spatial thinking. Additionally, a brief explanation of the selected musical pieces was provided to establish context and encourage deeper emotional engagement.

2.3 Procedure

Each musical piece was played twice, with a duration of three minutes per section. Students were instructed to draw what they felt, emphasizing spontaneous and intuitive responses. To ensure an immersive experience, the studio space was acoustically optimized, and distractions were minimized. Dimmed lighting and comfortable seating arrangements further contributed to a focused and reflective environment.

Completed sketches were numbered and pinned for group reflection. To deepen the analytical component, students were encouraged to annotate their drawings with brief descriptions of their thought processes and emotional reactions during the exercise. This additional step allowed for a richer interpretation of the creative outputs, linking visual elements to the underlying auditory inspirations (Figure 3).

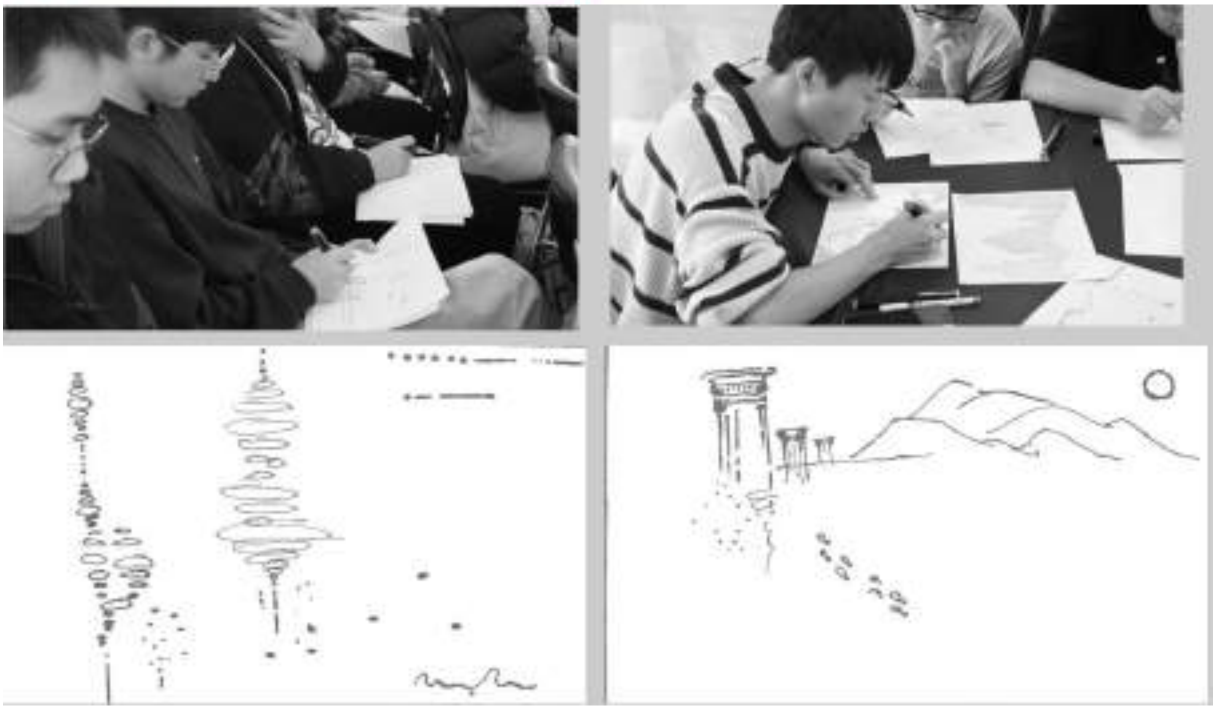

Figure 3. Above: The musical drawing practice, conducted by an experienced tutor, involves design students from various courses at Tianjin University who do not have prior music education. Below: Examples of drawings created by students who interpreted two of the provided music pieces within a three minute timeframe

2.4 Data collection

Data collection involved multiple qualitative and quantitative methods to capture the breadth and depth of student experiences:

1. Qualitative Feedback**:** Feedback was gathered through structured group discussions and individual interviews. These interactions provided insights into how students perceived the relationship between music and their creative processes. Key questions included: "How did the music influence your design decisions?" and "What emotions or thoughts did the music evoke?"

2. Questionnaires**:** A structured questionnaire probed students' perceptions of the workshop's impact on their creativity, engagement, and understanding of spatial design principles. Questions ranged from Likert-scale ratings to open-ended reflections, offering both statistical data and nuanced insights.

3. Drawing Analysis**:** The drawings were analyzed for patterns, themes, and creativity indicators, such as diversity of forms, originality, and emotional expressiveness. Particular attention was given to how visual elements mirrored the musical characteristics, such as rhythm, tempo, and mood.

4. Observational Notes**:** During the workshop, tutors recorded observations on student behavior, noting instances of heightened focus, collaboration, or innovative thinking. These notes complemented the other data sources, providing a holistic view of the workshop's dynamics.

3. Reflection and Evaluation

Following the musical drawing exercise, a reflection session was conducted to allow students to articulate their creative journeys. In this session, students pinned their annotated drawings on a board and shared their interpretations with peers. The tutor facilitated discussions to explore recurring themes and differences in responses, encouraging a deeper understanding of the interplay between music and design.

This reflective practice was supplemented by an evaluative session where students provided suggestions for improving future workshops. Many participants expressed appreciation for the workshop's novel approach, citing enhanced focus and inspiration as key benefits. Suggestions included expanding the range of musical genres and incorporating collaborative drawing exercises to explore group dynamics in creative processes (Figure 4).

Figure 4. Students are encouraged to share their feedback on the workshop and express their emotional experiences throughout the learning process.

3.1 Enhancing methodological rigor

To strengthen the reliability and validity of the findings, the study employed triangulation by integrating multiple data sources and perspectives. For instance, the combination of student reflections, tutor observations, and questionnaire results ensured a comprehensive understanding of the workshop's impact. Additionally, pilot testing was conducted to refine the workshop structure and address potential logistical challenges, such as ensuring sufficient time for reflection and annotation.

3.2 Long-term observations and future directions

Building on the initial findings, the study incorporated follow-up observations to evaluate the sustained impact of music-integrated pedagogy. Students were invited to revisit their earlier sketches and reflect on how their creative approaches had evolved since participating in the workshop. This longitudinal perspective revealed that the integration of music not only enhanced immediate creative outputs but also fostered a deeper appreciation for the interplay between auditory and spatial elements in design processes over time.

The study also identified opportunities for future exploration, such as incorporating neuroscientific tools like EEG to measure brain activity during musical drawing exercises. This approach could provide quantitative insights into the cognitive mechanisms underlying music-inspired creativity. Additionally, collaborations with musicologists and psychologists could deepen the interdisciplinary understanding of how different musical genres and emotional contexts influence design thinking.

By incorporating these methodological enhancements, the study provides robust evidence for the transformative potential of music-integrated pedagogy in landscape architecture education. The findings not only highlight the immediate benefits of such approaches but also lay the groundwork for future research exploring long-term impacts and interdisciplinary applications.

4. Results and Discussion

4.1 Enhanced creativity through music

The workshop revealed that music significantly enhanced students' creative processes. Participants reported that music helped them "visualize" abstract concepts, translating auditory cues into spatial elements. For instance, fast-tempo pieces inspired dynamic and bold sketches, while slower melodies evoked more intricate and contemplative designs. The diversity in student outputs highlighted music's capacity to unlock a wide range of imaginative possibilities, transcending conventional design boundaries.

Detailed analysis of the drawings indicated recurring motifs influenced by specific musical elements. For example, rhythmic patterns in the music were often mirrored in geometric forms, while melodic progressions inspired flowing, organic shapes. This alignment between auditory and visual expressions underscores the potential of music as a medium for bridging sensory modalities in design.

4.2 Emotional resonance and design inspiration

Students described music as a "bridge" connecting their emotions to their designs. One participant noted that "melodic patterns guided my hand, allowing me to explore forms I wouldn't have considered otherwise." This aligns with existing research emphasizing music's capacity to evoke emotional responses conducive to creativity (Muecke & Zach, 2007).

Moreover, the emotional resonance of the workshop extended beyond individual outputs. Group discussions revealed that shared musical experiences fostered a sense of community and mutual inspiration among participants. This collective dimension of creativity suggests that integrating music into studio teaching can enhance not only individual capabilities but also collaborative dynamics.

The findings underscore the potential of music as a pedagogical tool in design education. By fostering an immersive and emotionally engaging environment, music encourages students to think beyond conventional boundaries. The workshop also highlighted the importance of reflection, as students articulated the connections between their drawings and musical perceptions during feedback sessions. Additionally, the inclusion of diverse musical genres in the workshop design provided insights into how cultural and stylistic variations can influence creative outcomes, paving the way for more inclusive and globally relevant pedagogical practices.

5. Conclusion

This study represents a pioneering effort to integrate music into landscape architecture education, demonstrating its transformative potential to foster creativity, emotional engagement, and interdisciplinary connections. By bridging auditory and visual realms, music serves as a powerful catalyst for innovative design thinking, enhancing students' ability to conceptualize abstract spatial relationships while inspiring emotional and cultural connections that enrich design outcomes.

The findings contribute to the growing discourse on interdisciplinary pedagogy, highlighting how music can unlock new pathways for creative exploration and problem-solving. This research underscores the value of interdisciplinary approaches, offering educators tools to nurture adaptable, empathetic, and forward-thinking designers who are well-prepared to address the evolving challenges of landscape architecture.

Future applications of music in education could include leveraging technological innovations such as AI-driven soundscapes and VR environments to deepen students' experiential understanding of space and sound. These advancements promise to foster a holistic approach to design education, enabling students to engage with complex design challenges through imagination, sensitivity, and an appreciation of the interconnectedness of art and science.

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Innovative Pedagogy for Environmental Education Landscape and Environmental Interpretation System Design

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Abstract

The traditional landscape architecture education has relatively fixed professional boundaries, design contents, and targets students within majors. This makes it difficult to break through professional boundaries in teaching and teach students in accordance with their interests and strengths. This study aims to explore the pedagogy of transdisciplinary landscape teaching, in terms of environmental education landscape and environmental interpretation system design, construct the knowledge chain based on the perceptual thinking way of art students and their artistic knowledge structures.

This study was conducted at Central Academy of Fine Arts in China. The campus-wide elective course, Beijing Natural History and Biodiversity Study, is provided for second year and third-year students. The method of Education for Sustainable Development was used to improve students' environmental emotions, attitudes, and cognition, inspiring their interests in related thematic inquiry themes of educational site design, art integration into popular science communication, ecological art, and any other biodiversity conservation issues. The course is structured into five units: theoretical instruction, lectures, field studies, eco-art study, and project presentations. Lectures within different academy background are invited to give tours at field studies. Students are not taught pre-defined concepts but are encouraged to develop their own logic through observation, listening, and discussion. This approach allows them to define and explore the boundaries of environmental education landscape and interpretive system. Up to now, the course has nurtured over 100 future designers and artists from diverse majors, including painting, engraving, sculpture, interaction design, jewelry design, social design, transportation design, animation, graphic design, art education, curation, and more.

Keywords: Landscape architecture pedagogy, environmental education landscape, environmental interpretation system design, education for sustainable development, art school

1. Background Introduction

With the increasing prominence of ecological and environmental issues, the number of landscape sites with environmental educational functions has grown rapidly in China over the past decade. These sites can be categorized into four main types. 1) Zoos and Botanical Gardens: These sites are rich in species resources and primarily serve functions related to ex-situ conservation and breeding. 2) Newly Planned National Parks and Nature Reserves: These feature large-scale natural environments and are major destinations for ecotourism. 3) Nature Education Bases, Labor Education Bases, and Environmental Education Bases: These are primarily targeted at youth and family groups. 4) Urban Parks and Community Gardens: Located in densely populated areas.

The design of interpretive systems and environmental education landscapes requires effectively conveying information to the public, with the medium of communication defining the type of design. Common media forms in interpretive systems include visitor guides, signage, online apps, and ecological art. In site design, common media forms include ecological guided pathways, exhibition halls, museums, eco-friendly facilities, microhabitats, and community gardens. These media are used to communicate species information, ecological phenomena, environmental issues, and related economic and cultural contexts to the public. Freeman Tilden, known as the "Father of Interpretation," emphasized that interpretation should incorporate creativity, storytelling, and emotional engagement to captivate the audience（Tilden, 1957）. At the same time, effective communication must also focus on enhancing audience memory. Cognitive psychology research suggests that the combined use of various media, along with repeated exposure at the critical points of forgetting, can strengthen people's memory of environmental interpretation (Bian, 2021). However, in mainland China, the current landscape education system is constrained by relatively fixed curricula, making it challenging to implement such interdisciplinary training. Therefore, this research aims to explore cross-disciplinary design education to address these challenges.

Challenges and opportunities and coexist. Contemporary university students' growing awareness of ecological and environmental issues presents opportunities for this type of design education. In recent years, due to the emphasis on ecological and environmental issues media coverage, students are increasingly paying attention to topics such as environmental justice and biodiversity conservation, actively exploring solutions. Some students also develop hobbies related to nature exploration. These factors contribute to the appeal of site design and interpretive system design for environmental education landscapes among students. Today's university students are more driven by personal interests in their studies. They are willing to devote after class time to subjects that excite them, rather than being confined solely to their major. This makes cross-disciplinary learning models might work well.

Against this backdrop, Associate Professor Niu Mujing at the Central Academy of Fine Arts (CAFA), opened a university-wide elective course, *"Beijing Natural History and Biodiversity Studies"*, focusing on site design and interpretive system design for environmental education landscapes.

2. The Focus on Biodiversity Conservation

At the very beginning, Professor Niu Mujing organized a five-day zoological park design workshop for architecture students at CAFA in January 2016 during the winter break. The workshop focused on designing animal exhibit areas and interpretive systems. Before the workshop, two theoretical lectures were held, delivered by science educators from Beijing Zoo. These lectures covered topics including domestic and international zoos, species conservation in zoo, biodiversity conservation education, and zoo signage systems. Students registered for the workshop after thoroughly understanding its themes. A total of 20 students were selected to participate. The workshop began with a one-day visit to Beijing Zoo, where students examined the current state of exhibit areas and educational facilities. Over the following four days, students worked at school, conducting research, developing design concepts, and creating visual representations, and Professor Niu provided one-on-one guidance. Due to the tight schedule, most students completed only conceptual designs, with further refinement, detailed drawings, and manual crafting tasks continuing during the winter break. The students' works included visitors' rest areas, enrichment facilities, educational panels, and educational books. Ultimately, from March 3 to March 20, an exhibition titled "*Humans Entering the Zoo*" was held at the Science Education Hall of Beijing Zoo to showcase the students' designs.

