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INTERNATIONAL FEDERATION
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IFLA 60TH WORLD CONGRESS
CODE RED FOR EARTH

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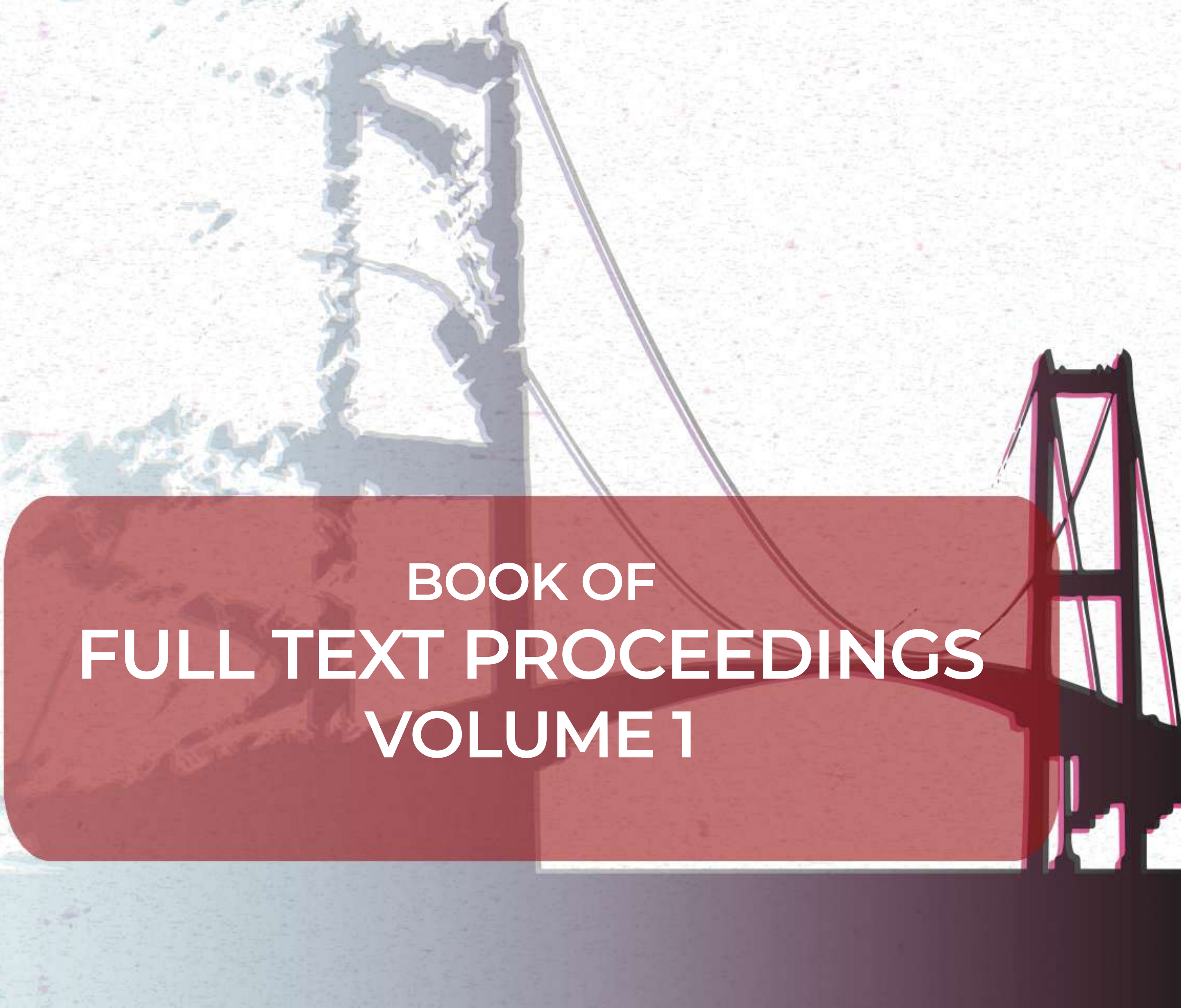
İSTANBUL-TÜRKİYE



BOOK OF
FULL TEXT PROCEEDINGS
VOLUME 1

60th IFLA WORLD CONGRESS
2024 İSTANBUL TÜRKİYE

BOOK OF
FULL TEXT PROCEDINGS

CODE RED FOR EARTH

UNION OF TURKISH ARCHITECT AND ENGINEERS (UCTEA)
CHAMBER OF TURKISH LANDSCAPE ARCHITECTS (CTLA)

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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 I 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

Beyond the Green Space Per Capita: Exploratory Research

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Abstract

Green space per capita (GSPC) is a well-known global indicator of the environmental benefits of public green spaces (PGS), but its mitigation relationship with the urban heat island (UHI) phenomenon is undefined. This research has shown that in the city of Paraná, Entre Ríos province, the increase in T° at different points of a PGS and in different situations of sun and shade does not evolve in an inversely proportional relationship to the GSPC (census tract related urban sector). That means that areas with more m^2/capita should have recorded the lowest temperatures per season, and vice versa. However, different results were obtained from the data collected and its processing. The study has shown a clear tendency: certain T° and H° are mainly related to the thermal energy exchange of the grey infrastructure (GI) depending of its heat exchange potential, and that the presence of more m^2 of GSPC does not have a direct relationship with the moderation of T° in the surrounding area. It is therefore concluded that the presence of PGSs alone does not mitigate the UHI effect, and that the decrease in T° sometimes follows an environmental pattern generated by contextual urban spatial qualities.

Keywords: Urban heat island phenomenon, green space per capita, public green spaces, environmental benefits.

1. Introduction

In all worldwide conducted studies related to environmental benefits of public green spaces (PGS) in cities, it is used as the green space per capita, an indicator proposed by the UN. We have not found the original document that methodologically supports the determination of the green space per capita indicator attributed to the UN. That indicator supposedly ranges from 10 m2 to 15 m^2/capita. It is also assumed that the more m^2 of PGS per capita, well distributed and in good condition, apart from being a social benefit of appropriation and collective social construction, the situation itself would contribute to the mitigation of the urban heat island effect locally and globally in the city territory. We think the latter is not proven to be true, but an assumption added to the list of the environmental benefits of PGSs in cities. We have been working on GPS since 2000 as a Department of Green Spaces (FCA, UNER), from different aspects of the matter. Having searched investigation data in this exact aspect and not finding it, makes us lead our study in this direction.

Objectives:

To prove whether the presence of PGSs reduces by itself the urban island heat phenomenon.

To track the relationship between GSPC and the mitigation of the urban island heat phenomenon.

Aim(s) of Study:

We would confirm, as it is widely informed, if the relationship between green area space per capita evolves to check if the way in which the current urban forestation pattern, in sidewalks and in green spaces, mitigates the UHI beyond the shadow area projected by the trees. This will make it possible to measure, if there is only a direct mitigating heat effect, if it exists, a noticeable influence beyond the shadow projected area. If the second situation is a reality, we could be proving the GSPC as a consistent indicator of the effect of GPS over the mitigation of UHI in cities. According to these results, new strategies, both specific and combined, should be proposed to reduce the urban heat island effect at the city system level.

2. Material and Method

Materials

Four thermohydrometers and four identical tripods were purchased for measuring temperature (T°) and humidity (H). The best equipment that fit the budget was acquired.

Method

Samples were taken every two weeks from October 2021 until May 2022, to obtain a record from the time the temperature begins to rise until it starts to decline during the warm seasons. To carry out the project, the city was divided into sectors of different types of urban densification, and a medium-sized GPS was sampled from each type of urban densification. For this, the data collected for the morphological characterization of the environment from the "Survey and Planning of Urban Tree Canopy in Paraná" (2015), conducted by this department in collaboration with the Municipality of Paraná, Province of Entre Ríos, Argentina, was considered.

Some of the analyzed GPSs from the PID UNER 2165 "Characterization and evaluation of public green spaces in the city of Paraná, Entre Ríos" (Carponi et al. 2020) were taken as sampling units. These data, already produced by the Department, served as inputs for the characterizations of the environment and the percentage of green space in the GPSs. It is shown in table 1, the sample list of GPSs selected for this work, and the useful data associated with each one of them that would be relevant to the present study.

Table 1. GPS sample and basic associated data (Own work, 2023)

GPS NAME	GPS Area	GSPC for Census Area Density
Plaza Mujeres Entrerrianas	25,930 m²	1.37 m²/capita
Plaza Saenz Peña	19,823 m²	2.27 m²/capita
Plaza Alvear	12,000 m²	28.5 m²/capita
Plaza Eva Perón	8,180 m²	15.78 m²capita
Plaza Filiberto Reula	7,427 m²	4.46 m²/capita
Plaza Francisco Ramirez	6,976 m²	2.5 m²/capita
Plaza Puerto Argentino	5,097 m²	2.5 m²/capita
Plaza Mansilla	3,575.28 m²	28.5 m²/capita

Then, we introduce the location of each GPS in the city of Paraná as it is shown in Figure 1.