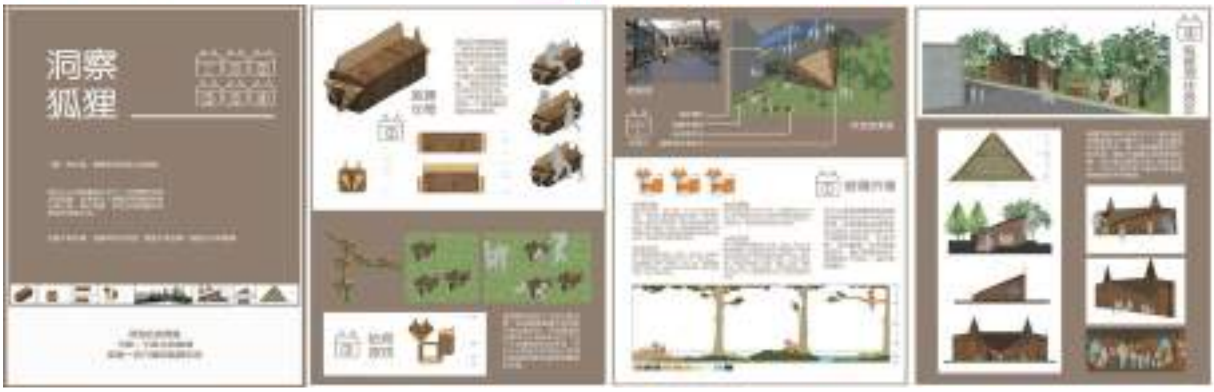

Figure 1. Design of the Rest Area near the Fox Exhibition Zone (Guo & Jiang, 2016)

Despite receiving positive feedback from students, the zoo educators, and the public, the workshop could not be integrated into CAFA's formal curriculum. As informal education approach, there is insufficient guidance time for students and imperfect course structure.

In June 2020, Professor Niu introduced a university-wide elective course at CAFA titled *"Biodiversity Conservation Design."* （about 36 course hours, in 4 weeks, opens to second- and third-year students）. It had 15 spots available. Normally a university-wide elective course is designed to help non-major students gain insight into the major. Therefore, the course primarily focused on site design using landscape techniques. The course chose three sites in Beijing Zoo. The goal was to renovate space to enhance their educational functions in engaging and creative ways. The course comprised three units: lectures, theoretical instruction, and design guidance. Lecture about Beijing Zoo's was given by chief educator of the zoo. In the theoretical unit, Professor Niu covered topics including design methods of landscape architecture, the history of zoos, the development zoo exhibition modes, and scientific communication in outdoor zoo spaces. Students then selected issues they concerned, and the instructor provided one-on-one guidance. Issues included public communication of habitat knowledge, correcting bad visitor behaviors, combining online and offline conservation education, nighttime visiting that respect nocturnal animals' biological habits, and enrichment. And all these are solved in form of site design or facility design. Ultimately, in October 2020, the students' works were showcased in an exhibition titled *"Humans Entering the Zoo 2.0"* at the Beijing Zoo Science Education Hall.

Figure 2. Design of the AR Exhibition for Animal Habitats (Lin, 2020)

In the next year, 2021, the course still focused on zoo but removed the requirement to follow a landscape design approach. This change aimed to break the limitations of design media. As a result, some interesting topics emerged. For instance, one student addressed the negative impact of obsessive fan behavior among Giant Panda enthusiasts in China on panda conservation. She designed an App that incorporated panda conservation knowledge into a fan points system to encourage more rational fan behavior.

However, this course faced two challenges. One is, as a studio course, it required one-on-one guidance from the instructor, which constrained the number of participants. The other one is, as a design course, it relied heavily on drawing skills, posing difficulties for students without a drawing background and raising the barrier to enrollment.

3. Integrating Natural History Studies and Sustainable Development Education Methods

Many disciplines at CAFA have started paying attention to ecological issues in recent years. However, apart from the landscape program, which offers an ecology course, other disciplines lack relevant courses. Campus-wide elective courses can be utilized to provide students with opportunities to learn about these knowledges. Therefore, starting in 2023, the *Biodiversity Conservation Design* course was upgraded to *Beijing Natural History and Biodiversity Studies.* The enrollment capacity was increased to 30 students. The course is structured into five units: theoretical instruction, lectures, field studies, eco-art study, and project presentations. Experts and instructors with various academic background have been invited to participate in teaching.

This course itself is an application of Education for Sustainable Development (ESD). It aims to enhance students' emotions, attitudes, cognition, and abilities. And it integrates various fields, including environmental degradation, behavioral research, economic concerns, ethic, etc. It encourages the use of critical thinking to address sustainability issues, adopting a learner-centered approach that motivates students to actively engage in their own learning processes and think proactively about future challenges.

Additionally, the course incorporates extensive nature observation activities, making it more engaging and appealing. Compared to abstract theoretical models and data, focusing on species and habitat experiences resonates more deeply with students, making ecological crises more tangible. In the Chinese context, the name of the course is essentially understood as gaining knowledge about animals, plants, physical geography, and natural history through filed study. This clearly conveys the course's characteristics, making it easier for students to understand its objectives when choosing the course.

The first three units of the course are primarily teacher-led. Theoretical instruction is conducted in one session by Professor Niu, covering topics including the history of natural history studies, the development of zoos, botanical gardens, and museums; China’s biodiversity conservation system; and environmental interpretive systems. There are two lecture sessions, featuring case studies on ESD activities and wild animal research and conservation. Guest speakers include the chief of science education from the Chenshan Botanical Garden and an editor from *The Museum* magazine （focused on biodiversity conservation）. Additionally, eight field study sessions are conducted in Beijing, the city where CAFA is located, with experts or educators from the respective venues providing in-depth tours. Theoretical instruction, lectures, and field studies are arranged in a sequence from theory to case studies to hands-on experience, reinforcing students’ understanding of educational site and interpretation system. In the field study process, students, as users, experience educational sites and interpretive systems. This allows them to intuitively identify problems, which helps them pinpoint topics for their research and design projects.

The field study sites are divided into four groups:

1. National Botanical Garden, Beijing Zoo, and National Zoological Museum: These sites help students understand biological knowledge, habitat information, and conservation work related to living animals and plants.

2. China Geological Museum and National Museum of Natural History: These venues provide students with a broader understanding of physical geography and evolutionary history.

3. Beijing Institute of Landscape and Forestry Sciences: Here, students learn about ecological science research related to urban green spaces.

4. Birdwatching activities at Olympic Forest Park: Students observe wildlife within urban ecosystems.

Figure 3. Field trips (Niu, 2024)

CAFA currently offers 30 undergraduate programs, including fine arts, applied art, and non-drawing-based programs like Art History, Art Theory, Art Management, Art Education, and Conservation and Restoration of Cultural Relics. To fit students from different backgrounds, this course does not require design drawings as the sole form of expression for assignments. Students can choose the medium of expression based on their own fields of study.

This diversity academic backgrounds of students and lectures allows for multidimensional explanations of environmental education landscapes and interpretive systems. The exchange and collision of different perspectives are a key resource provided by the course. During the field studies unit, instructors deliberately initiate discussions on relevant issues to stimulate students' exchange of ideas. Meanwhile, all the guest lecturers are ensured fully understand the primary teaching objectives of the course to make the series of field trips a whole.

The final two units of the course are student-led. One unit involves students sharing ecological art cases. The other unit is assignment presentation. With the increasing accessibility of online learning resources, students demonstrate strong information-gathering capabilities and adaptability to new technologies. Based on the issues discussed during the field studies and aligning with their personal interests, students identify research questions and, leveraging their professional skills, conduct research or design. The course serves as a platform for students to explore and engage in inquiry-based learning.

4. Course Outcomes

Students approach issues from multiple dimensions, including education, behavior, and communication media, and their solutions in design and research reflect an integrated way. For example, Xiao Siruo's App design explores the issue of invasive species in the pet market and examines how to influence consumer behavior to ensure species sustainability. Xiao observed that the trend of owning exotic pets among pet enthusiasts—driven by fashion, novelty, and curiosity—has led to problems such as high abandonment rates, expensive and complex pet treatments, and a lack of legal knowledge. In response, this pet-focused online community App integrates basic functionalities like pet product sales, veterinary care, and care guides while incorporating educational features to raise awareness about the risks of keeping exotic pets and to disseminate related legal knowledge. The solution is from the user's perspective, first addressing practical user needs and then cleverly embedding educational elements.

Figure 4. Pet App design to solve invasive species issue (Xiao, 2023)

The engaging nature of environmental interpretation is a key focus for many students. For instance, Liu Yening designed a book on how to remember animal names, providing a fun and interactive tool for learning about animals. She observed that most people without specialized knowledge find it challenging to quickly memorize the names of wildlife when they first encounter them. Drawing on memory studies, she proposed that factors such as habitat, animal's distinct features, and imagining a dialogue with the animals could enhance memory retention. Using this approach, she created a fun memory book featuring 80 species she photographed in the wild.

Figure 5. Two pages of the book *What Animal* (Liu, 2024)

Another focus for students is the integration of cultural elements into environmental interpretation. Zhang Wanxin curated an exhibition titled *"Harmony and Coexistence"* to raise public awareness about biodiversity conservation by exploring the historical connection between humans and animals in Chinese painting. The exhibition follows a timeline divided into four phases: *Totem and Shamanism*, *Animism*, *The Way of Nature*, and *Harmony in Diversity*. It aims to illustrate the evolving relationship between humans and animals over time.

Big data is an important tool for contemporary environmental interpretation. Liu Peipei conducted research on the relationship between greenhouse gas emissions and bird migration. Data from 2012 to 2022 showed that Beijing's average temperature increased year by year, greenhouse gas concentrations rose, cloud droplet radii decreased, cloud droplet concentrations increased, and the number of Anas Zonorhyncha （a bird） declined annually. Although the scientific validity of such correlation analyses requires further discussion, the student tried to explore ways to visualize this relationship for public engagement.

After the course, interviews were conducted with students to gain insights into their experiences. Most students indicated that their reason for taking the course stemmed from hobbies such as raising animals or cultivating plants, an interest in natural history, or the need for natural science-related knowledge in their own field of study. Some students mentioned that the course assignments would be a foundation for their graduation projects or other related creative work. And all of them enjoyed the field trips.

5. Social Service Activities

During the summer, Professor Niu organized students to participate in environmental education social service activities. The participants included students from this course as well as those from her "Ecology " course in the Landscape Department. These activities have included youth-oriented environmental education programs in urban parks, the construction of ecological art installations in urban parks, the design of natural classrooms in environmental education centers, and community-based environmental education exhibitions.

Figure 6. Urban Farmer: community garden environmental education and exhibition project (Niu, 2022)

Figure 7. Natural classroom and eco installations (Niu &Chen, 2024)

6. Reflections and Impacts

Initially, the Professor Niu lacked confidence in the quality of class assignments, as the course, *Beijing Natural History and Biodiversity Studies*, did not offer design guidance. However, student projects in this course showed no decline in quality compared to the previous *Biodiversity Conservation Design* course, which included design guidance. And this shows that students' creativity has been actively stimulated in this course.

Mean a while, the course also has its limitations. The field study unit is divided into four groups which was planned to be carried out sequentially. However, due to the specialized nature of the field study sites, different instructors are needed, and coordinating their schedules often prevents the trips from following the intended order. This sometimes leads to a fragmented learning experience for students, which is currently an unavoidable challenge.

Since the teaching began in 2016, the course has nurtured over 100 future designers and artists from diverse majors, including painting, engraving, sculpture, interaction design, jewelry design, social design, transportation design, animation, graphic design, art education, curation, and more. It is hoped that this course will provide more study opportunities for students to explore in this field.

Note

Figure 1. Student Guoxiaojing and Jiangyijia together designed the rest area near the Fox Exhibition Zone, with education of fox habitat.

Figure 2. Student Lin Shihan designed of the AR Exhibition for Animal Habitats in Beijing Zoo.

Figure 3. Photos of field trips at National Zoological Museum， National Botanical Garden，

Olympic Forest Park. Photograghed by Niu Mujing.

Figure 4. Student Xiao Siruo designed a App for pet owners to solve invasive species issue by integrating Biodiversity Conservation and Legal education features into.

Figure 5. Student Liu Yening design the book *What Animal* to help people remember the name of wild animals.

Figure 6. *Urban Farmer*: community garden environmental education and exhibition project orgnized by Niu Mujing was held in Shuangxiu Community park in Beijing. Three students Wang Ziye, Yang Andi, Chen Ming participated. Photograghed by Niu Mujiing.

Figure 7. The left picture is natural classroom project accomplished by Niu Mujing and student Chen Ming. Photograghed by Chen Ming. The middle picture is an eco-installation about endangered plant conservation in the classroom accomplished by Chen Ming, instructed by Niu Mujing. Photograghed by Chen Ming. The right picture is the exhibition, *Education & Garden*, organized by Niu Mujing. The eco-installation, *Manmade Tree*, is in the center of this picture, accomplished by Chen Ming, instructed by Niu Mujing. Photograghed by Niu Mujing.

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Introducing Landscape Literacy in Architecture Students Through Pedagogical Exercises

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Abstract

Landscape Literacy is described as the ability to read landscapes and decipher the stories they tell. Developing/Imbibing this ability in all disciplines whose work impacts the landscape would go a long way in ensuring that human interventions tread lightly on the natural environment. This poster documents the teaching methodology adopted at my school, IESCOA Mumbai, for the landscape architecture introductory course for undergraduate students of architecture - the generation of one of the key professions that is next going to lay claim to our built and unbuilt environment. The poster presentation outlines the course objectives and learning outcomes obtained through a series of short exercises conducted over two semesters.

The method adopted is documentation and self-assessment of a personal journey and the study sample is the work of a single batch of students over 3 years. In this documentation, the academic exercises done for the course are mapped over 3 years (beginning with the year that the introductory course is taught up to the final year of Architecture school) to monitor the nuances that exhibit landscape literacy:

- Response to site and setting

- Response to social, cultural and climatic context

- Strengthening existing associations in a context and introducing newer narratives in the design

Keywords: Landscape associations, sensitising architecture students, reading landscapes

1. Introduction

Teaching landscape as part of the undergraduate course in Architecture can be seen as an opportunity to open an alternative window to the aspiring architect, or at the very least, give the young architect the tools to understand the impact that architecture can make on the landscape and viceversa. Landscape literacy is a good description of what an undergraduate introductory course in landscape architecture may hope to achieve – a degree of familiarity with the language of landscape, and its vocabulary.

Beginning to appreciate language helps analytical thinking; it clarifies the concepts of structure, sequence, narrative, connection, allusion, and their significance to how we think about what we see and make. In talking of literacy, we are also speaking of grammar and construction, in what we say, what we write, and what we draw. To learn that each subject has its own language is to understand also that without being at ease in that language, very little progress can be made in acquiring the creative and technical skills that would enable proficient practice of that discipline. It is important to know that this language, whilst having its own peculiarities and special identity, is inseparably connected to the vocabulary of other creative arts and crafts.

In this short course of one or two semesters (it differs in different programs across different universities), the demonstration of how concepts in landscape architecture intersect with architecture may be a good beginning. Each aspect of the undergraduate architecture program can find a resonance in landscape concerns. For example, in history, one can revisit architectural sites with a landscape perspective, structural engineering is intrinsically associated with terrain, slope stabilisation, retaining walls, etc.

Landscapes capture the fourth dimension of time – designed landscapes need time to grow into what they were imagined to look like, they take time to bloom and showcase their seasonal glory and bear the fruits they were planted to produce and provide shade to their patiently-waiting nurturer. Much akin to this, is the knowledge of landscape architecture that is introduced to the students…every exercise/assignment is completed and graded but the real learnings will only appear in a few months and years - in their studio designs and eventually live projects. The assessment of landscape literacy and the measure of success of the pedagogical model can only be tested over time, one sensitive student at a time.

This poster illustrates the pedagogical exercises that were used to introduce the subject of landscape architecture to students in the third year of undergraduate studies in Architecture with an intent to inculcate landscape literacy in them.

2. Material and Method

Following is the list of studio exercises conducted in the introductory course of Landscape architecture for third year students of Architecture (at the Indian Education Society's College of Architecture, Mumbai)

- ❖ Associations in the Landscape (at the Personal, Collective and City level - cultural, social, educational, recreational, ecological engagement and significance)
- ❖ Decoding Landscapes (through an understanding of scale, composition, textures, colour)
- ❖ Understanding Landscape Settings (in architecture)
- ❖ Learning from History (traditional responses to natural and designed landscapes)
- ❖ Site Analysis and Ecological Planning
- ❖ Spacemaking with Landscape Elements (Land, Water, Vegetation)

The first semester:

The first three exercises were conducted in the first semester (14 weeks) and the next three exercises were conducted in the second semester (14 weeks).

Both semesters also included guided walks – first one in the natural environs of the city and the second one through a designed landscape in the urban environs. During these field trips, the students were asked to prepare posters that exhibited the associations with the landscape at a personal level (largely felt in the natüre walk), a Collective level (perceived more at the neighbourhood, semi-urban scale) and at the City level (clearly exhibited in the urban walk).

Photo documentation of the above visits was also mandatory.

The second exercise was titled Decoding Landscapes and the students read an existing landscape (through a photograph) by breaking it down in layers to understand scale, composition, texture, colour, datum, background and foreground, etc. Physical models were also made to recreate the layers.

Figure 1. Decoding Landscapes (Exercise 2) **Figure 2.** Landscape as a Setting (Exercise 3)

Understanding Landscape Settings was an exercise that was done using the Case Study methods where students worked in groups and analysed a project that had a dominant built intervention that responded to its landscape setting. This included studying the geographical setting, surrounding context, terrain and datum mapping, hydrology mapping, sectional studies of the structure and site as well as mapping the colour palette and textures. The study also looked at the relationship between the built form (indoors) and the outdoors through framed views and role of the larger setting in design. The projects which were selected for study either had detailed documentation available or the students had access to the sites and the possibility of communicating with the architects/landscape architects.

The second semester:

At this stage the students were introduced to lessons from the past – looking at landscape heritage gardens depicting different times, geographic locations, sociocultural and economic conditions around the world. The case study method was adopted for this exercise as well, however, sources of reference included books, research articles, documentation resources, films and photographs. The attempt was to understand different typologies of gardens and open spaces across varying global regions and to see how landscape responses were a result of societal structure and geographic location.

After having looked at historic as well as contemporary examples of landscape architecture and design, the next exercise demanded that the students conduct a detailed site analysis of a contoured site that included study of terrain, surface hydrology, vegetation, geology and geomorphology and arrive at a site suitability criteria for siting their built programs. This exercise synthesised their earlier learnings and introduced the idea of site planning based on natural systems.

The final exercise on Spacemaking with Landscape Elements permitted the students to develop their own aesthetic and finctional response to the design program and also equipped them with basic graphical representation skills for a landscape design project.

3. Findings and Discussion

Each of the above exercises were developed for set objectives and outcomes and while it was seen that the attempt was successful at an exercise level, the evaluation of these skills two years later in their design dissertation portfolio was not always as evident.

Table 1

Exercise	Title	Objectives	Outcomes
1	Landscape Associations	Landscape perception at various scales	Understanding the concious and sub-conscious connection with the landscape (natural, man-modified and manmade)
2	Decoding Landscapes	Reading a landscape through different lenses	Understanding that every landscape is a mosaic of colours, textures, varying depths, engaging with the ground plane and the sky plane
3	Landscape as a Setting for Architecture	Understanding the relationship between the built and unbuilt in a particular landscape setting	Responding to an existing setting – borrowing a view from the landscape, merging into the landscape, using the landscape as a canvas
4	Lessons from the Past	Learning about landscape typologies and styles across the world, in space and time	Relating landscape architecture to the arts, humanities and social sciences
5	Site Analysis and Ecological Planning	Mapping natural systems, assessing values and overlay method of site analysis	Ecologically responsible site planning
6	Spacemaking with Landscape Elements	Assigning functions, materials and detail design to spaces	Developing a design aesthetic that is sensitive to the natural setting

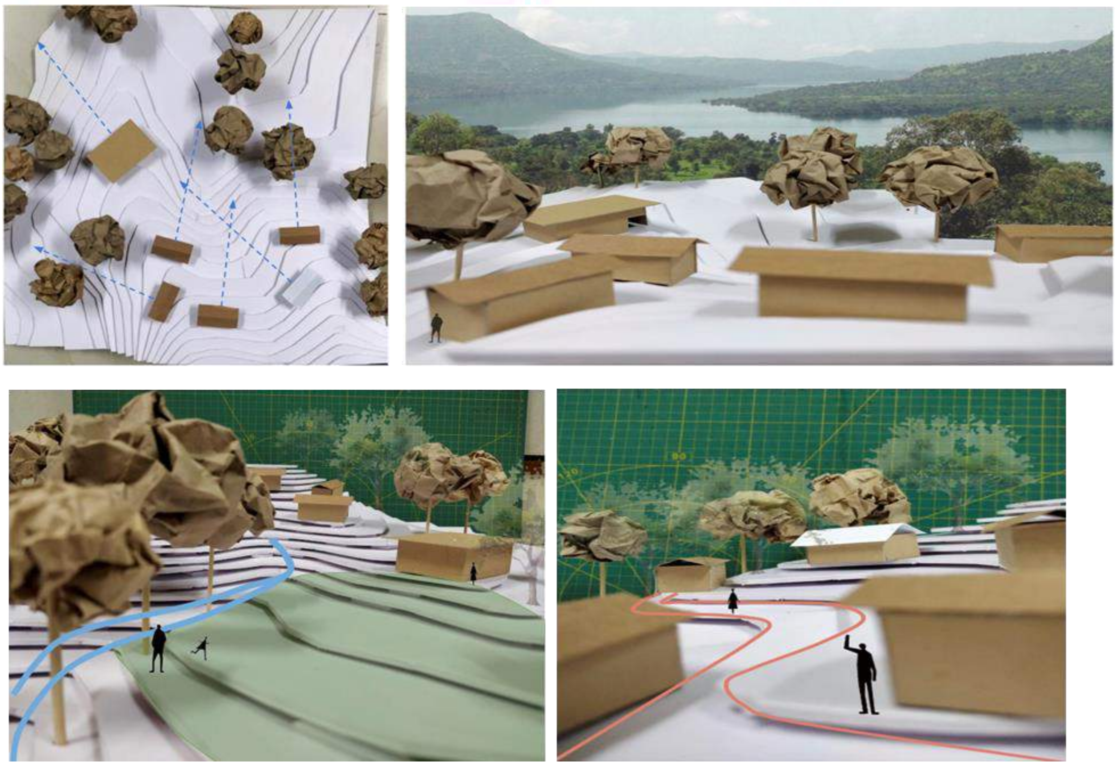

Figure 3. Site Analysis and Ecological Planning (Exercise 5)

Figure 4. Final year design project (student, batch of 2019-2024)

The final year design projects of the same set of students in their final year did not show all the above points in their site planning or landscape design. It was felt that some of the landscape literacy lessons were lost in prioritising site restrictions, budgetary limitations, construction technology, site services, etc.

4. Conclusion

Landscape architecture is an allied subject in the undergraduate course of Architecture and the studio can introduce the language and vocabulary but for the student to apply this knowledge well, it is important that all other subjects also acknowledge the relevance of landscape architecture in their respective domains.

It is often felt that other disciplines (architecture and allied fields) also need to have the same level of landscape literacy to be able to encourage the student to further their learnings and apply them.

Note

The author acknowledges the participation of the other IESCOA faculty members Prachi Nadkarni and Khushboo Adhiya (both landscape architects) in formulating and teaching this studio. The poster showcases the work of the students of the batch of 2019-2024

Landscape In Focus – LIF-T

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Abstract

This study investigates the challenges and opportunities in sustainable landscape development faced by small municipalities across four European countries: Czech Republic, Slovakia, Finland, and Germany. Through a qualitative multiple case study approach utilizing 'structured, focused comparison' methodology, the research analyzed twenty cases, with five from each participating country. The study particularly focuses on municipalities with fewer than 2,000 inhabitants, which comprise over 50% of German municipalities and 85% of Czech municipalities. The research reveals that small municipalities face significant obstacles including limited financial resources, technical expertise shortages, and demographic challenges, while struggling to fully utilize available funding programs due to administrative constraints. A comprehensive needs analysis identified 13 thematic areas, which were refined through stakeholder validation and expert consultation. The findings informed the development of a digital learning environment and educational materials, structured around five core principles: sustainability, conceptuality, inclusivity, architectural quality, and health benefits. The study concludes that successful implementation of sustainable landscape projects in small municipalities requires context-specific solutions and emphasizes the importance of accessible, practical resources. The resulting tools and guidelines will undergo testing with over one hundred municipalities to ensure their effectiveness in real-world applications.

Keywords: Landscape, rural areas, education, best practice, climage change

1. Introduction

Municipalities play a significant role in combating climate change through various strategies and actions that address both mitigation and adaptation challenges. They can set up policy frameworks and implement local policies and take actions that impact not only spatial and landscape planning, for example by means of land use regulations and zoning, but also other fields like transport, energy and green infrastructure. Often being the first responders to localized climate impacts like floods or heatwaves they develop strategies and plans in order to be prepared and build resilience for the communities (Kastelein, 2024). At the same time, they manage their natural resources like water and green spaces to mitigate risks that are associated with changing weather patterns (Climate Alliance, n.d.) (Cappell et al., 2022). Local governments have the capability of engaging both the community and key stakeholders in climate actions through partnerships, incentives and campaigns raising awareness and educating on the topic. It is crucial to build public trust through inclusive climate action in order to accelerate and amplify local efforts. There are many examples of formal actions that signal the municipality's commitment to tackling climate change, such as adopting formal climate strategies, declaring climate emergencies or developing specific toolkits (Cappell et al., 2022). By advocating for supportive national policies and funding frameworks they can enhance their capacity for action. Working alongside state or provincial governments they align local efforts with broader climate goals. Hence, municipalities can be considered key drivers of localized climate action. Their efforts are crucial for achieving global climate goals while addressing the unique needs of their communities.

More than half of the municipalities in Germany have fewer than 2,000 inhabitants. According to a source from mid-2024, these municipalities account for over 50% of the total of around 11,000 municipalities in Germany (komuno GmbH, 2024) (Statistisches Bundesamt, 2024). In the Czech Republic, the figure is as high as 85%.

In the summer of 2020, the European Investment Bank's Economics Department conducted a comprehensive survey of 685 municipalities across the European Union to evaluate their infrastructure challenges and investment landscape. The study revealed concerning gaps in municipal infrastructure development, particularly in climate-related projects. Most notably, approximately two-thirds of surveyed municipalities reported they lacked the necessary resources and capabilities to implement environmental initiatives. The findings also highlighted a significant shortage of technical expertise required to execute these critical infrastructure projects effectively (McGoldrick et al., 2021).

Funding programs for climate change mitigation and adaptation are available for both urban and rural areas, although the focus and objectives of the programs vary depending on the type of area (C). Overall, the funding is comparable in scope, but more tailored to the respective needs of the areas: urban programs focus on infrastructure and resilience measures, while rural programs focus more on natural mitigation measures and agricultural sustainability (D). Small municipalities often have limited personnel and administrative capacities to submit and process funding applications. This can lead to funding not being fully utilised (Sixtus et al., 2020). Funding programs such as 'Smaller towns and municipalities' are explicitly aimed at smaller municipalities, but often require inter-municipal cooperation, which means additional effort (Bundesministerium für Ernährung und Landwirtschaft [BMEL], 2019) (Bundesministerium für Wohnen, Stadtentwicklung und Bauwesen [BMWSB], 2021).

Small municipalities in rural areas face distinct challenges compared to larger cities when addressing climate change, stemming from differences in resources, governance structures, and socio-economic dynamics. The budgetary situation of these municipalities is particularly tense and characterized by structural challenges (Bundesinstitut für Bau-, Stadt- und Raumforschung [BBSR], 2021) (Deutscher Landkreistag (DLT), n.d.). According to the KfW Municipal Panel 2024, necessary projects cannot be realized in more than half of municipalities due to a lack of own funds, with many funding programmes requiring an own contribution of at least 10% (Deutscher Landkreistag (DLT), n.d.) (Sixtus et al., 2020). These municipalities often lack technical expertise and struggle with staff shortages, resulting in work overload. Unlike larger cities, which can more readily attract external funding or private investment, rural areas rely mainly on government grants or programs (Zeigermann et al., 2022).

The demographic and economic constraints further complicate these challenges. Aging populations and declining labor availability hamper long-term planning and project implementation (Ministry of the Environment, Nature and Transport of the State of North Rhine-Westphalia, 2023). Economically, these regions often depend on agriculture or other climate-sensitive sectors, making them particularly vulnerable to climate impacts (International Fund for Agricultural Development [IFAD], 2010). Community engagement also presents unique challenges, with dispersed populations and limited access to communication channels making it difficult to maintain consistent involvement (Covenant of Mayors - Europe, 2023) (International Fund for Agricultural Development [IFAD], 2010), although traditional knowledge in rural communities remains an important asset in addressing complex landscape development issues (Su et al., 2022).

To address these challenges, there is a critical need for suitable information sources tailored to municipal employees' needs and skills. Given the limited time and resources available, such information must be clear, appealing, and easily accessible, providing both fundamental understanding and references to further resources. Currently, educational materials on landscape development and planning in small and medium-sized municipalities are inadequate or non-existent in some regions, with most materials lacking interactivity and flexible learning opportunities. This project aims to address these deficiencies by creating high-quality, accessible, and flexible educational materials to support sustainable landscape development in small municipalities.

2. Material and Method

The research process commenced with a comprehensive needs analysis conducted across four European countries (Czech Republic, Slovakia, Finland, and Germany), engaging experts in landscape architecture. This initial analysis identified 13 distinct thematic areas for investigation, which underwent further refinement through a dual validation process: first, through the practical expertise of the project team, and second, through feedback from stakeholders in rural municipalities involved in ongoing projects. The findings were verified through interviews with key stakeholders, including municipal leaders in small communities.