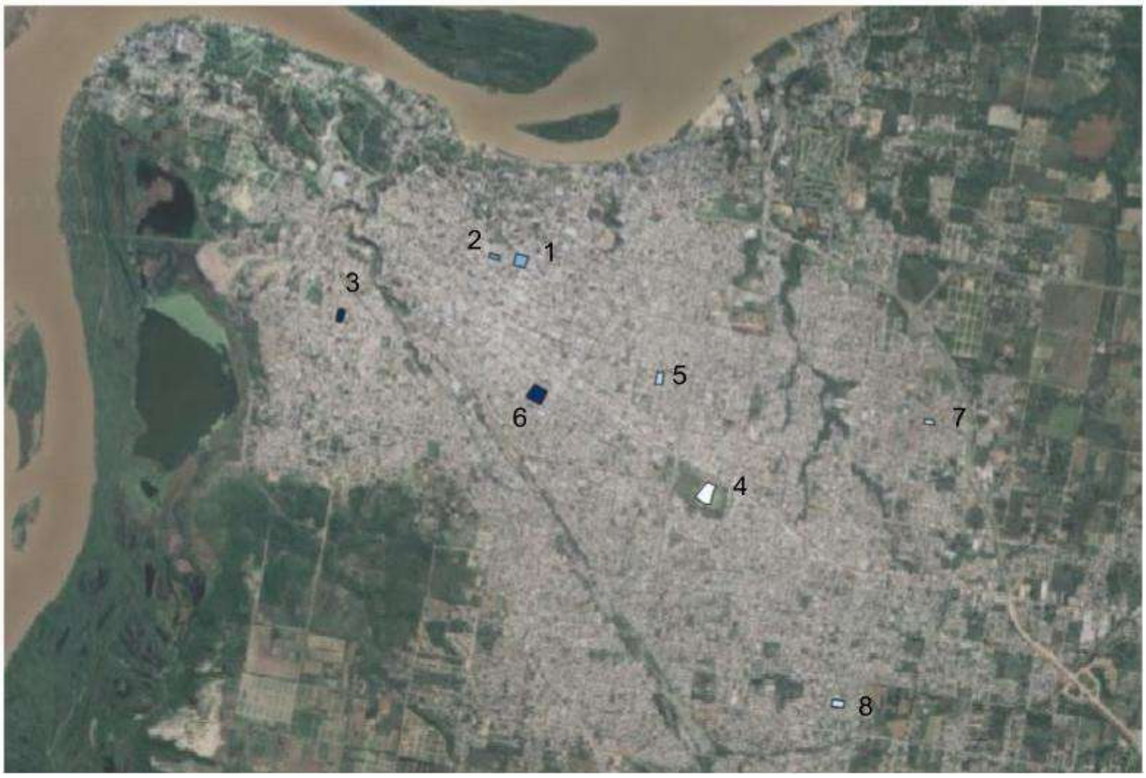

Figure 1. Territorial location of the sample of green spaces (Own work, 2023) Note. References: 1. Plaza Alvear. 2. Plaza Mansilla. 3. Plaza Eva Perón. 4. Plaza Mujeres Entrerrianas. 5. Plaza Francisco Ramirez. 6. Plaza Sáenz Peña. 7. Plaza Puerto Argentino. 8. Plaza Filiberto Reula.

In Figure 2 it is shown the comparison between the GPS area and the GSPC per census district fraction. This is a very important value to relate the ecosystemic services of the GPS to their own city influence area.

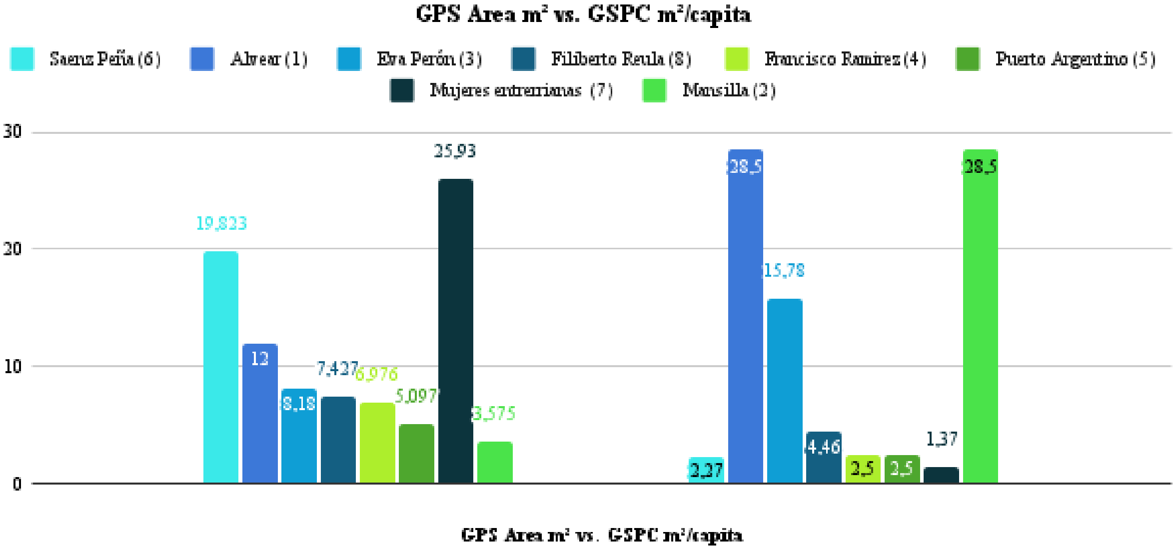

Figure 2. GPS area vs. GSPC (Own work, 2023)

We chose 6 different environmental situations for collecting the data. The selection of these were related to the possibility of evaluating the mitigation heat reach of the tree shadows. Figure 3 states the environmental situations in which data collection took place. Each position has three characteristics: localization, surface and exposure.

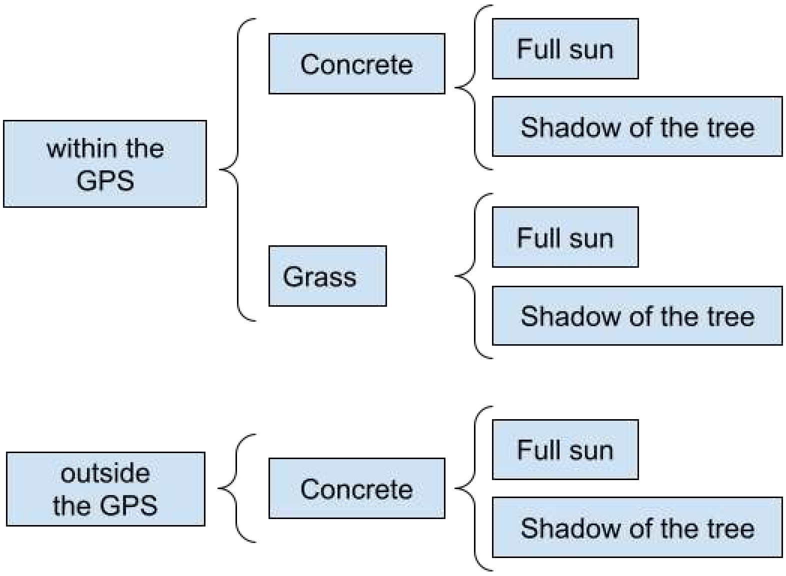

Figure 3. Types of situations collecting data. (Own work, 2023)

While collecting the data, the thermohydrometers were placed on the tripod at 1.2m for data collection. Measurements were taken every 2 minutes, each one alternating between the different situations. All team members conducted the data collection on the same days (Thursdays), every 15 days, during the time window from 2 PM to 4 PM, meaning the measurements had to be taken within that two-hour window. To have a general comparison of temperature and humidity readings in the city during the data collection period, climate records were sought from the National Meteorological Service for the hours of 2 PM, 3 PM, and 4 PM for each date. The data collected from all the parks was entered into an Excel spreadsheet and organized into tables designed for the subsequent generation of analysis graphs. With this information, the environmental situations of each GPS and the comparative data from the 8 GPSs were analyzed.

Data Treatment

First, data collection tables were created to serve as a database for the different analyses. Data collection tables were made for each GPS in temperature (Tº) and humidity (Hº), as well as tables for data collection situations comparing the behavior of these in the different selected GPSs. Subsequently, with the collected data, the averages of temperature (Tº) and humidity (Hº) for spring, summer, and autumn during the measurement period were calculated for each data collection situation and each GPS. Using these base tables, interpretative graphs were constructed with the following characteristics:

- Comparative graphs of temperature data by GPS for the data collection period.
- Comparative graphs of humidity data by GPS for the data collection period.
- Comparative graphs of average temperature data by season for each GPS during the data collection period.
- Comparative graphs of average humidity data by season for each GPS during the data collection period.

Within the products, maps were created from data using open-source GIS software to display the different occurrences of temperature across the various seasons (spring, summer, and autumn). Subsequently, the constructed instruments were analyzed, and corresponding conclusions were drawn to verify or refute the hypothesis.

3. Findings and discussion

In this research, the main goal was to record and compare temperature (Tº) and humidity (Hº) in the selected GPS and to verify how much of the effect of the present vegetation was evident as a mitigator of the UHI.

To carry out this data comparison, averages were calculated by season from the collected data to observe the behavior of the variables in different situations and across the various GPSs.

The behaviors of the temperature and humidity variables were analyzed in the different GPSs of the study and for all data collection situations.

For the SUN-CON situation about Tº data, as shown in Figure 4 the observed trend is similar for the eight GPSs, with two groups of GPSs standing out in summer: one group of four with higher temperatures and another group with the remaining four, with lower temperatures. The difference between them is 3.52ºC, with the highest average temperature being 44.56ºC in Plaza Saenz Peña and the lowest in Plaza Filiberto Reula at 38.34ºC. This behavior suggests that the lower average records are not related to the presence of higher percentages of vegetation cover (AV/H), but rather are contextually territorial.