The study employed a qualitative multiple case study design, utilizing the 'structured, focused comparison' methodology (George & Bennett, 2005). Given resource constraints, the investigation relied on comprehensive desktop research, prioritizing projects with substantial published documentation and reliable secondary data sources. Where feasible, findings were corroborated through stakeholder consultations. The selection process incorporated cases familiar to the project team through their professional experience, yielding more than 20 potential cases initially. Following a rigorous selection process, the final sample was narrowed to exactly 20 cases, ensuring equal representation with five cases from each participating country.

To systematically document these cases, the research team developed a structured fact sheet system. This innovative template was designed to capture both basic municipal information and detailed project specifics in a bilingual format, serving both international knowledge sharing and local implementation needs.

Erasmus+ LIF-T "Landscape in Focus" - Tools for Small Municipalities for Sustainable Landscape		
Case Study Research / Collection of Best Practices in Small and Medium-Size Municipalities in Czechia, Finland, Germany, and Slovakia		
WP2 Landscapes for both, environment and good living		
Factsheet		
	English	Your national language
Case study		
Title/name of the case study:		
Basic information on the municipality		
Country:		
Region:		
Municipality:		
Homepage:		
Number of inhabitants:		
Overall administrative territory of the municipality (km2):		
Population density (inhabitants/km2):		
Story of the case study		
Years of planning/design/ implementation, etc.		
Key local stakeholders/actors:		
Short description of the case study:		
Keywords:		
References		
Further publications/links:		

Figure 1. Template for systematic documentation of case studies, designed to capture municipal information and project specifics in a bilingual format (Schüppel et al., 2024)

The fact sheet framework was built around five core principles: sustainability (examining aspects like circularity and economic efficiency), conceptuality (evaluating integration with broader planning approaches), inclusivity (assessing community participation levels), architectural quality (considering design values), and health and wellbeing benefits for inhabitants.

Principle / Aspect	Relevance	Principle / Aspect	Relevance	Principle / Aspect	Relevance	Principle / Aspect	Relevance	Principle / Aspect	Relevance
Sustainability (e.g. circularity, materials, maintenance, economic efficiency, etc.)	**	**Conceptuality** (e.g. the case study is part of a wider/broader conceptual approach)	***	**Inclusivity** (e.g. local residents were involved through participatory planning, co-design, etc.)	***	**Architectural quality** (architectural values of the case study)	***	**Health and wellbeing** (benefits for the health and quality of life for inhabitants)	***
Subtheme(s)	Approach/solution(s)	Subtheme(s)	Approach/solution(s)	Subtheme(s)	Approach/solution(s)	Subtheme(s)	Approach/solution(s)	Subtheme(s)	Approach/solution(s)
Resource efficiency	E.g. using local resources, reducing transportation costs and environmental footprint	Integrated planning	e.g. the case study is part of a master (landscape) plan and is implemented [illegible]	Involvement of locals in planning and/or design	E.g. local citizens were involved in the preparation of the landscape plan / in developing the design	Professional architectural quality	e.g. the case study was designed by architect(s), the concept is unique and original	Improving health and well-being of citizens	E.g. improving local microclimate, reducing the heat island effect, providing shade, etc.
Maintenance	E.g. applying selective management forms ([illegible])	Complexity	e.g. the case study addresses multiple challenges and problems	Involvement of locals in the implementation	E.g. local citizens were involved in planting of trees/flowers, building elements, etc.	Visual values	E.g. the architecture addresses regionally unique forms and materials	Improving recreational possibilities	E.g. providing new opportunities for recreation, leisure and local tourism
Community	E.g. there is a local community that will sustain the case study	Continuity	e.g. the project builds upon existing [illegible], continues in activities and further develops them, etc.	Involvement of locals in maintenance/management	E.g. local citizens participate in the maintenance/management of the area	Material quality	E.g. the architectural elements use high quality materials / locally identical and authentic materials from nearby sources, etc.	Enhancing safety	E.g. Providing new possibilities for safe mobility (pedestrian paths and cycling)

Figure 2. Evaluation framework showing the five core principles and their associated subthemes and approaches used to assess landscape development projects (Schüppel et al., 2024)

The researchers developed a comprehensive topic classification system covering five main thematic areas: water and soil management, nature and biodiversity, aesthetics and culture, public space, and mobility.

Figure 3. Comprehensive classification system showing the five main thematic areas (water and soil, nature and biodiversity, aesthetics and culture, public space, and mobility) with their respective subthemes and approaches (Schüppel et al., 2024)

This classification helped structure the findings and make them more accessible to end users. The data collection process employed a mixed-methods approach, combining questionnaires to municipal stakeholders, systematic image collection, and documentation of narratives and personal stories. This comprehensive methodology ensured that both quantitative and qualitative aspects of the projects were captured, providing a rich understanding of each case study.

The needs analysis ultimately informed the development of a comprehensive criteria framework, which subsequently guided the case study selection process and ensured consistent evaluation across different contexts and scales. This systematic approach enabled the research team to develop a robust foundation for analyzing and sharing sustainable landscape practices across European municipalities.

3. Findings and Discussion

The research revealed several significant findings regarding the challenges and opportunities in sustainable landscape development for small municipalities. A primary discovery was the substantial impact of municipality size on both decision-making capacity and resource availability. Many smaller municipalities struggle with limited awareness of how landscape solutions can address broader social and economic challenges. Technical knowledge gaps and implementation difficulties further compound these challenges, while maintaining consistent community engagement emerged as a persistent concern across different contexts.

A notable methodological challenge emerged regarding the definition of "small and medium municipalities" across different countries. This highlighted important variations in how size is measured, with some regions focusing on total population while others emphasized population density. These differences in national standards for municipal classification necessitated a more nuanced approach that considered both the number of inhabitants and territorial size.

The research successfully gathered a minimum of five case studies from each partner country, enabling the development of a sophisticated clustering system based on user motivation. This led to the creation of an integrated framework that effectively connects principles, approaches, and solutions, while identifying critical cross-cutting themes and success factors. The findings demonstrate the essential role of local context in sustainable landscape development, emphasizing how community involvement in both planning and implementation phases contributes to project success.

The practical implications of these findings are being translated into actionable tools through the development of a comprehensive digital learning environment and educational materials. The documentation of twenty case studies across four European locations provides concrete examples and insights for other municipalities to learn from. These materials are being compiled into practical implementation guides that address the specific needs and challenges identified through the research.

The findings are now informing the development of detailed step-by-step guides and digital learning tools. These resources will undergo rigorous testing with at least one hundred municipalities before being made available to the public, ensuring their practical utility and effectiveness. This testing phase represents a critical step in validating and refining the tools based on real-world feedback and experience.

The research underscores the ongoing need for support and knowledge-sharing among municipalities. Case studies have proven particularly valuable in providing practical examples and solutions for sustainable landscape development at the local level. The findings suggest that successful implementation requires careful attention to the integration of multiple objectives, including environmental, social, and cultural considerations. This holistic approach, combined with practical, accessible tools, appears to offer the most promising path forward for small municipalities seeking to enhance their landscape development practices.

Looking ahead, the research indicates that continued emphasis on knowledge exchange and practical support will be crucial for helping small municipalities overcome their unique challenges in sustainable landscape development. The development of accessible, tested tools and resources represents an important step toward building capacity and expertise at the local level.

4. Conclusion

The research highlights the complex challenges faced by small municipalities in implementing sustainable landscape development, particularly those with populations under 2,000 inhabitants. These challenges are multifaceted, encompassing financial constraints, limited technical expertise, and resource scarcity. Despite these obstacles, the study demonstrates that successful implementation of sustainable landscape projects is possible when properly supported with appropriate tools and resources.

The comparative analysis across four European countries (Czech Republic, Slovakia, Finland, and Germany) has yielded valuable insights into effective approaches for supporting small municipalities. The development of targeted educational materials and digital learning tools, informed by twenty detailed case studies, represents a significant step forward in addressing the knowledge gap identified in the research. The emphasis on practical, accessible resources tailored to the specific needs of small municipalities shows promise in overcoming traditional barriers to implementation.

A key finding emphasizes the importance of context-specific solutions that consider local conditions, resources, and community engagement. The research underscores that successful landscape development projects must integrate environmental, social, and cultural considerations while accounting for the unique constraints and opportunities present in rural settings. The planned validation of these tools with over one hundred municipalities will further ensure their practical utility and effectiveness.

Moving forward, the findings suggest that continued investment in knowledge-sharing platforms, practical support mechanisms, and accessible educational resources will be crucial for empowering small municipalities to pursue sustainable landscape development effectively. This research contributes to building a foundation for more resilient and sustainable rural communities, while acknowledging the ongoing need for targeted support and resource allocation to address the specific challenges faced by smaller municipalities in their sustainability efforts.

Note

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IFLA 60th WORLD CONGRESS

CODE RED FOR EARTH

04-06 SEPTEMBER 2024
İSTANBUL-TÜRKİYE

TMMOB PEYZAJ MİMARLARI ODASI
UCTEA CHAMBER OF LANDSCAPE ARCHITECTS

IFLA INTERNATIONAL FEDERATION OF LANDSCAPE ARCHITECTS

Days / Hours		HALL	THEME	DAY 1 - SEPTEMBER 4, 2024 (WED)
08:00	09:00	Congress Center Entrance Hall		REGISTRATION
09:00	10:00	Main Hall (Üsküdar Hall)	OPENING	Opening Ceremony Opening Remarks
10:00	10:30		AWARDS	Sir Jellicoe Award 2024
10:30	11:00			*Break*
11:00	11:30	Main Hall (Üsküdar Hall)	AWARDS	IFLA President's Award 2024
11:30	12:00		KEYNOTE SPEAKER	Kotchakorn Voraakkhom
12:00	12:15		PANEL SYMPOSIUMS	Transforming Landscape Design: Introducing RhinoLands, the Advanced BIM Software - **Elham Ghabouli, Lands Design | Asuni**
12:15	12:25			Anadolu Fidanclık, Platinum Sponsor Turkish Stones, Welcome Cocktail Sponsor
12:25	12:30		EXPO	IFLA EXPO & Exhibition Opening
12:30	13:30	*Foyer*		*Lunch + Poster Sessions*

13:30	14:00	Üsküdar 2 Hall	INVITED SPEAKER	Jala Makhzoumi	Üsküdar 1 Hall	INVITED SPEAKER	Hayriye Eşbah Tunçay	Üsküdar 3 Hall	INVITED SPEAKER	Ashleigh Ward

15 min Oral Presentations

		Break-out Session 1 (Üsküdar 2 Hall) Codifying Code Red: Eco-Emergency, Global Solidarity Session Chair: DAMIAN TANG	Break-out Session 2 (Üsküdar 1 Hall) Cultivating Resilience: Sustainable & Resilient Communities Session Chair: MARIA IGNATIEVA	Break-out Session 3 (Üsküdar 3 Hall) Sustaining Life: Protection, Mitigation & Management Session Chair:ŞÜKRAN ŞAHİN	Break-out Session 4 (Beylerbeyi 1 Hall) Building Bridges, Breaking Barriers: Education & Practice Session Chair: TANER OZDIL	Break-out Session 5 (Beylerbeyi-2 Hall) Sustaining Life: Protection, Mitigation & Management Session Chair: PATRICIA ODONNELL	Break-out Session 6 (Yıldız-1 Hall) Engaging with the Digital: Innovation, Technology & Big Data Session Chair: YING LI	Break-out Session 7 (Hamidiye Hall) Design Projects Session Chair: SADIK ARTUNÇ
14:00	14:15	Landscape Architecture Accreditation in a Code Red Era: Comparative Perspectives - **Ebru Ozer**, Kristopher Pritchard, Gert Bischoff, Torey Carter Conneen	Te kori a te kō redefining our sustainable, prosperous future - **Debbie Tikao**	Impact of New Urbanization on Landscape Patterns' Spatial Characteristic - **Yaxuan Ning**, Hao Yin	Integration of the tools of landscape-architects to the architecture studies - **Frédéric Dellinger**	Construction and Optimization of North-China Leopard Habitat Network in Jinzhong - **Jiarui Liu**, Lu Yang	Emerging trends in the digital revolution in landscape planning - **Beata Dreksler**, Katarzyna Rędzińska	Bantayo Subayi: Obu Manuvu Pusaka as Panigan-Tamugan Watershed Management Approach - **Jyllean Marye Tupaz**
14:15	14:30	Carbon Dynamics in Water-Rich Cities: A Climate Perspective - **Yixiao Li**, Yang Liu, Ziyao Wang, Haoran Li, Xi Zheng	Improving Outcomes for Iconic Species: Metro Vancouver Salmon Action Plan - **Karin England**	Urban fringe biodiversity: coexistence of avian conservation and recreation - **Qianxiang Sun**, Xiong Li, Yiqi Zhao, Yutong Duan, Yue Zhou, Yingxue Ma, Ruinan Zheng, Linxin Zhu, Hongye Wei, Lingyi Deng	A pedagogical experiment: strategies for populating landscapes - **Sezin Sarıca**, Bengisu Derebaşı, Dilara Yaraş Er, Funda Baş Bütüner	Framework for selecting areas in integrating wildlife into landscape planning - **Tuğçe Öztürk**, Meltem Erdem Kaya, Zeynel Arslangündoğdu	An interconnected conceptual readingbetween practice&theory in search of a Lexicon - Bahar Başer Kalyoncuoğlu, **Barış Kalyoncuoğlu,** Mehmet Cemil Aktaş, Pınar Kesim Aktaş	Portrait to Landscape: A Landscape Strategy to Reframe Our Future - **Alexandra Steed**
14:30	14:45	After the flooding: Living within a Mediterranean torrentscape - Efthymia Dimitrakopoulou, Eliki Athanasia Diamantouli, Antonios Petras, Penelope Papailias, Sophia Vyzoviti, Thalia Marou, Monika Themou, Lampros Kissas, Romanos Ioannidis, **Aspaso Kouzoupi**	Bylaws Proposal for Multifunctional Rooftops of Istanbul - **Hasibe Akin**, Yasin Çağatay Seçkin	Climate Justice Design for Resilient Community - **Chingwen Cheng**	Parks in Kuwait: between historical accounts and contemporary perceptions - **Reem Alissa**, Dalal Musaed Alsayer	Ecological wisdom of traditional settlement Landscape in Wuling Mountain Area - **Lin Peng**, Qin Yang, Ting Yang, Lan Chun Du	Assessment of Cultural Services in Protected Areas - **Aoxue Li**	Baruthane Ecological Park - **Baray Işık**
14:45	15:00	Across the estuarial periphery - **Alexis Liu**	Reviving Traditional Village Regulations for Environmental Sustainability in Chinese Villages - **Yilei Wang**, Chi Gao	Maximizing synergistic benefits in the urban ecosystem service provision - **Haopeng Zhang**	Anticipating the next 80 years of Portuguese Landscape Architecture - **Maria Matos Silva**, Cristina Castel-Branco, Luís Paulo Ribeiro, João Ferreira Nunes, Teresa Andresen	Valuing trees and people-plant relationships through memorialisation - **Susan Wake**	Engaging with Digital Twin and Landscape Biography: Protecting an Ecosystem - **Emily Shakespeare**, Robin Stubbs	Keelung Sino-French War Memorial Compound public space - **Alessandro Martinelli**
15:00	15:15	Economy and Landscape – a vicious circle impacting humanity's future - **Didier Vancutsem**	Perceived Restorative Effects of Landscape Components on University Campus - **Yi Luo**, Cenqi Zhu, Rui Hu	Landscape Heritage preservation: vernacular spa revitalization through Community Design - **Albert Fekete**	Landscape in Focus – LIF-T - Magdalena Smetanová, Eva Jeníková, Maketa Sandová, Lucie Ficková, Attila Tóth, **Steffi Schüppel**, Sylvia Staudte, Pia Kuusiniemi, Zuzana Štemberová	Nature Based Solutions For Climate Change Mitigation In Metropolitan Copenhagen - **Henrik Vejre**	Optimizing Distinctive Pedestrian Spaces in Mountainous City through Big Data - Dr Bo Li, **Ms Xin Li**	A Agroecological Farm Model: Adaptive Re-Use with Nature-Based Solutions - **Nuran Altun**
15:15	15:30	Prioritizing Lakescape site for NbS Implementation Using AI tool - **Hind Mostafa**, Sahar Attia, Zeinab Feisal	Water quality microbiological assessment in the Magdalena River, Mexico City - **Marisa Mazari-Hiriart**, Liliana Cano Valles, José Manuel Moctezuma Salgado, Nallely Vázquez Salvador, Marco Antonio Tapia Palacios	Mixed Method Approach to Landscape Design of Child-Friendly Green Space - **Dewi Rezalini Anwar**, Gehan Selim	BOPPPS Pedagogical Model towards Cultivating Awareness of Environmental Crises - **Xiaodi Zheng**, Mingrui Wang	Landscapes: memories of cities' - Nihan Sevinç Muşdal, **Nilufer Kart Aktas**, Betül Rüveyda Ay Ak	Smart Cities in Africa; A case of Konza Technopolis, Kenya - **Cecily Wanjiku Murage**	Flowing lives. Landscape as a social change-generating tool - **Juanita Leal Ochoa**
15:30	16:00	*Foyer*	*Break*			*Break*		

15 min Oral Presentations

		Break-out Session 8 (Üsküdar 2 Hall) Building Bridges, Breaking Barriers: Education & Practice Session Chair: PAT CRAWFORD	Break-out Session 9 (Üsküdar 1 Hall) Codifying Code Red: Eco-Emergency, Global Solidarity Session Chair: PAUL Y K CHAN	Break-out Session 10 (Üsküdar 3 Hall) Cultivating Resilience: Sustainable & Resilient Communities Session Chair: YIN-LUN J CHAN	Break-out Session 11 (Beylerbeyi 1 Hall) Acting for All: Diversity, Equity & Inclusion Session Chair: CARLOS JANKILEVICH	Break-out Session 12 (Beylerbeyi 2 Hall) Projecting the Process: Monitoring, Assessment & Applications / Design Projects Session Chair: XIONG LI	Break-out Session 13 (Yıldız-1 Hall) Sustaining Life: Protection, Mitigation & Management / Design Projects Session Chair: ARIYA ARUNINTA	Break-out Session 14 (Hamidiye Hall) Design Projects Session Chair: CAREY DUNCAN
16:00	16:15	Revealing The Hidden Landscapes of Halicarnassus by Incorporating Modern Technologies - Gülşen Aytaç, Elif Kutay Karaçor, **Lâl Dalay,** Rabia Ezgi Beyen	Campus Climate Effects on Student Well-being: Mapping Heat Resilience - **Hamide Somuncu**, Celen Pasalar	Design scenarios for floating architecture to mitigate, adapt climate change - **Dilara Ayşegül Köse**, Ayşem Berrin Zeytun Çakmaklı	The Flow of Power: Shifting Socio-Ecological Memory of Alakır River - **Çisem Demirel Koyun**, Arzu Güler, Ebru Erbaş Gürler	Spatiotemporal monitering of urban hot spots and land change relation - **Burcu Çevik Değerli**	Transformative Landscape Design for Carbon-Neutral Camping Experiences - **Bingrui Yang**, Yipeng Zhang	Cruz do Montalvão Park, a lively urban park - **ateliervmdo arquitectura paisagista**
16:15	16:30	Adapting to emerging global dynamics in the age of environmental crises: US experience - **Sadık Artunç**, Taner R. Ozdil, Ebru Ozer	Beyond the green space per capita: An exploratory research - **Myriam Ana Martinez Dupont**, Marina Lorena Butus, Vanina Martínez, Federico Sebastián Solari, Valeria Caro Marcó	Metropolitan Public Space Network in Lisbon: a linchpin for resilience? - **Ana Beja da Costa**, Marina Carreiras, João Rafael Santos	From Hidden to popular: brownfield landscapes as "Internet celebrity" - **Jiechen Liu**, Xiaodi Zheng	Our Green Region: Can this Conceptual Framework Deliver Real Change? - **Emma Oldroyd**	Research on Climate Crisis Response through Nature-Based Solution - **Mi hu Kim**	From Viaduct To Carbon Reducting Pedestrian Friendly Urban Square: Mecidiyekoy - **Mehmet Cemil Aktaş**
16:30	16:45	An exploration through education: Landscape architecture in Kenya and Sweden - **Maria Kylin**, Carolin Wanza, Nupur Prothi, Caleb Toroitich, Emily Wade, Pia Jonsson	Monitoring Land Use/Land Cover (LULC) Changes in Çankaya, Ankara - **Öner Demirel,** Tuğba Üstün Topal, Meryem Bihter Bingul Bulut, Sultan Sevinç Kurt Konakoğlu	Synecocultural forest: a resilient forest landscape in Isabela, Philippines - **Aegirine Rei Masigan Taylan**, Nappy Lacorte Navarra	Child-friendly City Steps In Urban Landscape Areas - **Tuba Gizem Aydoğan**, Emine Figen Dilek	Evaluating the performance of urban green infrastructure: Case of Istanbul - **Bahar Başer Kalyoncuoğlu**, Chouaib Guerrout, Jale Gürel	Second development opportunities for traditional settlements featuring Yaodong, in China - **Kun Yan**	Historic Jackson Park Enhancing Resilience & Inclusion, People & Planet - **Patricia ODonnell**
16:45	17:00	A Terrestrial Words – Stock - **Gizem Deniz Guneri**, Funda Bas Butuner, Sezin Sarica, Bengisu Derebasi	Questioning Landscape Architecture-Planet Relationship -In Today's Multiple Crises/Uncertainty Environment - **Adnan Kaplan**	Urban landscape co-design framework: linking participatory activities and landscape design - **Julia Nerantzia Tzortzi**	Exploring Pathways for Child-Friendly Play Spaces in Undeveloped Regions - **Kailun Wang**, Anran Liu, Zhenlong Wang, Boyu Xin	Research on accounting method and application of ecosystem carbon sink - Xiaomin Luo, Ran Chen, **Yushan Liu**, Jing Zhao, Chenxi Wang	Hybrid landscapes: Qing Agricultural Experiment Station's design fusion - Rui Gu, **Shanshan Liu**	Nodeul Island: Infrastructure Transformation for Urban Resilience - **Gyoung Tak Park**
17:00	17:15	Geodesign as a participatory tool for adaptive strategies - **Joana Pimentel Guedes**, Newton Becker Célio De Moura, Maria Gabriela Cunha Appleyard, Tainah Frota Carvalho, João Victor Mota Alexandrino	Way Beyond Bigness - **Derek Hoeferlin**	Perception and Valuation of Cultural Ecosystem Services of Agroecosystems - Tiffany Woods, **Brent Chamberlain**, Arthur Caplan	Research on street environment behavior and perception in public community - **Wenzhen Jia**, Lu Chen, Bowen Fu, Xuenan Liang, Qing Lin	Landscape in the process: Jinjiao Shore Park - **Shixian Shen**	Growth and Blossom with Nature: A Playground of Natural Style - **Guangsi Lin, Libei Jiao, Bowen Lv, Xukai Xu, Hanyi Xiao, Zhaoyu Zhong**	Floating Oasis: Future Urban Park Pavilion - **Guangsi Lin,** Xiaoqi He, Xingjian Miao, Mengyun Chen, Ye Lin, Hanyi Xiao, Zhaoyu Zhong, Linju Jiang, Qiantong Cheng, Xiaowei Yang
17:15	17:30	Forgetting public space - celebrating public space - **Robert Dalton**, Jeremiah Bergstrom, Don Burger, Pat Crawford, Elizabeth Tofte	Xylella, a landscape problem - **Francesco Del Sole**	Echoing radical traditions: rural E-commerce revolutions in Yellow River floodplain - **Ruyang Sun**, Qing Su, Manfredo Manfredini	*	*	*	Cerro Calán, Ecological Rehabilitation of an Urban Island Hill - **Paula Livingstone**

6 min Short Oral Presentations

		Break-out Session 15 (Üsküdar 2 Hall) Sustaining Life: Protection, Mitigation & Management Session Chair: YIWEN CUI	Break-out Session 16 (Üsküdar 1 Hall) Engaging with the Digital: Innovation, Technology & Big Data Session Chair: PIA KUUSINIEMI	Break-out Session 17 (Üsküdar 3 Hall) Codifying Code Red: Eco-Emergency, Global Solidarity Session Chair: ADNAN KAPLAN	Break-out Session 18 (Beylerbeyi 1 Hall) Acting for All: Diversity, Equity & Inclusion Session Chair: PAMELA SARUNYA PAGANA	Break-out Session 19 (Beylerbeyi 2 Hall) Cultivating Resilience: Sustainable & Resilient Communities Session Chair:CEMRE KORKMAZ	Break-out Session 20 (Yıldız-1 Hall) Building Bridges, Breaking Barriers: Education & Practice Session Chair: NORMAN JUNE BRITO	Break-out Session 21 (Hamidiye Hall) Sustaining Life: Protection, Mitigation & Management Session Chair: STEFFI SCHUPPEL
17:30	17:36	Evaluation of cultural heritage protection benefits based on landscape perception - **Yu Cheng**, Huasong Mao, Changyu Zhang, Lingna Zhu	Revealing Landscape Preferences for Recreation Based on Social Media Data - **Jiaxuan Duan**, Haiyun Xu, Tian Qiu, Qiping Lu	A dynamic evaluation framework for ecological networks adapting to urbanization - **Hao Li**, Zhicheng Liu	Landscape Progressive-action Design: Exploration based on 2 practices - **Liang Li**, Xiangrong Wang, Qing Lin	Landscape Architects: Superheroes of the 21st Century - **Alper Çabuk**, Saye Nihan Çabuk	Exploring the A&T Center through the "Phenomenology of Perception" - **Kuan Chu Liao**, Chuang Hung Lin	Country (Türkiye) Land Management Based on Conservation Policies - **Öner Demirel**, Sultan Sevinç Kurt Konakoğlu, Meryem Bihter Bingul Bulut, Tuğba Üstün Topal
17:37	17:43	Rethinking planning through ecosystem services in the Mexican Caribbean - **Rosa Michelle Meza Paredes**, Laura Jaloma López, Enrique Soto Alva, Rodrigo Peyret Garcia, Mariela Martínez Álvarez	Quantifies Human Perception of Riverside Spaces from Network Text Data - **Yiji Lu**, Dan Luo	Human Factorial Changes in Karst Areas and their Ecological Impacts - **Zhouyu Fan**, Jie Xi, Siyu Wang, Yitong Pan, Jiping Wen, Wei Fu	Advancing seniors' equity: Climate-adaptive park planning & design for Healthy-ageing - **Wenqing Wang**, Liang Li	Layered Memory Flow of the Landscape: The Ancient Roman Roads - **Sevgi Görmüş**, Serhat Cengiz, Bülent Yılmaz, Gaye Taşkan, Sıla Balta	Tracing what we eat - EDUSCAPE - **Silvia Ribot**, Cristina Del Pozo, Laura Jeschke	Wastescapes as landscapes of care: From wasteland to landscape - **Eliki A. Diamantouli**, Luigi Stendardo
17:44	17:50	Sydney's Koala Belt to Blue-Green Grid: Governance issues - **Saul Deane**	"The Impact of Park Features on Sports Based on Image-Data" - Zhengqi Han, **Jing Zhao**	Ravine reclamation: Thinking beyond immediate economic benefits - **Devayani Pranav Upasani**	The impact of multiple landscape features on public citywalk intensity - **Haiyun Xu**, Yuan Zhou, Weiwen You, Peng Ding, Mohammed Almahmood, Mohammed Almahmood	"Weaving a communal narrative" Community agency through spatial activation - **Sophie Graefin Von Maltzan**	Potential of Antalya's urban landscapes regarding to environmental education - **Hafize Nur Sılay Emir**, Meryem Atik, Demet Demiroğlu	Soundscape research and strategy discussion based on cultural perspective - **Simin Wang**, Manping Qu, Chi Li
17:51	17:57	Cultural heritage research: west lake in southern song dynasty - **Shixian Shen**, Yari Jin	A generative design method for 3D parks - **Ran Chen**, Xueqi Yao, Xiaomin Luo, Jing Zhao, Chumin Liu	Fostering solidarity through dissolving boundaries - **Yin-Lun J Chan**	Construction of aging-friendly streets from the perspective of street soundscape - Ruixi Zhang, **Xinyi Chen**, Peiyao Hao	Urban Agriculture as a landscape approach for sustainable urban planning - **Yu Huan**, Steffen Nijhuis, Nico Tillie	*	Ecosystem service recreational value assessment of Forest Park, Saint Louis - **Yixin Jiang**
18:00	18:30	*Extra time, if needed*				*Extra time, if needed*		

19:00	21:30	Entrance Hall	EVENING EVENT	OPENING RECEPTION & COCKTAIL	OPENING RECEPTION & COCKTAIL

IFLA 60th WORLD CONGRESS

CODE RED FOR EARTH

04-06 SEPTEMBER 2024 İSTANBUL-TÜRKİYE

TMMOB PEYZAJ MİMARLARI ODASI
UCTEA CHAMBER OF LANDSCAPE ARCHITECTS

IFLA
INTERNATIONAL FEDERATION OF LANDSCAPE ARCHITECTS

DAY 2 - SEPTEMBER 5, 2024 (THU)