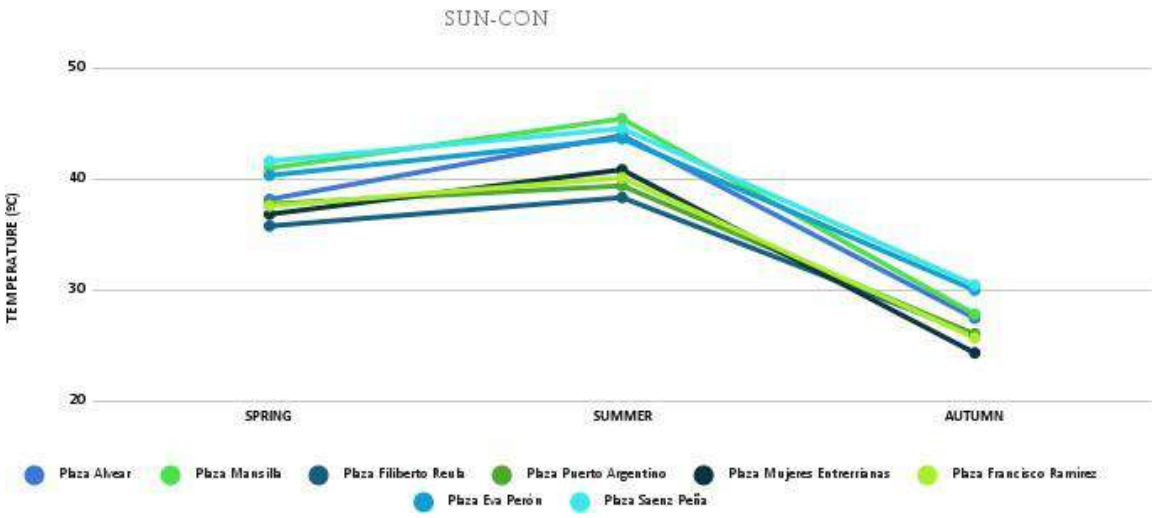

Figure 4. Average Tº (Cº) (%) for spring, summer and autumn all PGS. (Own work, 2023)

In Figure 5, it is observed that for the SUN-CON situation about Hº data, two well-defined groups are observed: one consisting of Plazas: Filiberto Reula, Mujeres Entrerrianas, Puerto Argentino, Francisco Ramírez, Saenz Peña, y Eva Perón, whose humidity percentage increases from spring to autumn. The second group, composed of two Plazas, Alvear y Mansilla shows a decrease in humidity percentage from spring to summer and an increase from summer to autumn. The smallest amplitude among the eight GPSs is recorded during spring and summer, while the largest amplitude occurs in autumn.

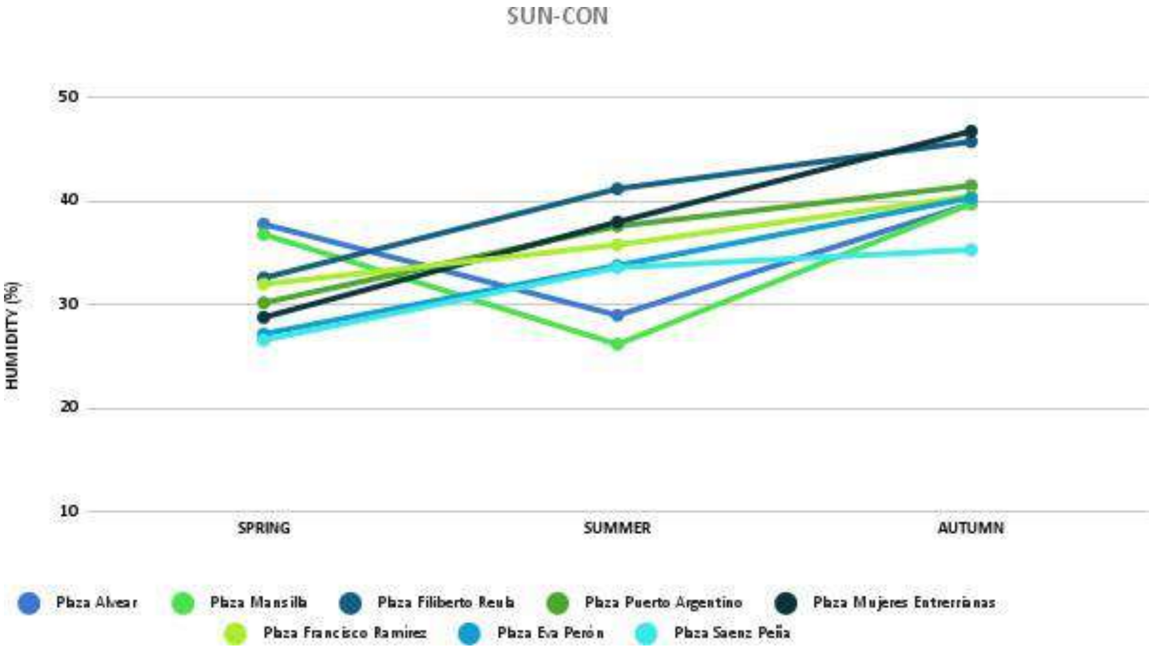

Figure 5. Average H (%) for spring, summer and autumn all PGS. (Own work, 2023)

Then we analyzed the findings in relation to location and this changed dramatically. We made a map, coloring each GPS, in a scale from white to red being white the lowest temperatures and the red the highest, choosing the most extreme setting average summer Tº for SUN-CON situation, because this data collection situation shown to be, the most influenced by the environmental context location. As it is observed in Figure 6, that from the 4 GPS with higher average Tº for SUN-CON, 3 were located in high densify urban areas (central district: UM 1) with the highest rates of GSPC, and only 1 in an intermediate densify area but nearby the central area. And the other 4 GPS showing the lower average Tº rates belong to less densify areas. None of the results in average Tº are openly related to the urban location % of GSPC. To assure that GPS helps to mitigate by their mere presence the UHI phenomenon, the mathematical relation should be inversely proportional between %GSPC and average T, and this was not the case. There is a much more complex analysis to be done.

Figure 6. Map of GPS showing behavior of the average summer temperature for SUN- CON in a white to red. (Own work, 2023) Note. References: 1. Plaza Alvear. 2. Plaza Mansilla. 3. Plaza Eva Perón. 4. Plaza Mujeres Entrerrianas. 5. Plaza Francisco Ramirez. 6. Plaza Sáenz Peña. 7. Plaza Puerto Argentino. 8. Plaza Filiberto Reula.

We also proposed another a bubble chart to picture this non direct relational behavior of the average summer temperature for SUN-CON and GSPC. The chart depicts the relationship between the average summer temperature and the % GPS/District, showing the bubble size the area of the GPS. Bigger ones are larger GPS and vice versa. In Figure 7, it can be observed more clearly, that the 3 highest average temperatures belong to Plazas: Mansilla, Sáenz Peña, and Alvear, located in central district: UM 1, which has the highest percentage of green at 7.82% among all UMs. It is also worth noting that Plaza Filiberto Reula, located in district, UM3 which GSPC is only 0.33% has an average summer Tº for SUN-CON, 38.34ºC, the lowest value in this series. The difference between the highest and lowest averages is 7.1ºC, that means that the thermal situation in both locations it noticeable at a person sensitive level. Again, there was no behavioural correlation between higher average Tº and GSPC. In other words, if the mere presence of a higher percentage GSPC were enough to mitigate the UHI.

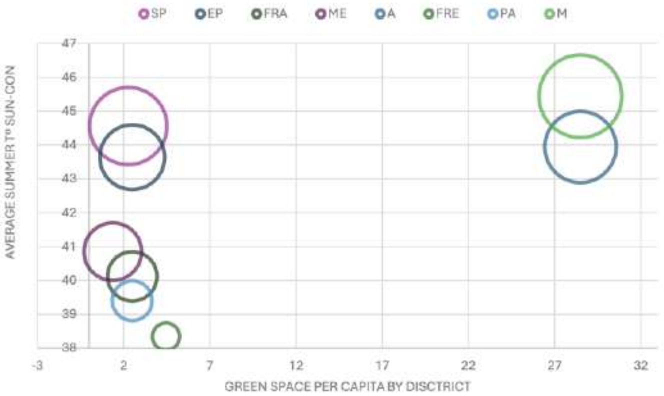

Figure 7. GSPC by district related to GPS area and average summer Tº for sun on concrete situation. (Own work, 2023)

4. Conclusion

The research conducted indicates that the UHI mitigation generally attributed to GPS environmental benefits is not accurate in predictability, range and scope. GPS do not have a visible UHI mitigating impact due to their mere presence in the city, nor even due to their abundance in each area; rather, the UHI behaviour is the result of the ratio between % of GI areas exposed to the sun, and their heat exchange potential, and the total volume of urban space considered. In general, it can be concluded that the behaviour of Tº and Hº in particular city location during the year is directly correlated to the UHI city system and its territorial particularities. It is dismissed that in areas with higher GSPC, the mere presence of urban greenery does exert a mitigating effect on UHI phenomenon.

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Exploitation of Natural Resources, Forced Removals and Ghosted Landscapes

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Abstract

The top-down implantation of large infrastructures by powerful companies has been causing in silence environmental damages of enormous scale and territorial impact. Although the discussion about these issues have been around for a long time, they still provoke intense debates among different fields of study regarding the interaction between the economic exploitation of natural resources and the radical transformation of spaces. Our objective is to reflect on the impact of forced removals on the landscape caused by large-scale exploitation of natural resources and undergoing a process of obliteration in both their physical and symbolic aspects at different stages. Through a comparative study of two European cases (Kiruna - Sweden and Aldeia da Luz - Portugal) and the current urban disaster in the South American case (Maceió - Brazil), our purpose is to present an analytical framework for reflecting on the various spatial and social impacts. After all, what does the idea of ghosted landscapes represent in the study cases scenario? And what actions have been taken or not taken that can help us to think about possible futures?

Keywords: Exploitation of natural resources, forced removals, ghosted landscape, urban-environmental disaster.