6 min Short Oral Presentations

Days / Hours		Break-out Session 22 (Üsküdar 2 Hall) – Projecting the Process: Monitoring, Assessment & Applications	Break-out Session 23 (Üsküdar 1 Hall) – Codifying Code Red: Eco-Emergency, Global Solidarity	Break-out Session 24 (Üsküdar 3 Hall) – Cultivating Resilience: Sustainable & Resilient Communities	Break-out Session 25 (Beylerbeyi 1 Hall) – Sustaining Life: Protection, Mitigation & Management	Break-out Session 26 (Beylerbeyi 2 Hall) – Acting for All: Diversity, Equity & Inclusion	Break-out Session 27 (Yıldız-1 Hall) – Cultivating Resilience: Sustainable & Resilient Communities
		Session Chair: BENNI YU-LING PONG	Session Chair: NİKOLA WATTé	Session Chair:BENJAMIN STOCKWIN	Session Chair: REEM ALISSA	Session Chair: RUKKUMANY RAMAKRİSHNAN HARİSHANKAR	Session Chair: EMILIA WECKMAN
08:30	08:36	Revealing Relationship between Environmental Features Combinations and Cultural Ecosystem Benefits - **Mengyun Chen**, Guangsi Lin	How does blue-green space mitigate water hazards in shallow mountains - **Siyao Liu**, Xuanying Li, Yue Lai, Huiyi Sun, Xiaoyu Ge	The resilient landscape of a community - **Marilena Baggio**	"{" From biodiversity to heterogeneity as landscape development factor "}" - **Carmen Angelillo**	Assessing recreational-services in Post-COVID Beijing via social media camping data - **Haiyun Xu**, Guohan Zhao, Tianzi Xie, Meng Miao	Landscape Approach: Cultivating Landscape Literacy through New Models of Practice - **Sonja Vangjeli**, Maria Catalina Picon, Cristina Contreras Casado
08:37	08:43	Policy-driven brownfield transformation in declining mining cities in China - **Yihao Sun**, Xiaodi Zheng	Landscape Structure, Forms and Agency: Re-imagining Open Spaces of Chennai - **Anupama Bharti**	Daily Behavior of Urban Village: A Case Study in Guangzhou - Minzhi Li, **Chunxi Zhu**, Wei Tan, Tong Wang, Shanshan Ran	Examination of Ecosystem Services: A Case Study of Amasya University - **Öner Demirel,** Sultan Sevinç Kurt Konakoğlu, Kadir Tolga Çelik, Tuğba Üstün Topal, Meryem Bihter Bingul Bulut	Ruin, Nature and Culture: Discussions on Brownfield Aesthetic - **Jianpeng Wang**, Jiechen Liu, Xiaodi Zheng	Greening Cities for Prosperity: The Economic Imperative of Ecological-Oriented Development - **Fin Church**
08:44	08:50	Construction of ROS of river beach IGS in mountain city - **Wenyi Shao**, Rongrong Luo, Dan Luo	Golf Course Renovation Under the Goal of Carbon Neutrality - **Yutong Ji**, Xuqing Cao, Lu Chen, Wenzhen Jia, Lingjun Liu, Jinjie Ren, Tianqi Qiu, Hikaru Oishi	Doing urban home gardening: Ways of operating - **Thalia Marou**	Conservation, Landscape Enhancement of Agricultural Heritage Site: with VR Technology - **Yichen Jiang**, Fei Zhao, Rouran Zhang	Suitable dwelling growth of Geelong - **Yipeng Zhang**, Zhiqing Zhao, Bingrui Yang	Traditional Water Adaptive Rural Stormwater Resilience Study - **Xuewei Zhang**, Chaohan Lin, Xiaoqing Lan, Xinchen Hong
08:51	08:57	Garden Expo theme park Discussions from perspective of ecological restoration - **Liang Zhao**	Analysis of urban elastic coupling difference and its driving factors - Xiaomin Luo, Ran Chen, **Yi Xingjian**, Jing Zhao, Xueqi Yao	Cultivating creative climate resilience, three projects from Northern England - **Simon John Ward**	Utilizing the Historic Urban Landscape Approach for Heritage Trees Conservation - **Warong Wonglangka**, Feng Han	Logistics Transit Boxes as Micro-Mediators of Recycled Landscapes - **Simin Bian**, Liang Li	Stream Daylighting: The Lost Streams of Ankara - **Hilal Özge İdali Özden**

Days / Hours		HALL	THEME	
09:00	09:30	Main Hall (Üsküdar 2 Hall)	AWARDS	**IFLA Student Competition Awards**
09:30	10:00	Main Hall (Üsküdar 2 Hall)	KEYNOTE SPEAKER	**Ceylan Belek Ombregt**
10:00	10:30	Main Hall (Üsküdar 2 Hall)	KEYNOTE SPEAKER	**Christophe Girot**
10:30	**11:00**	*Foyer*		***Break***

11:00 - 12:30

Special Session 1 (Üsküdar 1 Hall) – BRIDGING THE DIVIDE: COLLABORATIVE DESIGN FOR A PLANET IN CRISIS – Interdisciplinary Collaboration

Moderator: Dr. Jala Makzoumi, *IFLA Vice-President and IFLA Middle-East President*

- **Pietro Elisei** – ISOCARP President (International Society of City and Regional Planners)
- **José Luís Cortes** – UIA Immediate Past President (International Union of Architects)
- **James Hayter** – IFLA Immediate Past President (International Federation of Landscape Architects)
- **Mona Rady** – Chairperson (UN-Habitat Professional Forum)
- **Barış Işık** – CTLA President (Turkish Chamber of Landscape Architects)
- **Debbie Tikao** – NZILA President (New Zealand Institute of Landscape Architects)
- **Emilia Weckman** – Head of Programme (Aalto University, Finland)

Special Session 2 (Üsküdar 3 Hall) – REDEFINING PRACTICE: INNOVATIVE APPROACHES TO LANDSCAPE ARCHITECTURE FOR A CHANGING WORLD – Professional Practice and Standards

Moderator: Marina Cervera Alonso de Medina, *IFLA Special Envoy*

- **Torey Carter-Conneen** – ASLA CEO (American Society of Landscape Architects)
- **Matt Miller** – CLARB CEO (Council of Landscape Architectural Registration Boards)
- **Yuko Nagamura** – Director (TabbyCat Japan) and Member (Japan Landscape Architects Union)
- **Indra Purs** – IFLA Professional Practice and Policy (PPP) Chair
- **Carey Duncan** – Past-President (IFLA Africa)
- **Henri Bava** – President (French Federation of Landscape Architects)
- **Yasin Otuzoğlu** – CTLA Past-President (Turkish Chamber of Landscape Architects)

Special Session 3 (Beylerbeyi 1 Hall) – HEALTHY PLACES, HAPPY PEOPLE: THE POWER OF LANDSCAPE TO IMPROVE PUBLIC HEALTH – Environmental Health, Urban Health and Well-being

Moderator: Katerina Gkoltsiou, *IFLA Europe President*

- **Giselle Sebag** – Executive Director, International Society of Urban Health (ISUH)
- **Elisabeth Belpaire** – ISOCARP President-Elect (International Society of City and Regional Planners)
- **Nathalie Laure Roebbel** – WHO Urban Health Leader (via Zoom)
- **Jane Welsh** – IFLA Special Envoy for AIPH
- **Pia Kuusiniemi** – President of the Finnish Association of Landscape Architects
- **Helen Andreae** – Interaction e-Health Designer, Victoria University of Wellington
- **Gül Sayan Atanur** – European Healthy Cities Network Scientific Committee Member

Special Session 4 (Beylerbeyi 2 Hall) – INDUSTRY IN TRANSITION: EMBRACING SUSTAINABILITY IN LANDSCAPE ARCHITECTURE – Industry and Outreach

Moderator: Chris Tidswell, *IFLA Asia-Pacific President*

- **Mike Wood** – Director of Landscape Architecture, ARUP
- **Mikko Partanen** – Head of Design, Lappset Group Ltd
- **Audrey Timm** – AIPH (International Association of Horticultural Producers)
- **Selim Bayraktar** – WGIN (World Green Infrastructure Network) and Researcher (İstanbul University-Cerrahpaşa)
- **Maria Ignatieva** – President of URBIO (Urban Biodiversity and Design Network) and Professor of Landscape Architecture (University of Western Australia)
- **Lea Ann Macknally** – President (Council of Landscape Architecture Registration Boards)
- **Peta-Maree Ashford** – Immediate Past President (Australian Institute of Landscape Architects) and Director (Emerge Associates)

12:30	**13:30**	*Foyer*	***Lunch + Poster Sessions***

Start	End	HALL	THEME	
13:30	14:00	Üsküdar 2 Hall	INVITED SPEAKER	**Gareth Doherty**
13:30	14:00	Üsküdar 1 Hall	INVITED SPEAKER	**Ahmet Oktan Nalbantoğlu**
13:30	14:00	Üsküdar 3 Hall	INVITED SPEAKER	**Alexandra Steed**

15 min Oral Presentations

Days / Hours		Break-out Session 28 (Üsküdar 2 Hall) – Projecting the Process: Monitoring, Assessment & Applications	Break-out Session 29 (Üsküdar 1 Hall) – Acting for All: Diversity, Equity & Inclusion	Break-out Session 30 (Üsküdar 3 Hall) – Codifying Code Red: Eco-Emergency, Global Solidarity	Break-out Session 31 (Beylerbeyi 1 Hall) – Cultivating Resilience: Sustainable & Resilient Communities	Break-out Session 32 (Beylerbeyi 2 Hall) – Engaging with the Digital: Innovation, Technology & Big Data	Break-out Session 33 (Yıldız-1 Hall) – Sustaining Life: Protection, Mitigation & Management
		Session Chair: MONICA PALLERES	Session Chair: AYŞEGÜL İBİCİ ORUÇKAPTAN	Session Chair: INDRA PURS	Session Chair: LEA ANN MACKNALLY	Session Chair: BAHAR BAŞER KALYONCUOĞLU	Session Chair: STEFFI SCHUPPEL
14:00	14:15	The Effectiveness of Indices in Measuring The Naturalness of Cities - **Nurdan Erdoğan**, Betül Çavdar, Ilgaz Ekşi, Ayşenur Kaylı	Comparing Performances across State-led, Co-managed, and Community-based Conservation in China - **Ying Lou**, Yin Zhang	Light Rail Vs. Highway: Influence on land-use & habitat fragmentation - **Behnoud Aghapour**	Water Consumption for Irrigation in the Case of Adanalıoğlu, Çukurova - **Fırat Fırat,** Beyza Sat	Intergrating VGI and SVI data in designing exercise-friendly blue spaces - **Haoxiang Zhang**, Steffen Nijhuis, Caroline Newton	Urban afforestation against biodiversity loss: integrating design in science experimentation - **Thomas Cabai**, Chiara Geroldi, Matteo Umberto Poli
14:15	14:30	Green Corridors: Istanbul's Life Valleys - **Tuğba Ölmez Hancı**	The representation of women in landscape architecture education - **Ebru Ozer**, Hala Nassar, Charlene Lebleu, Ashley Steffens	"Park City" theory: Urban parks system in High-density urbanization - **Zhongjie Wang**, Yan Wu, Quan Wang, Zeyu Jing, Wen Wu, Yajing Zhao	Characteristics of Home Horticultural Activities and Their Health Effects - **Lu Yang**, Liang Li, Lingyun Zhang, Yining Liu, Jiarui Liu	Assessing and Interpreting Perceived Park Quality from Social Media Data - **Xukai Zhao**, Guangsi Lin	Sustainable Drainage Systems in Urban and Rural Landscape Design - **Türkan Erdem**
14:30	14:45	Projecting Community Participation: Assessing Effectiveness in Aotearoa New Zealand - **Yiwen Cui**, Bruno Marques, Morten Gjerde	Planning and design methods for avian habitats in Beijing - **Zhiruo Liu**, Qiushuang Cheng, Hao Yin	'A tool combating climate change: native plants and utilization potentials'' - **Nihan Sevinç Muşdal**, Nilüfer Kart Aktaş	Resilient Landscapes, Resilient Minds: Highlighting the Role of Perceived Oppressiveness - **Hanieh Jafari Khaledi**, Mehdi Khakzand, Mohsen Faizi, Minou Gharehbaglou	"Redefining Smart City Implementation: A New Model From Turkey's Experience" - **Gülnar Bayramoğlu Barman**	Urban green space form influencing spatial patterns of noise complaints - **Xinchen Hong**, Danyin Zhang, Lianhuan Guo, Jiabing Wang, Xuewei Zhang
14:45	15:00	Improved methodology for Urban Green Infrastructures in historic centres - **Maria Stella Lux**, Julia Nerantzia Tzortzi	Analysis of open-green areas according to universal design principles - **Mustafa Ergen**, Gülennur Şanlı	Exploitation of natural resources, forced removals and ghosted landscapes - **Tuanne Monteiro de Carvalho**, Tamires Aleixo Cassella, Denise B. Pinheiro Machado, Roseline Vanessa Santos Oliveira	URDX: Pioneering User-Driven Regenerative Design Experience in Landscape Architecture - **Damian Tang**	Goodbye Photoshop: AI Turns Hand-Drawn Sketches Into Detialed Planning Maps - **Jing Zhao**, Ran Chen, Xueqi Yao, Xiaomin Luo, Chumin Liu	Spatial Narratives in Urban Landscape and Identity - **Eylem Akgül Yalçın**, Kenneth Foote
15:00	15:15	Territory as a transdisciplinary milieu for built environment disciplines - **Sinan Cem Kızıl**	Quantifying Visual Features of Chinese Traditional Gardens using Deep Learning - **Huang Xinyan**, Liu Zhicheng, May Ziyu	Remote Sensing as a Proxy for Urban Air Temperature Studies - **Majid Amani-Beni**, Yang Chen, Laleh Dehghanifarsani, Sajad Asadi Alekouei, Mohammad Reza Khalilnezhad	Turkey's Potential Implementable Net Zero Carbon Model and Resilient Cities - **Tulû Tohumcu Kaya**, Ayşem Berrin Çakmaklı	Ecodesk: Digital Green Infrastructure Planning Tool for Jiangnan Water Villages - Weixuan Wei, **Nannan Dong**, Fei Chen	Shared Waterfronts: Regeneration of Industrial Remains in Huangpu Riverside Area - **Lyuyuan Jia**, Ping Ma, Da Huo, Qing Lin
15:15	15:30	Memorial Space Design Through Abstraction Of Natural Disasters - **Ali Kemal Arkun**	Public participation in landscape architecture and social governance - **Lyuyuan Jia**, Yuxin Hao, Mengjiao Li	Interaction mechanism between carbon emission and carbon sequestration in China - **Jingyuan Lin**, Ziyu Lu, Qiuzi Chen	Desakota and the possibility for a wet electricscape - **Alessandro Martinelli**	Landscape design's sustainability evaluation digital twin and user decision-making support - **Zaixian Piao**, Yumi Lee	Coastal Erosion Mitigation: Relationship between Seaweed and the Coast - **Ceylan Sözer**, Ikhwan Kim
15:30	**16:00**	*Foyer*	***Break***		***Break***		