1. Introduction

The increase in urban environmental disasters is a global emergency. There are landslides, floods, earthquakes, droughts, but there are also those caused by the exploitation of the Earth's natural resources. The top-down implantation of large infrastructures by powerful companies has been causing in silence environmental damages of enormous scale and territorial impact (Hein, 2021; Nixon, 2011). Considering this ongoing phenomenon as a symbolic image of global urbanization, our objective is to reflect on the impact of forced removals on the landscape caused by large-scale exploitation of natural resources. This will be achieved through an analysis of three case studies involving forced removals and undergoing a process of obliteration in both their physical and symbolic aspects at distinct stages. The first, in Maceio (Brazil), our hometown and the empirical motivation for this research, is about an imminent risk of land collapse that has led to the ongoing forced removal of more than 57,000 residents from nearly five neighborhoods since 2019, triggered by the destabilization of cavities from the rock salt extraction operated for more than four decades by a petrochemical company. The second, in Kiruna (Sweden), is also related to mining activities; the idea of relocation of almost

18,000 residents was announced in 2004 due to the risk of ground subsidence and collapse because of iron ore exploration. The third, Aldeia da Luz (Portugal), involves the displacement of a village of 400 people as the area was going to be immersed by a dam, which began in the late 1980s.


Maceió (Brazil)
Kiruna (Sweden)
Aldeia da Luz (Portugal)

Figure 1. Collage: maps of displaced areas (in red) in Maceió, Kiruna and Aldeia da Luz. (Google Earth, 2024; adapted by authors, 2024)

Through a comparative study of the two European cases and the current urban disaster in the South American case, the purpose of this paper is to present an analytical framework for reflecting on the various spatial and social impacts caused by large-scale exploration activities in localities. Although the discussion about these issues have been around for a long time, they still provoke intense debates among different fields of study regarding the interaction between the economic exploitation of natural resources and the radical transformation of spaces. After all, what does the idea of ghosted landscapes represent in the study cases scenario? And what actions have been taken or not taken in the two European case studies that can help us to think about futures for Maceió, Brazil?

2. Material and Method

A qualitative approach was adopted in a multiple case study, with the methodological procedures based on the method of “structured, focused comparison” (George and Bennett, 2005). Our research design was structured according to the following path: initially, we reflected on the situation in Maceió, our main case study and the empirical motivation of this research. With the objective definition in place, we searched for other case studies within the scope of forced displacement caused by large-scale resource exploitation. Subsequently, the criteria for the multiple cases election were defined. Given our roles as fellow researchers in European universities during this research process, we limited our selection to European cases. Given the limited period and budget, we opted to conduct desktop research and identify cases with substantial published material and reliable secondary data. In accordance with the criteria, the Kiruna City (Sweden) and the Aldeia Luz (Portugal) cases were selected.

Following the case studies' selection, a preliminary analysis of the two new cases was done. This analysis enabled the gathering of general information and the formulation of three key questions for the structured and focused comparison: 1. How is a landscape erased? What is the process of erasing a landscape? 2. How can the loss of a landscape be compensated for? 3. How to grieve a landscape? These questions guided our efforts toward defining and refining the topics to be examined in the comparative analysis of the three cases. The topics included the following: (a) historical background, (b) cause of displacement, (c) negotiations/agreements, (d) main conflicts, and (e) challenges/perspectives. As previously stated, a depth search was conducted for each topic in academic articles, theses, and dissertations. To conduct a proportional and comparable search, five main productions (sources) were defined for each case, as listed in the references. We also have used institutional documents and reports concerning the Maceió Case (as it is an ongoing process). Naturally, we had access to a variety of other publications, including media sources, and websites. However, these were utilized primarily as supplementary materials to enhance our interpretations.

Our research design was not fixed, rather, it underwent refinement throughout the process. Nevertheless, to ensure a coherent comparison, we attempted to remain as close as possible to the content of each topic and selected data, reflecting on our three key questions and, consequently, our objective. Finally, we engaged in a comprehensive discussion of the findings and formulated our final conclusions. As previously stated, we elected to conduct desktop research, which resulted in our decision to limit our analyses to the use of secondary data. It has been acknowledged that the scope of our analysis is constrained by the limitations of the data gathered by other researchers. This is why our research was conducted using a comparable number of academic sources (which have undergone peer review), and to adhere strictly to our selected topics.

3. Findings and Discussion

Maceió

The first case is situated in Maceió, the capital of Alagoas State on the Brazilian northeast coast. The case was brought to public attention due to an imminent risk of land collapse triggered by the destabilization of cavities from the rock salt extraction operated for more than four decades by a petrochemical company. There have been signs of damage to the ground caused by extraction wells since 1985, but it was at the beginning of 2018 that seismic tremors occurred in a region that encompasses some of the city's first urban centers: Bebedouro, Mutange, Bom Parto, Farol and Pinheiro. Only more than a year after the disaster began did the mining company reach an agreement with local authorities to vacate the properties and relocate the families. Even so, the company has still not officially taken responsibility for what happened.

The situation has never ceased to be nebulous, because for the affected families to receive the financial compensation they are owed, they need to sign a tenure agreement that gives the mining company control over the land, making the future of this urban space uncertain. As soon as the properties in the eviction and monitoring area are vacated, the company takes possession of the properties and begins to adopt measures for cleaning, conservation, pest control and property security, among others, always in cooperation with the public authorities. The transfer of ownership of the indemnified properties is also provided for in the agreement and is necessary so that Braskem can act to solve the problem. Also in the document, signed with the Federal Public Prosecutor's Office, with the participation of the Public Prosecutor's Office of the State of Alagoas, Braskem undertakes not to build on the vacated areas for commercial or housing purposes. Future discussions about the area and its use can be based on the Municipality's Master Plan, an instrument that has been widely debated by the authorities and society, that at no point will the decision about the future of the area be up to Braskem alone.

The process of soil subsidence is still underway, and it is estimated that it will take around 20 years to re-stabilize. Suddenly, there were immeasurable changes and losses in the city, with impacts in various spheres: residents' mental and physical health (documented testimonies report that there have been cases of suicide and death due to deep depression caused by the need to relocate); urban mobility (the area, which is now closed to access, used to be an integrating hub between the upper and lower parts of the city, as well as being part of the railway line that connected the capital to various municipalities bordering the Mundaú Lagoon); the real estate market (there was a general increase in the value of property for sale and rent, as well as a devaluation of those located in neighboring districts), and cultural heritage.

The residents of the affected neighborhoods have suffered both from the disruption caused by the sinking of the ground and from the weakening of religious and cultural traditions that used to take place there, such as the popular folklore groups that were discouraged after their members moved to places far from each other. On the other hand, there are still families living close to the so-called risk area (Flexais community), at risk of sinking and lacking basic infrastructure. Some of these residents are protesting about being relocated, while others remain in the area without any other prospects for their lives.

Kiruna (Sweden)

Located near the Arctic Circle in Sweden, the city of Kiruna was founded in 1900 by Luossavaara-Kiirunavaara Aktiebolag (LKAB), a state-owned mining company. According to Karlsson (2018), the region has been mined since the beginning of the 20th century and has one of the largest underground iron mines in the world.

Since 2004, Kiruna's 22,000 city residents have been dealing with the relocation and demolition of part of the city, including 5,000 homes and 70 hectares of residential, commercial and institutional areas, such as the city center, due to the expansion of iron ore mining beneath the city (Karlsson, 2018; Boyd, 2023; Nobile, 2023). The city's economic dependence on the mines has led to the local population's acceptance of the continued operation of the dominant extractive industry as a matter of greater importance than other concerns. First, the MineralLaw which regulates the Swedish exploitation of resources indicates that the State has a right to expropriate and to negotiate with homeowners about lands with potential minerals and economic significance to the country (Karlsson, 2018).

The necessity of moving the city was made for the continuity of iron ore production, and a plan was drawn up together with the municipality for the areas that would need to be demolished. In 2005'a contest was announced, where 10 architecture offices were invited to submit their visions, design, and strategies for the "New Kiruna. The material of the contest (sketches and 3D models) was available for the public to vote for their favorite proposal. The Norwegian architects Ghilardi + Hellsten and the Swedish White Architects were the developers of the winning submission named "Kiruna 4-ever" (Gebremedhin, 2018). In addition, the construction of new homes, city hall, hotels and a train station were planned too, and the historically important buildings were planned to be relocated subsequently. The impacted area will gradually become a buffer zone for an industrial park, situated between urban residential zones and industrial production facilities.

For the residents of Kiruna, the deformations in the city's surface constituted a clear indication that the relocation and demolition of a third of the city's urban fabric was unavoidable. The historical relationship between iron ore mining and the founding of the city, and consequently the municipality's economic dependence on KLAB, meant that the inhabitants of Kiruna had no real choice in the matter. "LKAB's relationship to Kiruna residents is also fraught with dynamics of patronage and paternalism which is also important for understanding people's relationship to LKAB and the city space" (Karlsson, 2018, p. 27). An Informant of Boyd (2023, p. 170) in the mine's public relations office during an interview in May of 2021 says: "What do we have to mourn? We are giving them a new city, and we are able to continue mining. There is little to be mourned, yes people are giving up their homes and businesses, but we are paying them more than is fair". For Boyd (2023) the denial of the right to mourn is a means of silencing and dehumanizing those who disagree with the expansion of the mine.

Aldeia da Luz (Portugal)

Located on the left margin of Guadiana River, in the Alqueva region of Portugal, the site where the old Luz village was located has attracted attention since early civilizations, by those who found in the water a way of living and surviving, through fishing, hunting and, later, farming (Silva, 2003). But it was with the romans that the place really found its importance, starting with the construction of Lousa castle, leading to the development of roads and routes to and from it, and then with the built of the main church in the XV century, which was essential to the implementation of the village itself (Torres, 2010).