15 min Oral Presentations

Days / Hours		Break-out Session 34 (Üsküdar 2 Hall) – Acting for All: Diversity, Equity & Inclusion	Break-out Session 35 (Üsküdar 1 Hall) – Codifying Code Red: Eco-Emergency, Global Solidarity	Break-out Session 36 (Üsküdar 3 Hall) – Sustaining Life: Protection, Mitigation & Management	Break-out Session 37 (Beylerbeyi 1 Hall) – Cultivating Resilience: Sustainable & Resilient Communities	Break-out Session 38 (Beylerbeyi 2 Hall) – Sustaining Life: Protection, Mitigation & Management	Break-out Session 39 (Yıldız-1 Hall) – Engaging with the Digital: Innovation, Technology & Big Data
		Session Chair: ROBERT DALTON	Session Chair: EMRAH YALÇINALP	Session Chair: EMRAH YALÇINALP	Session Chair: CATHE DESIREE NADAL	Session Chair: NESRİN KARAOĞLU OTUZOĞLU	Session Chair: ALPER CABUK
16:00	16:15	The ASLA Legacy Project for career discovery in landscape architecture - **Ebru Ozer**, Emily O'mahoney, Sulin Kotowicz	Human impact on ecosystems: Human-based landscape vulnerability codes in Istanbul - **Sevgi Gormus**, Serhat Cengiz	Is urban park a carbon sink or a carbon source? - **Mingzhu Yang**, Shangcen Luo, Yangyang Yuan	Code Red for Disaster Risk Reduction and Resilience - **Syed Nil Ainuddin**, Chamawong Suriyachan, Ariya Aruninta	'Suitable Mechanization Transformantion' Effects on Farmland Ecosystems in China's Hills - **Jie Ren**, Xiaohui Xu	LA-GPT: Supermodel Forged by Training on Billion-Scale Landscape Architects Corpus - **Xueqi Yao**, Ran Chen, Xiaomin Luo, Jing Zhao
16:15	16:30	Green Space Inequalities in Istanbul: An Assessment of Spatial Justice - **Ahmet Cemil Tepe**	Irrigation policies agency in operational landscapes generation - **Silvia Ribot**	Exploring Climate Change Effects on Bird Diversity: A Landscape-based Approach - **Xiaoxi Li**, Haoran Li, Yuhan Ji, Xi Zheng	Cyclic Food Security at Regional scale of UAE - **Amna Rafi Chaudhry**, Sonakshi Ruhela	Survival of Heritage Gardens Along the Silk Road - **Abdullahi Isa Adamu**, Xin Cao, Elaf Nabil Esmail Al Mutawakel	Refining urban perception measurement through on-site questionnaires and streetscape data - **Hao He**, Yuxin Yan, Wenchen Jian, Zhicheng Liu
16:30	16:45	Interdisciplinary Framework: Integrating and Landscaping Urban Infrastructure and Public Space - **You Wu**, Ming Zhang, Linghuizi Mo	Evolution, Movement of Urban Voids in Antakya:From Existence to Nothingness - **Ezel Yağmur Çebi Okumuş**, Demet Yılmaz Yıldırım, Cemil Hamdi Okumuş	Urban Heat Island Analysis in Winter: The Case of Izmir - **Nurdan Erdoğan**, Selami Beyhan, Besna Aydemir	From Power Lines to Green Lines - **Nazlı Deniz Ersöz**, Onur Aksoy	Societal challenges in coastal landscape transformation in Sisal, Yucatán - **Rosa Michelle Meza Paredes**, Gabriela Mendoza González, Francisco Hernández Spinola, Pavel Popoca, Arturo Godínez	Deciphering Anthropogenic Influences on Habitats: Implications from Interpretable Machine Learning - **Yuhan Xu**, Jun Tang
16:45	17:00	Marginalisation versus mainstreaming: Empowering youth to co-create their space - **Nupur Prothi**	Call for the Golden Horn: Water Resilience Design Investigation - Fatma Sultan Bozkurt, **Rabia Ezgi Beyen**, Elif Ağaoğlu Yıldırım, Meltem Erdem Kaya	The key factors of carbon sequestration in waterfront green spaces - **Shangcen Luo**, Mingzhu Yang, Yangyang Yuan	Winter Glamping in Kuwait's Desert Landscape - **Rua Alshaheen**	Examining dynamic urban open spaces: the case of Museum Gazhane - Akif Emre Tavlaşoğlu, **Hatice Ezgi Gülusta**, Nurşen Nesil Güler, Raana Buzghia	Generating Parks from Satellite: A Fully Automated AI Design Workflow - **Xingjian Yi**, Ran Chen, Xueqi Yao, Xiaomin Luo
17:00	17:15	Designing as Storytelling; Participatory Design Research from the Australian Borderlands - **Darcy Edmund Frederic Rankin**	Exploring Biophilic Nighttime Green Space Lighting Using Volunteered Geographic Information - **Meng Guo**, Qingyi Fan, Li Tan	Impact of landscape pattern on ecosystem service trade-off in the-South-Taihang-Area - **Shiyao Li**, Chi Li	Designing cities for zoonotic resilience - A landscape oriented approach - **Manju Rajeev Kanchan**	Cultivating Resilience through Landscape and Heritage Conservation: The Larissa Case-study - **Maria Markatou**	Park Recreation Function Optimization using Big Data Landscape Preference Analysis - **Siyao Liu**, Zhirong Liang, Xi Zhang, Yufei Jiao, Xiaoyu Ge
17:15	17:30	Developing an Equitable Framework for Stormwater Systems in South-East Queens - **Shibani Debnath**	Post-Disaster Design of the Yongding River Basin in Beijing - **Xiaoyu Ge**, Zheran Zhai, Haochen Pan	From toxic to resilient: ecological value of Terrain Vague - Lorenzo Iannizzotto, **Alexandra Paio**	Multidisciplinary Researches On Landscape Art And Sustainability In Ancient Landscapes - **Kübra Günbey**	Multi-scale driving mechanism and optimization of cultivated land "non-grain" - **Xi Zheng,** Xiaomin Luo, Ran Chen, Zhao Jing, Xueqi Yao	*
17:30	18:00	*Extra time, if needed*			*Extra time, if needed*		

Start	End	HALL	THEME	
19:30	22:30	KHALKEDON	EVENING EVENT	**GALA DINNER & PARTY** / **GALA DINNER & PARTY**

IFLA 60™ WORLD CONGRESS

CODE RED FOR EARTH

04-06 SEPTEMBER 2024 İSTANBUL-TÜRKİYE

TMMOB PEYZAJ MİMARLARI ODASI
UCTEA CHAMBER OF LANDSCAPE ARCHITECTS

IFLA INTERNATIONAL FEDERATION OF LANDSCAPE ARCHITECTS

Days / Hours | HALL | THEME | SEPTEMBER 6, 2024 (FRI)

6 min Short Oral Presentations

Break-out Session 40 (Üsküdar 2 Hall) — Sustaining Life: Protection, Mitigation & Management — Session Chair: RUTH WANJIKU MWAI

08:30	08:36	Ecological sustainable development planning and protection of grassland-volcanic geological landscape - **Wenzhen Jia**, Yushan Xu, Qing Lin
08:37	08:43	Cultural Heritage Protection from the Perspective of Landscape Architecture - **Zaichen Wu**, Xiangrong Wang, Qing Lin
08:44	08:50	*

Break-out Session 41 (Üsküdar 1 Hall) — Acting for All: Diversity, Equity & Inclusion — Session Chair: SAYE NİHAN ÇABUK

Start	End	Presentation
08:30	08:36	Design Guidelines for Child-Friendly Rooftop Gardens in High-Density Urban Areas - **Chumeng Li**, Rui Wang, Yueshan Ma
08:37	08:43	Landscape design: from surface to service. landscape design in crisis situations - **Julie Weltzien**
08:44	08:50	Exploration of Methods and Applications of LLCA and PPGIS - **Wenhui Zhong**, Ziting Bao, Ziting Bao

Break-out Session 42 (Üsküdar 3 Hall) — Cultivating Resilience: Sustainable & Resilient Communities — Session Chair: VARPU MIKOLA

Start	End	Presentation
08:30	08:36	Sowing Resilience: A framework for Adaptive Planting Design and Management - **Catarina Patoilo Teixeira**, Cláudia Fernandes, Jack Ahern
08:37	08:43	Larissa: An Example of how Urbanization led to Environmental Degradation - **Maria Markatou**
08:44	08:50	The LATENT LAYER of The LANDSCAPE: PLANT BIOACOUSTICS - **Sıla Günaçan Odabaşı**, Çisem Demirel, Ebru Erbaş Gürler

Break-out Session 43 (Beylerbeyi 1 Hall) — Codifying Code Red: Eco-Emergency, Global Solidarity — Session Chair: CHINGWEN CHENG

Start	End	Presentation
08:30	08:36	Rehabilitation of landfills in thessaloniki: from landscape destruction to recovery - **Vaia Karypidou**, Argiri Voumvouraki
08:37	08:43	Environmental Compliance of Turkish Coal-Fired Thermal Power Plants: Legislation Perspective - **Ece Yorulmaz**
08:44	08:50	Biodiversity and Sustainability in Cities: The Role of Landscape Architects - **Tuba Gül Doğan**, Engin Eroğlu

Break-out Session 44 (Beylerbeyi 2 Hall) — Building Bridges, Breaking Barriers: Education & Practice — Session Chair: PAUL Y K CHAN

Start	End	Presentation
08:30	08:36	Path of experiential learning education stimulating cultural services in rural-ecosystems - **Lin Zhu**, Youhua Wen, Lin Zhu, Youhua Wen
08:37	08:43	Nature communication - **Ana Ines Bajcura**
08:44	08:50	Landscape planning pedagogy based on Chinese traditional landscape painting - **Shixian Shen**

Break-out Session 45 (Yıldız-1 Hall) — Engaging with the Digital: Innovation, Technology & Big Data — Session Chair: ALİ KEMAL ARKUN

Start	End	Presentation
08:30	08:36	Visual Landscape Management Strategies and Mountain Protection - **Zaichen Wu**, Steffen Nijhuis
08:37	08:43	Parametric-generative landscape design research based on perception survey - Xiang Yu, Mengling Yan, **Tiantian Zhang**
08:44	08:50	Assessment of Regional Ecosystem Health in Beijing under Multi-objective Scenarios – **Shuyi Yan**

Main Hall (Üsküdar 2 Hall)

		Theme	
09:00	09:30	AWARDS	**2024 National Awards of CTLA**
09:30	10:00	AWARDS	**IFLA Student Charrette Award**
10:00	10:30	KEYNOTE SPEAKER	**Peter Veenstra**
10:30	11:00	Foyer	*Break*

11:00 - 12:30 Special Sessions

Special Session 5 (Üsküdar 2 Hall) — Türkiye'nin Farklı İklim Bölgesinde Yeşil Alan Stratejileri ve Su Yönetimi: Mavi-Yeşil Altyapı Modelleri (This session will be held in Turkish)

Moderator: Ahmet Cemil Tepe, *İstanbul Büyükşehir Belediyesi Park ve Bahçeler Dairesi Müdür Yardımcısı*

- **Tuğba Ölmez Hancı** — İstanbul Büyükşehir Belediyesi Park Bahçe ve Yeşil Alanlar Dairesi Başkanı
- **Müge Deniz Bal** — İzmir Büyükşehir Belediyesi Park ve Bahçeler Dairesi Başkanı
- **Çiğdem Hacıoğlu** — Antalya Büyükşehir Belediyesi Park ve Bahçeler Dairesi Başkanı
- **A.Samed Yağır** — Samsun Büyükşehir Belediyesi Park Bahçe ve Yeşil Alanlar Dairesi Başkanı
- **Ersin Özbadem** — Gaziantep Büyükşehir Belediyesi Kent Estetiği ve Yeşil Alanlar Dairesi Başkan Vekili
- **Serap Aylin Şener** — Eskişehir Büyükşehir Belediyesi Park ve Bahçeler Dairesi Başkanı
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Special Session 6 (Üsküdar 1 Hall) — SPCLIMATE ACTION NOW: LANDSCAPE ARCHITECTS DESIGNING FOR A RESILIENT TOMORROW — Climate, Environment, Sustainability

Moderator: Graham Young, *IFLA Africa President*

- **Gulnara Roll** — Head of Cities Unit, UN Environment Programme (UNEP)
- **Damian Tang** — Chairman of the Circular Cities Network (CCN)
- **Kathryn Moore** — IFLA Past President, International Landscape Convention Task Force (ILC)
- **Chingwen Cheng** — CELA Past President - Director and Professor, Stuckeman School, Penn State University
- **Yotam Ashkenazi** — CEO Environment for Revit (via Zoom)
- **SuLin Kotowicz** — ASLA President (American Society of Landscape Architects)
- **Funda Baş Bütüner** — CTLA Past-ExCo Member, METU Architecture Faculty Member
- *

Special Session 7 (Üsküdar 3 Hall) — FROM CRISIS TO CURRICULUM: REIMAGINING EDUCATION FOR THE ANTHROPOCENE — Education

Moderator: Alessandro Martinelli, *IFLA Education and Academic Affairs (EAA)*

- **Taner Özdil** — CELA President-Elect (Council of Educators in Landscape Architecture)
- **Ebru Özer** — ASLA Vice-President Education (American Society of Landscape Architects)
- **Alexandru Mexi** — *ECLAS Board Member (European Council of Landscape Architecture Schools)*
- **Gareth Doherty** — Harvard Graduate School of Design, USA
- **Roxi Thoren** — *Chair of the Landscape Architecture Accreditation Board (LAAB)*
- **Rafael Dodera** — Chair of the Red Americana de Educación en Arquitectura del Paisaje (RAEAP)
- **Saye Nihan Çabuk** — Board Member of Design and Planning Accreditation Association (TAPLAK)
- **Roberto Rovira** — Immediate Past President (Landscape Architecture Foundation)

Special Session 8 (Beylerbeyi 1 Hall) — LANDSCAPES OF HOPE: DESIGNING FOR RESILIENCE IN THE FACE OF CRISIS AND CONFLICT — Crisis and Conflict

Moderator: Maria Gabriella Trovato, *IFLA Landscape Architects Without Borders (LAWB) and Norwegian Life Sciences University (NMBU)*

- **Carlos Jankelevich** — *IFLA Working Group on Migration and Landscape (WG)*
- **Monica Pallares** — IFLA Americas President
- **Xiaodi Zheng** — Tsinghua University, China
- **Ruth Wanjiku** — AAK Kenya
- **Klas Groth** — Senior Urban Planner (UN-Habitat)
- **Şükran Şahin** — CTLA Board Member, IFLA Delegate (Turkish Chamber of Landscape Architects)
- **Gabriel Diaz Montemayor** — Fay Jones School of Architecture and Design at the University of Arkansas
- *

Special Session 9 (Beylerbeyi 2 Hall) — WEAVING CULTURAL THREADS INTO A SUSTAINABLE TAPESTRY: CULTURAL LANDSCAPES, NATURAL HERITAGE AND PLANETARY RIGHTS — Culture and Cultural Landscapes

Moderator: Hermann Georg Gunnlauggson, *IFLA Thresurer*

- **Patricia O'Donnell** — Heritage Landscapes LLC, USA
- **Maria Matos Silva** — Board Member (Portuguese Association of Historic Gardens AJH) and Assistant Professor of Landscape Architecture (University of Lisbon)
- **Ashleigh Ward** — WSP Indigenous Director, New Zealand
- **Michelle Meza** — Principal (Trazo Verde) and Professor (Universidad Nacional Autónoma de México UNAM, Mexico)
- **Carolin Göhler** — President (Landscape Institute, UK)
- **Monica Kuo** — IFLA APR Immediate Past President and Dean of the Institute of Architecture and Urban Planning (Chinese Culture University, Chinese Taiwan)
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		Hall	
12:30	13:30	Foyer	*Lunch + Poster Sessions*

Invited Speakers

		Hall	Theme	
13:30	14:00	Üsküdar 2 Hall	INVITED SPEAKER	**Maria Gabriella Trovato**
13:30	14:00	Üsküdar 1 Hall	INVITED SPEAKER	**Murat Zübeyir Memlük**
13:30	14:00	Üsküdar 3 Hall	INVITED SPEAKER	**Prof. Dr. Alper Çabuk**

15 min Oral Presentations

Break-out Session 46 (Üsküdar 2 Hall) — Sustaining Life: Protection, Mitigation & Management — Session Chair: EBRU OZER

Start	End	Presentation
14:00	14:15	Adapting to climate change: a new terrapin habitat projection model - Jinyu Zhang, **Chenhao Zhu**, Xiaofan Wu
14:15	14:30	Highlighting the landscape, sustainable projects in the Magdalena River - **Luis Eduardo De La Torre Zatarain**
14:30	14:45	Comparative research on Mining and Biodiversity Conservation in National Parks - **Jing Ye**, Xiaodi Zheng, Mingrui Wang, Jingyuan Zhu
14:45	15:00	Excavation Management: less CO2, truck movements and a new park - **Uwe Fischer**
15:00	15:15	Mugnone River Contract: a tool for landscape and territorial development - **Claudia Mezzapesa**, Elena Moretti
15:15	15:30	Simulating mangrove biomimetic landscapes for coastal defense in Capiz, Philippines - **Raia Alexis Torrefranca Gallardo**

Break-out Session 47 (Üsküdar 1 Hall) — Projecting the Process: Monitoring, Assessment & Applications — Session Chair: MONICA KUO

Start	End	Presentation
14:00	14:15	Projecting Istanbul Alternative Futures: An Approach for Understanding Urban Change - **Daniel Cronan**, Tristyn Moyer, Max Stamberger, Shaowen Li, Cecilia Zajac
14:15	14:30	Reading the impacts of land-use/land-cover change around watersheds of Istanbul - **Bahar Başer Kalyoncuoğlu**, Burcu Çevik Değerli, Jale Gürel
14:30	14:45	Repositioning City Centers for Environmental Crises: Potentials of Social Performance - Gul Sayan Atanur, Taner R. Ozdil, **Nazli Deniz Ersoz**, Merve Dilman Gokkaya
14:45	15:00	Agent-based modeling for nature-based water management system - **Mürşit Sönmez**, Hayriye Eşbah Tuncay
15:00	15:15	Exploring the Barriers to Stream Daylighting: The Case of Ankara - **Ekin Ersözlü**
15:15	15:30	La Cantera Natural Park: Enhancing Open Spaces through Nature-Driven Design - **Catalina Picon**, Paula Aguirre, Javiera Pizarro

Break-out Session 48 (Üsküdar 3 Hall) — Acting for All: Diversity, Equity & Inclusion — Session Chair: HERMANN GEORG GUNNLAUGGSON

Start	End	Presentation
14:00	14:15	Issues of death and ecology: Redefining the future cemeteries - **Georgios Dionysios Lountzis**, Galini Nikolaidi
14:15	14:30	An investigation of spatial inequality in urban greenspace - **Ruike Xiao**, Xiong Li
14:30	14:45	"Migration a Positive Driving Force Facing the Current Environmental Crisis." - **Carlos Marcelo Jankilevich Dahan**
14:45	15:00	Associations between socioeconomic status and multi-hazard exposure risks in Shenzhen - **Wenchen Jian**, Hao He, Yuxin Yan, Boya Wang, Zhicheng Liu
15:00	15:15	Social Justice in Istanbul's Urban Green Spaces: A Multi-Dimensional Evaluation - **Ece Yorulmaz**, Elif Kısar Koramaz
15:15	15:30	Accessibility-based analysis of green open space supply and demand equity - **Lu Meng**, Liang Li

Break-out Session 49 (Beylerbeyi 1 Hall) — Sustaining Life: Protection, Mitigation & Management — Session Chair: ANA INES BAJCURA

Start	End	Presentation
14:00	14:15	Research on the Historical Townscape Characteristics along the Shu Road - **Danyang Chen**, Chunlan Du, Ting Yang
14:15	14:30	Turning the Tide: Ethnic Aging and the Fight Against PM2.5 - **Ran Chen**, Xueqi Yao, Xiaomin Luo, Jing Zhao
14:30	14:45	Spontaneous Plant Library and Potential Application in Urban Landscape - **Benni Yu-ling Pong**, Hiu-yan Wong
14:45	15:00	Social-media photographs and deep learning for cultural ecosystem services assessment - **Haiyun Xu**, Jianxuan Duan, Guohan Zhao, Mujie Ren, Zhifeng Liu
15:00	15:15	Landscape sustainability of the hilly Southeast China based on PLUS-ESV - **Wei Ren**, Jialin Zhang, Junhan Lu, Xinwei Lin, Minying Zhou, Xuewei Zhang
15:15	15:30	Research on rural landscape characteristics under collective memory - **Ting Yang**, Chunlan Du, Danyang Chen

Break-out Session 50 (Beylerbeyi 2 Hall) — Cultivating Resilience: Sustainable & Resilient Communities — Session Chair: NAPPY NAVARRA

Start	End	Presentation
14:00	14:15	Renaissance to restoration: nature-based solutions and the resilient city - **Jane Welsh**
14:15	14:30	"Interaction of the Central Taurides cultural landscape and Sarıkeçili Yoruks" - **Gizem Büyükgüner Sönmez**, Emre Kishalı, Nurdan Kuban Orcan
14:30	14:45	Cultural Landscape of Italian inner areas to experiment sustainable development - **Claudia Mezzapesa**, Eletta Naldi, Maddalena Branchi
14:45	15:00	Increasing Ecological Resilience Through Climate Change Adaptation Studies in Mudanya/Bursa - **Elif Altaş**, Kamil Erken
15:00	15:15	The 15-minute city: A framework for sustainable, liveable, healthy neighbourhoods - **Nihan Yegin Yarayan**
15:15	15:30	Case study of Los Angeles Sustainability Plan towards sustainable urbanism - **Yixin Jiang**

Break-out Session 51 (Yıldız-1 Hall) — Engaging with the Digital: Innovation, Technology & Big Data — Session Chair: SAYE NİHAN ÇABUK

Start	End	Presentation
14:00	14:15	Augmented Reality and Resident Engagement in Restorative Environments Design - **Chengcheng Yin**, Bruno Marques, Jacqueline Mcintosh
14:15	14:30	Virtual Realities for Actor Sensibilization: Landscape Planning in Fortaleza, Brazil - **Tainah Frota Carvalho,** Newton Célio Becker Moura, Paulo Jorge Alcobia Simões, Diego Enéas Peres Ricca
14:30	14:45	Earthquake prediction methodology based on Neural Network Model - **Ikhwan Kim**, Azra Dilek Erhan, Rümeysa Merve Öksüz, Rana Ayoğlu
14:45	15:00	Research on AI enabling intelligent park management system in China - **Yang Zhang**, Changlin Li
15:00	15:15	Incorporating Human Perception in Digital Twins for Sustainable City Development - **Junjie Luo**
15:15	15:30	*

Start	End	Hall	Programme
15:30	16:00	Foyer	*Break*

15 min Oral Presentations

Break-out Session 52 (Üsküdar 2 Hall) — Codifying Code Red: Eco-Emergency, Global Solidarity — Session Chair: AYŞEGÜL İBİCİ ORUÇKAPTAN

Start	End	Presentation
16:00	16:15	Identifying suitable sites for drought tolerant trees in urban areas - **Ömer Öztoprak,** Jale Gürel, Bahar Başer Kalyoncuoğlu, Öner Demirel
16:15	16:30	Urban Riverside Green Space Cultural Ecosystem Services from Online Commentary - **Haoran Li**, Zhe Liu, Xiaoxi Li, Xi Zheng
16:30	16:45	Landscape Design for Earthquake Resistant Cities: Bakırköy Example - **Cemre Korkmaz**, Şükran Şahin
16:45	17:00	Ecological Degradation Assessment of Land Use: An Example of Ankara - **Duygu Doğan**, Merve Yilmaz, Meryem Bihter Bingul Bulut
17:00	17:15	A knowledge framework towards hypoallergenic urban residential environment - **Yanan Yao**, YU Wang, Xiaomeng Wang, Yiran Wang, Tingting Shang
17:15	17:30	Analyzing 'Code:Red' Theme in Turkish Postgraduate Theses - **N. Nihan Parlak**, Esra Şentürk, Elif Nur Sarı, Esra Latifoğlu

Break-out Session 53 (Üsküdar 1 Hall) — Sustaining Life: Protection, Mitigation & Management — Session Chair: ALİ KEMAL ARKUN

Start	End	Presentation
16:00	16:15	Ecological Niche Identification and Habitat Protection in Uludağ National Park - **Onur Aksoy**, Kamil Erken, Ruziye Daskin
16:15	16:30	Discovering public-perceived cultural ecosystem services for Maritime Cultural Landscape management - **Weiwen You**, Mujie Ren, Jiaxuan Duan, Haiyun Xu
16:30	16:45	Landscape character and capacity assessment in the Pearl River Delta - **Sijie Wang**, Simon Bell, Marc J Metzger
16:45	17:00	Urban blue-green space contribution to mitigation of particulate matter pollution - **Chunyang Zhu**, Wenyu An, Han Liu, Yimei Sun
17:00	17:15	Research Review on Urban Insect Pollination Habitat and Construction - **Lihua Yin**, Sining Gong, zhenghao shen, Xinyi Deng
17:15	17:30	Identification and Optimization of World Heritage Irrigation Structures Multifunctional Corridors - **Xuewei Zhang**, Shiying Li, Yaqi Cheng, Wei Ren

Break-out Session 54 (Üsküdar 3 Hall) — Cultivating Resilience: Sustainable & Resilient Communities — Session Chair: JAMES HAYTER

Start	End	Presentation
16:00	16:15	Grassroots environmental movement for code red: Ovacık mining landscape - **Dilara Yaraş Er**, Funda Baş Bütüner, Güven Arif Sargın
16:15	16:30	Vasikkasaari Urban Eco Island - **Varpu Mikola**, Laura Tuorila, Caroline Moinel
16:30	16:45	Planning of Bicycle Station Design in Terms of Urban Mobility - **Ülgen Bekişoğlu**, Çiğdem Gürel Ağır
16:45	17:00	Spatial and Social Resilience in Crises: Migration Response to Disasters - **Merve Dilman Gokkaya**, Nazlı Deniz Ersöz, Gul Sayan Atanur
17:00	17:15	Working Informally: The Role of Landscape Architects in Informal Upgrade - **Amy Thompson**
17:15	17:30	*

Break-out Session 55 (Beylerbeyi 1 Hall) — Acting for All: Diversity, Equity & Inclusion — Session Chair: NİLÜFER KART

Start	End	Presentation
16:00	16:15	The one-meter socialization for children in parks - **Wanlei Zheng**
16:15	16:30	Spatial variation of perceived equity across protected area communities - **Yin Zhang**, Qingyu Li, Junlong Huang, Guangcan Gu, Dan Brockington
16:30	16:45	Multiagent-based Interpretation of Heritage Comminity Valuse Supported by Public Empowerment - **Xiang Zhou**, Yaxu Liu, Yiming Xie, Yuhang Tang
16:45	17:00	Assessment and Optimization of RRA service in Urban Green Spaces - **Li Tan**, Yujia Zhong, Wen Zhang, Meng Guo
17:00	17:15	Impact on City Image of Bingöl's Native Oaks - **Müge Yurtcan**, Ahmet Caf
17:15	17:30	Submerge Knowledge and the Impact on Environmental Justice and Stewardship - **Diane Jones Allen**

Break-out Session 56 (Beylerbeyi-2 Hall) — Sustaining Life: Protection, Mitigation & Management — Session Chair: XIAODI ZHENG

Start	End	Presentation
16:00	16:15	Ecological effects of invasive species on migratory bird communities - **Yifei Xu**, Chi Li
16:15	16:30	Quantifying carbon-saving of urban blue-green space in high-density urban area - **Fei Yang**, Hongcheng Wang
16:30	16:45	Sustaining and managing ecosystem services in urban wetlands for all - **Xuezhu Zhai**
16:45	17:00	Spatial Patterns of Brownfield Clusters in Resource-Exhausted Cities, China - **Quanchuan Fu**, Xiaodi Zheng
17:00	17:15	The spatiotemporal Patterns and Mechanisms of Wilderness Ecological Benefits Impacts - **Zeyu Cao**, Ziyu Lu
17:15	17:30	*

Break-out Session 57 (Yıldız-1 Hall) — Projecting the Process: Monitoring, Assessment & Applications — Session Chair: ALPER ÇABUK

Start	End	Presentation
16:00	16:15	Green Areas, Disaster and Emergency Assembly Areas in Adana - **Ebru Turgut**
16:15	16:30	The Impact Assessment of Industrialization Using Geo-location Community Survey - **Ariya Aruninta**, Hajime Matsushima
16:30	16:45	City-scale Green Infrastructure Multi-objective Optimization based on Interpretable Machine Learning - **Chensong Lin**, Hongyu Chen, Yuxiang Dong, Shuangzhi Tian
16:45	17:00	Analyzing public emotions in residential green spaces using multi-source data - **Lingqian Tan**, Peiyao Hao
17:00	17:15	Urban Parks' Cooling Islands Effect in Hot and Humid Areas - Xinrui Jia, Rongjiao Xia, **Xinmin Liu**, Suyang Yuan, Feng Zhou
17:15	17:30	Multi-scale landscape character assessment in the Pearl River Delta, China - **Dingzhe Jiang**, Ziting Bao, Jianyun Zhou

Main Hall (Üsküdar 2 Hall)

Start	End	Theme	Programme
17:30	17:45	CLOSING	**Closing Ceremony & Flag Hand-Over**
17:45	18:00	CLOSING	**Closing Ceremony & Flag Hand-Over**