In 1957, it was developed Alqueva's irrigation plan, which intended to create a dam in the area, producing the largest artificial lake in Europe, 83 km long and 4 150 million cubic meters in the reservoir. But, to do so, the village of Luz would have to be submerged. The person responsible for the intervention was the Alqueva's Development and Infrastructure Company (EDIA), a state business that justified the plan by the opportunities water resources could bring to the region. According to EDIA, the dam would guarantee a strategic water reserve for public and industrial supply; change the agricultural model in the south of the country; generate hydroelectricity; create tourist potential; combat physical desertification and climate change; intervene in the areas of environment and heritage; promote the creation of jobs from the construction of the project to exploration (Moraes, 2019).

After many years of discussion and planning, it became a reality, and the construction of the dam made clear that the 373 inhabitants of the village had to move out and the new place started to be designed. The Luz population created a committee and, in 1981, started to analyze their options. The first one, they had the chance of financial compensation; the second was that each family would be moved elsewhere; or the third, to build a new village the closest they could. The strategy aimed to carry out a door-to-door poll to complete a survey that included listening to the population's wishes. In the end, with some controversy, the new village was built, between 1998 and 2002, almost 3 km far from the original, where an attempt was made to reconcile the image of the Alentejo village that continued to express the old habits of the past.

With the closure of dam gates and the filling of the reservoir, in February 2002, the population saw the original Luz village get under water and officially moved out to the new area. According to information from the Luz Museum, there are 214 houses following 25 typologies, based on traditional local architecture with a street layout like the old village. In terms of economic activities, services and rustic buildings, Luz has: a mini market; a bakery; a cheese factory; a restaurant; four coffees; a craft store (which also has the function of a mini market); a primary school; a playground; a nursing home; a health center; a museum; a parish council; a sports pavilion; a football field; a bullring; a pier; a picnic park; a park caravans; a cemetery and two Catholic churches, the Church of the Sacred Heart of Jesus, located in the square and the church of Nossa Senhora da Luz, located close to the Luz Museum and from the village cemetery. According to the inhabitants, the latter is a faithful copy of the church in the ancient village founded in the 15th century (Moraes, 2019).

Although we enter the new Aldeia da Luz thinking of it as a traditional Alentejo village, because it is structured and presented like one, we quickly realize that there is something different about the whole: the proportions found in the other Alentejo villages are subverted, and the codes that characterize them are reduced to mere stereotyped copies of their original models. Thus, it can be said that the new village of Luz fails in its interpretation of the towns it tries to emulate, never managing to establish a balanced relationship between its inhabitants and the surrounding plain (Pereira, 2010). So, although the Alqueva project has brought benefits to Alentejo, old customs and cultural practices associated with the river have been lost. No matter how many attempts have been made to please the population, the social impact has been severe, and emotional ties have been impossible to restore.

4. Results

From a chronological point of view, the three cases are not similar. The first settlements and the historical background of each case are quite different. What we have noticed, and what our results confirm, is the very tight connection between the formation of the city of Kiruna and mining activity. The timeline diagram (Figure 2), however, showed us the certainty of the maintenance of the extractive activities guided by the economic interests of the Swedish government and the EU, the negotiations came with a certain advance before the times of the removals. The same logic was applied to Aldeia da Luz, even though there was no possibility of preserving the community where it was located, the process of negotiating with the inhabitants took about 20 years, and the exploitation activity began only after the completed removal and relocation. The case of Maceió, on the other hand, was completely different from the other two, because all the inhabitants were evacuated urgently in the face of the accelerated sinking process and the imminent risk of collapse.

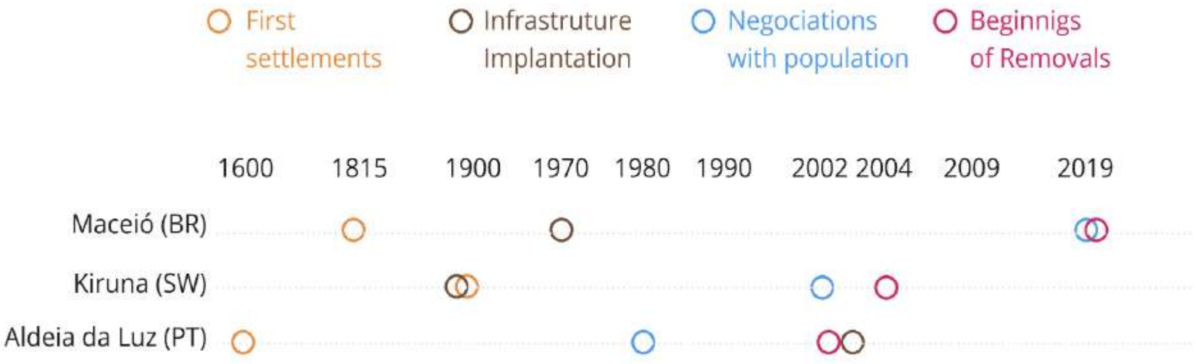

Figure 2. Diagram: timeline of beginnings. (Produced by authors)

The number of people affected by the situation in Maceió is also a topic of interest. The number of residents directly affected is 20 times higher than the number affected in Sweden and almost 200 times higher than the number affected in Portugal. Consequently, the first negotiations and agreements were conducted by government representatives, with the initial idea being the urgent necessity of evacuating the area. In our analysis, the "scale" and "urgent situation" provided the Braskem Company with a competitive advantage during the negotiations and the formation of agreements, as evidenced by the results of our study. Anxiety and despondency were the dominant factors throughout the entire process.

As previously stated, all three cases present different spatial scales and numbers of inhabitants. The three cases exhibit three distinct physical characteristics and three disparate geographical, historical, and economic contexts. However, a common thread runs through them all: the residents had no option but to remain. In both the case of the "rural areas" of Europe, where developmentalist arguments have been used to justify the maintenance of economic activities (Aldeia da Luz and Kiruna), and in the case of a petrochemical company's lack of socio-environmental responsibility in extracting salt rock exhaustively underground in an urban area, the option of non-removal has not been considered.

A reflection on these processes leads us to revisit the issue of forced removals resulting from the implementation and/or maintenance of large-scale resource extraction activities. According to Nixon (2011, p.151) “the production of ghosted communities who haunt the visible nation has been essential for maintaining the dominant narratives of national development, a process that has intensified during the era of neoliberal globalization”. Additionally, he introduces the term "developmental refugees," which he posits as overlapping with the notions of the "uninhabitant" as put forth by Rebecca Solnit (2014). Both terms are used to characterize individuals who are perceived as impediments to the "progress" of the developing world and who become erased. This notion is a link to the three cases illustrated here, so that despite the diverse ways of dealing with the relocation of communities - whether prior to the exploitation process, as in the European cases, or after an emergency, as in Maceió - in the end, people never had a real choice.

5. Conclusion

Figure 3. Collage: photos of affected areas in Maceió, 2022; Kiruna, 2022; and Luz 2020 (Respectively; Schorchit, 2022, Kiruna Municipality, 2022, Henriques, 2020)

Finally, the idea of ghosted landscapes in our reading carries with it the notion of haunting, whether it is the idea of not collaborating with the development of the land (Aldeia da Luz), the haunting of knowing that the city would not be able to sustain itself without the presence of mining activity (Kiruna), or the haunting of death itself (Maceió). The haunting takes place even before the removals, and the once inhabited landscape is quickly transformed into a blurred memory - flooded, demolished, or sunk.

Consequently, an additional layer of analysis is required to understand the relationship between this ghosted landscape and the formation of memory. Even though the landscape in question no longer exists in a physical sense, the memories of what it once remained with those who were present when it was still intact. In Aldeia da Luz, despite the attempt to construct a new village in the style of the old one, the horizon that delineated the former community's boundaries remains visible from the Windows of the Luz Museum, an institution established to document the region's history. However, this landscape is now inundated with water, evoking memories of the past and perpetuating a sense of the ghostly presence of the former community. In the case of Kiruna, despite the recognition that no memory can be divorced from the context of exploitation, it is challenging to avoid taking with you the ancient landscape that was selected for human habitation. In Maceió, the landscape of the neighborhoods has undergone significant changes over time, with the demolition of houses and urban fabric leading to the gradual erasure of the existing landscape. This has given rise to a dilemma regarding the relationship between the landscape as memory and the act of remembering. Some individuals find it challenging to recall memories associated with a particular place, particularly when those memories evoke positive sentiments. However, others may be inclined to move on from such memories. Regardless of individual perspectives, the ghost of the past continues to linger in the collective consciousness.

Note

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Xylella Fastidiosa, a Landscape Crisis

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Abstract

A bacterium called xylella fastidiosa started to desertify olive trees in Southern Italy, and to date no remedy has been found to stop the contagion. The European Union has imposed the eradication of every tree that is positive for the bacterium effectively proposing a desertification of the infected territory without addressing the issue of landscape protection. Here, an attempt will be made to explain the irrational gesture of many young rebels and peasants not to apply European decisions by highlighting the essential role that the olive tree plays in the landscape of south Italy, understood both as a landscape horizon and as a psychic horizon within which the citizen forms and recognises himself. The paper provide a critical comparison between the literary image handed down by travellers of the past and the present-day image of a landscape that seems to have lost its identity due to building speculation, the plundering of the land and a bacterium that has destroyed entire areas.

Keywords: Olive trees, landscape, crisis, desertification

1. Introduction

Andrea Zanzotto, one of the most important Italian poets of the 20th century, wrote that “saving the landscape of one's land is like saving its soul and that of its inhabitants” (Zanzotto, 1995, p. 130). In the fight against *xylella fastidiosa*, the bacterium responsible for the drying out of olive trees in Salento (the most peripheral part of Apulia, the easternmost region in southern Italy), little attention has been paid to the impact of this epidemic on the landscape or, to put it better, on the *no-longer-landscape* generated by the destruction of the trees: a condition that Zanzotto himself would have defined as ~~*landscape*~~, i.e. a place where visually glimpsing the “landscape” is impossible (Jakob, 2023). Here an attempt will be made to provide an explanation for the “irrational” gesture of many young Salento farmers who, united in associations and committees, have chosen not to eradicate the dying trees, opposing EU decisions. (Figure 1) The olive tree is the pivot around which the Salento landscape unravels, understood both as a *landscape horizon* and as a *psychic horizon* within which the individual forms and recognises himself and from which it cannot be eradicated (Alpi et al., 2021).

Figure 1. A young woman from Salento (South Italy) protests against the felling of an olive tree affected by xylella fastidiosa (2016)

2. Olive Trees on the Horizon Between Garden and Landscape

An early 19th-century French erudite wrote that "Europe ends in Naples and very badly too" (Creuzè de Lesser 1997, pp. 7-8). The annotations of travellers who, between the 18th and 20th centuries, ventured into Apulia constitute a valuable source as they provide an insight into the ways in which the landscape was perceived and described over time by "foreigners" (Canali, Galati, 2018-19; Cazzato, 2003). Reading their descriptions, the recurring topos is that of crossing a particularly fertile plain, dotted on the seaward side with ancient ports in which it is possible to perceive echoes of Greekness and mythical links with the past. The landscape is determined by looking at the territory from above and with a distant gaze, placing the perceptive parameter (the landscape as *panorama*) alongside the productive-economic one (design of the territory). In the category of the *picturesque,* repeatedly evoked to describe the Salento landscape, garden and landscape are two notions that interpenetrate, without precise demarcations. If on the one hand the landscape appears to be "an uninterrupted garden" (Fiorino, 1989, p. 25), on the other, it is possible to identify real gardens created in the most disparate places: in the moats of castles, in the enclosures of farms, on city walls (Cazzato, Mantovano, 2010). What holds the threads of this *overflowing nature* together is the ubiquitous olive tree. The olive tree is the glue between city, garden and landscape, a key element in that sort of descending climax that, in the stories of foreigners, allows one to break down and decipher what one sees. The olive tree has its own identity, it is the undisputed "ruler" (Ceva Grimaldi, 1821, p. 160), creating woods and forests so well shaped that they appear as "sacred groves" or "shady islets" (Placci, 1911, p. 610) that capture the traveller's attention. At times one almost has the feeling that the other trees, starting with the fruit trees, are like intruders in the midst of the dense foliage of the olive groves. In this horizon of green in which the mingling of tones gives the sensation of being in front of an "emerald cloth" (De Giorgi, 1882, I, pp. 4-7) or a "mantle of vegetables" (De Giorgi, 1882, I, pp. 322-323), it is not possible to perceive how far those "continuous olive groves" go that provoke a "monotony of lines" and a hint of *melancholy* (Tomasini 1828, p. 20; Canali, Galati, 2018-19, pp. 61-62; De Salis-Marschlins, 1973, p. 200; Von Stolberg, 1795, p. 330). One thus comes to perceive the olive grove as an immense sea. In fact, it is enough to look at the small leaves (green above, whitish below) on a windy day to realise that at bottom its "matronly" green is a true *green sea*. *Apulia felix* is thus configured as an *ocean of green* that, amid "flashes of light and shadow" (Meyer Graz, 1915, pp. 37-38), sets no boundaries with the *ocean of sunshine* and the blue sea. In this context the villas seem to "float like white sails on dark waves" and "the land, the sea, the sky, the towns, the hills, the cottages, the vegetation form together a magnificent landscape" (De Giorgi, 1882, I, pp. 175-178).

3. The Olive Tree From Admirable to Cultivable

Odeporic literature is fundamental in stimulating an awareness of the landscape of Terra d'Otranto to which the eye of the Salento inhabitants is habituated and unaccustomed, so much so that local scholars would have spoken of a real *debt of gratitude* to foreign travellers. That the Salento had the ideal characteristics for olive cultivation seemed clear to them, noting how this plant grew spontaneously in the most disparate places. One only has to look at the branches, "so heavy that they are supported by tufa pillars" (Placci, 1911, p. 255), to realise that it is precisely the oil extracted from the olive forests that drives the local economy. "Merchant of oil, merchant of gold!" (Columella Onorati, 1828, p. 214): *Green gold* was the fruit of divine abundance, a blessing bestowed by the local patron, a saint who "has gold imprinted in his name" (Da Palagiano, 1660, p. 5), Oronzo, depicted by the community as a heavenly farmer (Del Sole, 2021). After all, Oronzo is first and foremost an olive farmer, because it is oil that is his nectar of sanctity, the most precious product the area could offer. (Figure 2)

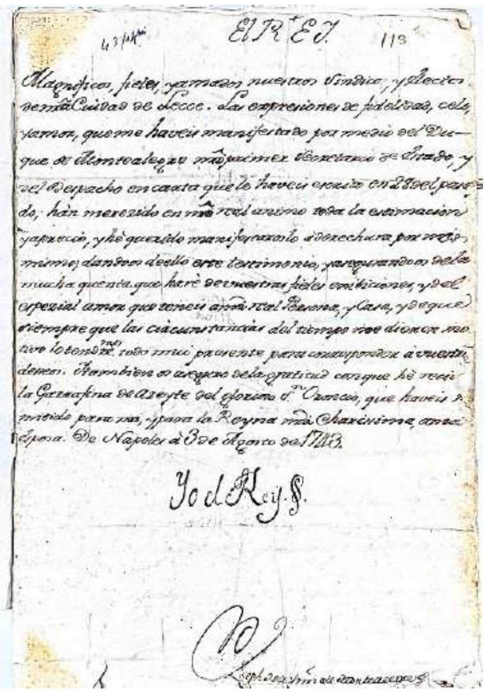


Figure 2. Letter from Charles III of Bourbon to the mayor of Lecce thanking him for the oil of Sant'Oronzo sent on the occasion of the pestiferous disease over the Kingdom (1743) - Source: Lecce State Archive - Scritture Università e Feudi, Atti diversi, Lecce, b. 17, 43/14

The absence of an iron discipline on good cultivation practices has over time reinforced erroneous customs that have only reduced the merits of the oil itself, which is mostly used industrially (wool, soap, lighting): the so-called *lampante oil*. In the last years of the 18th century, the circulation of new scientific achievements and the revival of old knowledge favoured the birth in Apulia of a school of thought oriented towards the study of rustic things. In order to spread good practices for the care of the olive tree among the peasant population (which was almost completely unschooled), authors such as Nicola Columella Onorati, Vincenzo Corrado, Giovan Battista Gagliardo, Giuseppe Maria Giovene, Giovanni Presta (and others) produced numerous studies on agricultural economics with a didactic slant, flanking them with initiatives of an associative and scholastic nature. The aim is to educate the farmer and to see in him a sort of *guardian of the landscape* (Pollice, Rinella, Epifani 2021), a professional who has a clear understanding of how to make the olive tree truly cultivable so that this plant is not only the emblem of a landscape to be protected, but also the heart of the Salento garden.

“Almost all our ancient olive groves are so thick, and without any order, that they look like woods, rather than plantations of fruit trees. Hence the result is that when they are laid out together, the product is not always happy” (Columella Onorati, 1828, pp. 193-194)

No longer olive woods, therefore, but olive groves, plantations of fruit trees. To achieve this goal, scholars dust off old cornerstones of the discipline, such as Piero Vettori's 1569 *Trattato delle lodi et della coltivazione de gli ulivi* (Treatise on the praise and cultivation of olive trees), widely quoted in its fundamental passages. Above all, Vettori dwells on explaining to the reader how to transform the olive tree from a wild tree into a fruit tree, mastering its potential, foreseeing its development, planning its reproduction: skills that, according to the author, have been handed down from the ancients and are specular to those of an architect about to construct a building. Just as the architect pays attention to the site, to the characteristics of the land on which to build, to the building materials, so the olive grower must take into account the field in which to plant the olive trees, understand whether "the country is cold or dry (...), whether it looks south or north" (Vettori, 1762, p. 83); not to mention the proportions, the right distances, the concordance between the compositional elements, architectural principles that an olive grower cannot do without in his work. Only with strict rules of rationalisation of space will it be possible to abandon *seminaria* (or *plantaria*) and use open spaces as *semenzajos* to grow small plants (*caelo libero*) (Vettori, 1762, p. 56). From Vettori to Gagliardi, all writers spend entire pages describing how to compose an efficient and productive olive grove. If Presta recommends arranging olive trees in several separate beds to experiment with various types of grafting, Gagliardo proposes precise and symmetrical arrangements that, according to the author, were first tested in the ancient Royal Gardens of Persia and allow light and wind to pass between the trees. Following such arrangements, for Columella Onorati, olive trees should take the shape of a glass in order to bear abundant fruit. (Figures 3-4)

Figure 3. Explanatory drawing on the creation of a semenzajo;

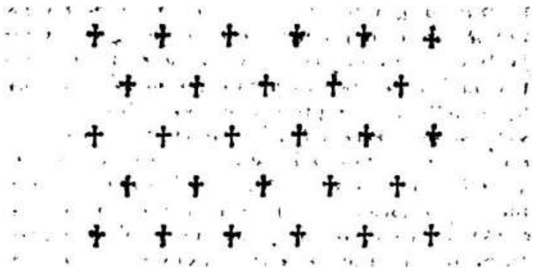


Figure 4. Explanatory drawing on how to plant olive trees in a field

In cultivating olive-grown fields architecturally, the farmer could therefore enjoy numerous advantages, as he would not only be taking care of a plantation of fruit trees, but also a true garden to be contemplated in its beauty. The authors do not fail to emphasise how the olive tree is the "best of all trees" not only for the fruit it produces, but for the gracefulness that "is therefore called *speciosa*, that is, that has a playful aspect (...), it delights marvellously" (Vettori, 1762, p. 43) so much so that it is capable of adorning a farm without the addition of other trees. The writings of these illuminists, even if they did not succeed in imprinting that 'new course' desired for the Naples Kingdom's agrarian economy, do however have the merit of outlining a true *architecture of landscape perception*. The land is no longer described, as in the accounts of foreign travellers, as a hybrid of garden and landscape, but aspires to take the form of a *worked landscape* (or *diffuse garden*) tending towards greater productivity and, at the same time, better care of the wooded space.

4. Olive Baroque

Writings on agriculture between the 18th and 19th centuries never forget to remind us that the olive grower, as well as going about his profession according to architectural principles, must also be a good philosopher in order to connect intimately with the complex soul of the land.

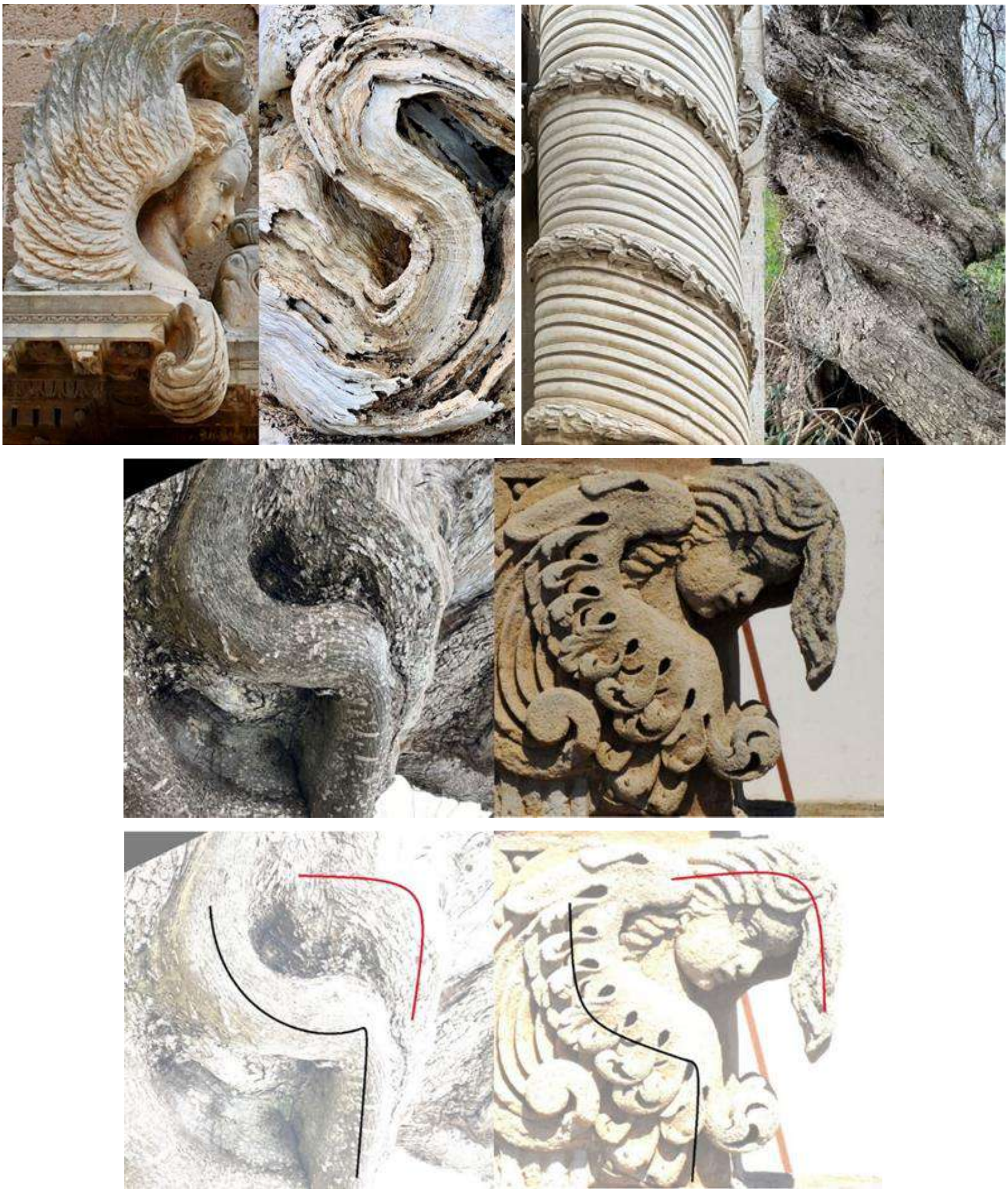
According to Giovanni Presta, “agriculture and philosophy are consanguineous with each other” (Presta, 1794, p. 1) and the olive tree itself, according to Giuseppe Tavanti, “shines with its pure light the face of philosophy, and of knowledge” (Tavanti, 1819, I, p. 42). If ancient myths already indissolubly linked the Apulian landscape to this tree (as confirmed by the story of Apulus, narrated by Ovid in his Metamorphoses), in order to fully understand the ancestral significance of the olive tree for the land of Salento, it is necessary to change the point of view from which we look at the landscape.

“To our gaze is presented a spectacle at once horrid and picturesque, wild and majestic, varied and monotonous; and dominating our soul with the law of contrasts, it drags it from the real to the realm of fantasy” (De Giorgi, 1882, I, pp. 319-320).

It is too easy to settle for an overall view, staring at that generic distant horizon that transpires from travellers' tales. If one looks closely, poetically, at the vegetation “grown without a drop of water”, one can realise that the immense sky so extolled in the pages of foreign travellers is nothing more than an architectural void of the heart, a lid that makes the horizon heavy and crushes the verticality of the elements that make up the landscape. This suffocation causes the natural baroque (Bodini, 2020, p. 74) of those olive trees which, for Vittorio Bodini, “seem to crawl on the ground like snails” (Bodini, 2020, p. 108). The idea of Baroque, according to Deleuze’s metaphysical analysis, cannot exist without the intersection of two elements: the folds of matter and the folds of the soul. For the philosopher, it is the veins of marble that best represent the folds that envelop living beings (Deleuze, 2004). If, following in the footsteps of some Salento poets, we were to juxtapose the inclinations of the Salento soul with the folds of matter, we could say that in this peripheral land, where marble arrived with difficulty, the folds to which Baroque architects looked are undoubtedly those of the olive tree. This tree has for Vittorio Bodini “the human heart”. It is a friend to whom one can entrust one’s most hidden secrets (“Love was a letter found/in the trunk of an olive tree”). In it “groans a fatigue of existence that has no equal” (Valli, 1999, p. 215), like that of the entire population of Salento that dreams of “detaching itself from the roots that tie it to the ground” (D’Annunzio, 1966, p. 31). For these reasons, on several occasions the poet himself comes to identify with the tree (“I become an olive tree and the wheel of a slow wagon”) (Bodini, 2020, p. 75). This profound sense of the Salento soul’s alberità, combined with anger at a sky that generates daily blood-red dramas (the sunsets), is at the heart of the scattering of the landscape reflected in the consciousness of the community, still anchored “in the bowels of the seventeenth century” (Bodini, 2020, p. 75) in a perpetual baroque season. (Figures 5)

Figures 5. Folds of olive trees

To search for this one great syntax that binds the landscape to the soul of its inhabitants, we need only use the method that Deleuze calls architecture of vision. If we carefully admire the grammar of “that absurd miracle of Lecce Baroque” that permeates the territory (Bodini, 2020, p. 74), we see references to “a breath of ancient sentiment of form that has never been extinguished” (Gregorovius, 1998, p. 357) and that indissolubly binds the twisted olive tree, “in an attitude of pain” (D’Annunzio, 1966, p. 31), to the soul of every inhabitant of Salento made up of “surly grumpiness”(Bodini, 2020, p. 108). (Figures 6)



Figures 6. Comparison of some elements of Lecce Baroque grammar with the natural forms of the olive tree

5. Conclusions

We should look at the Salento landscape from the sea. In this way, one would be prepared to grasp the essence of an area that has made olive-grown fields not only its green carpet, but a veritable glue with the liquid plain of the Mediterranean. At the same time, the olive tree (with its genesis, history and botanical characteristics) is the perfect reflection of the stubbornness of the people of Salento, who over the centuries have turned their folds into potential. The xylella bacterium has not hit a simple fruit tree that can be replaced at any time; it has literally taken the earth from under the feet of an entire community that, in order not to have its roots torn out, irrationally defends its dying trees, inaugurating a season of denied landscape, of non-landscape. Only by understanding the landscape and cultural value of the olive tree can one fully understand the stance taken by some inhabitants of Salento not to cut down infected trees, not to be reduced to economic motivations alone. One is faced with a profound act of beauty, the act of taking care of one's own territory, a primordial sentiment that does not aim at healing, but at the dignified acceptance of suffering in the hope that the disease may one day become a disease of change. One relies on the teachings of Giovanni Presta, who writes that, plague after plague, the olive tree seems to weaken and wither but always manages to find a way to green up in the end.

“If this same trunk of his in various parts is pitted, cavernous, split: if from the pith to almost the last outer layers it is empty, and naked, and deprived even of bark; yet it does not perish, but from the extreme upper edge, if a thread of green remains, from there it vegetates again, it dresses, it tends to the best of its ability, and produces (...) and sees the children, the grandchildren, the posterity of he who believed it so many years ago already imminent to perish” (Presta, 1794, p. 23).

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Conflict of Interests

The Author(s) declare(s) that there is no conflict of interest.

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Green Space Intervention Proposal in Climate Sensitive Landscape Design

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Abstract

The roles and responsibilities of plants in urban areas extend far beyond their aesthetic values, making them an indispensable part of designing successful and comfortable spaces. When climate change, one of the current global issues, is considered, establishing a consistent plant-climate relationship in urban areas can significantly contribute to creating a sustainable environment and combating climate change. This study aims to produce a model that defines the stages of plant species selection and plant placement principles to develop climate-sensitive landscape design projects. The proposed model is applied to the landscape design of an urban park in the Sancaktepe district of Istanbul. Initially, it organizes data under three categories; spatial analysis data, climate data, and landscape character data. These data—including topography, existing structures, green areas, roads and boundaries, temperature, precipitation, wind, sunlight, soil classification, geology, hydrology, and vegetation—are evaluated as components to produce an urban climate map for Sancaktepe. After creating the map, limiting factors for plant selection are identified. Plant hardiness zones, heat tolerance zones, origins of the plants, and ecological requirements are assessed. For predictive climate analysis, climate change simulation outputs for Istanbul are considered to address the projected impacts of climate change in the near future. As a final step, design principles for plant species selection and placement are developed for the urban park.

Keywords: Planting design, climate sensitive design, micro-climate parameters, plant selection principle, plant placement principle, GIS analysis

2. Introduction

Climate is recognized as a fundamental constraint in urban design and development planning. Planting design, in this context, represents a systematic process that must be initiated at the earliest stages of the design phase. This process demands the integration of objective and subjective data through a logical and sequential framework that enriches and harmonizes the design outcomes (Seçkin et al., 2011). In a well-executed landscape design, the health of all living organisms is preserved and improved, creating a vibrant living environment. Furthermore, effective and sustainable landscape design must address large-scale environmental challenges with implications at regional, national, and global levels (Melby & Cathcart, 2002). Consequently, integrating climate sensitivity into plant planning in landscape design projects offers a critical opportunity to mitigate climate-related issues that urban areas are anticipated to encounter in the coming years. The primary motivation of this study is to investigate the planning process by exploring the intricate relationship between plants, climate, and the urban environment.

3. Material and Method

The material for this study involves the evaluation of plant selection within the climate-sensitive vegetative design process of an urban park located in the Sancaktepe district of Istanbul. The methodology follows a systematic approach to analyze the specific climatic and spatial characteristics of the study area, guiding the selection of plants and the design process. Data for this study were sourced from the Istanbul Metropolitan Municipality and the Sancaktepe Municipality, while climate-related data, provided by the General Directorate of Meteorology, were accessed through the Istanbul Metropolitan Municipality. All data were categorized and analyzed using QGIS software to uncover the distinctive characteristics of the design area.

The methodology for the proposed model, designed as a framework for green space intervention in climate-sensitive landscape projects, is presented in **five stages** as illustrated in Figure 1.

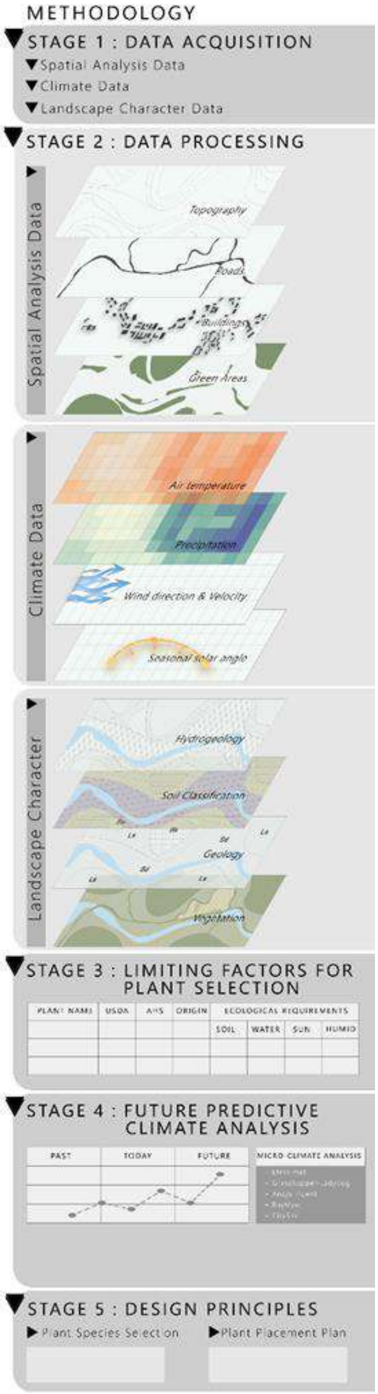


Figure 1. Green Space Intervention Proposal Model in Climate Sensitive Landscape Design

1. Data acquisition

In the initial stage, the necessary data for the study were collected, focusing on climate, spatial, and landscape characteristics. The climatic data considered include temperature, precipitation, wind, and sunlight. Spatial data encompass urban topography, existing structures, green areas, roads, soil, geology, and vegetation. These data were then categorized into three main groups: spatial analysis data, climate data, and landscape character data.

2. Data processing

The collected data were processed and organized into spatial and climatic layers using QGIS software. The model evaluates temperature limits, seasonal solar angles, wind direction and intensity, precipitation patterns, and humidity levels for the study area. These variables, critical to understanding the climatic characteristics of Sancaktepe, provide a foundation for the urban climate map. This map integrates various layers, including topography, existing green infrastructure, socio-cultural landscape features, and urban boundaries. The urban climate map allows for the development of region-specific strategies for urban planning and landscape design while addressing urban challenges on multiple scales.

3. Limiting factors for plant selection

Plant selection was guided by specific limiting factors, including plant hardiness zones, heat tolerance zones, ecological demands (light, water, soil), and the relationship between plant species and urban structures. A comprehensive plant list was created, detailing the origin, hardiness zones, ecological requirements, and adaptability of each species. This stage ensures that the selected plant species are sustainable under the current and predicted climatic conditions of the district.

4. Future predictive climate analysis

Predictive micro-climate analysis was performed to anticipate the potential impacts of climate change. This stage involved the use of climate projection models and micro-climate simulation tools, such as ENVI-met, Grasshopper-Ladybug, RayMan, CitySim, and Ansys Fluent.

For this study, QGIS was utilized to generate spatial maps and analyze climate parameters for the project area. Additionally, climate projections for Istanbul, derived from scientific data, were incorporated to address future challenges. This step enables the development of forward-looking strategies for mitigating climate change impacts.

5. Design principles

The final stage integrates the findings from all previous stages to develop a set of design principles. These principles aim to provide concrete, science-based guidelines for climate-sensitive urban planning and landscape design. The proposed model emphasizes conscious decision-making in urban green infrastructure, ecosystem preservation, and the restoration of degraded areas. This methodology, presented as a "green space intervention proposal" supports efforts to adapt urban environments to the impacts of climate change while promoting sustainable development practices.

4. Findings and Discussion

Based on the spatial data of the Sancaktepe district, several critical observations can be highlighted. The district serves as the basin for the Ömerli Dam, one of Istanbul's vital water resources, and encompasses Paşaköy, where agricultural activities are still actively practiced. Additionally, a portion of Aydos Mountain—the highest point in Istanbul at an elevation of 538 meters—falls within the district’s boundaries. Within Sancaktepe, the highest point reaches an elevation of 380 meters, while the lowest point is 70 meters above sea level.

The project area for the landscape design is a 6,000 m² urban park located in the Abdurrahmangazi neighborhood of Sancaktepe. Adjacent to a rehabilitated stream, the park is strategically positioned along the city's bicycle route, enhancing its accessibility and recreational value. The site is characterized by a southeast-facing aspect (Figure 2), resulting in abundant sunlight during the morning and early afternoon hours. This orientation makes it highly suitable for incorporating sun-loving plant species into the design. Furthermore, the southeast-facing aspect minimizes excessive heating during the afternoon, creating a more temperate microclimate. This characteristic reduces water evaporation rates in the summer months, thereby lowering the risk of water stress for plants. Such conditions suggest the viability of selecting plant species with moderate drought tolerance for this area. However, it is imperative that the selection process be informed by a comprehensive evaluation of intersecting factors, including hydrology, soil characteristics, and climatic conditions. This integrative approach ensures that the chosen plant species are not only compatible with the site's environmental parameters but also contribute to the long-term sustainability and functionality of the park.

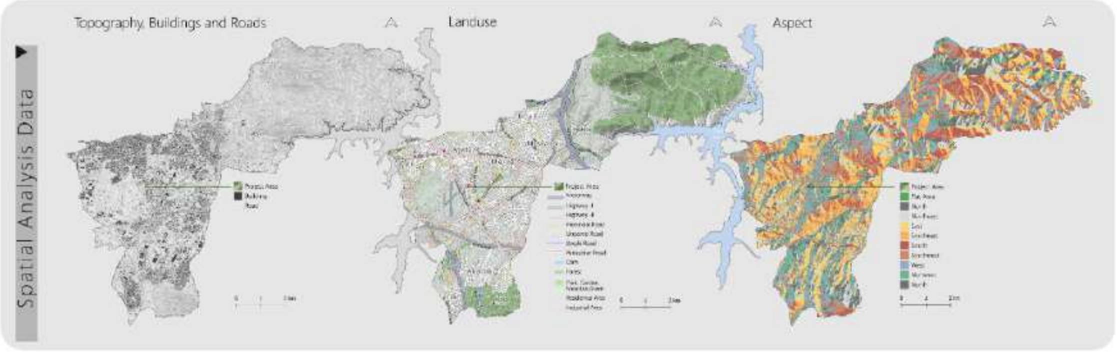


Figure 2. Spatial Analysis of Sancaktepe District.

The climatic data for the district were derived from measurements between 2011 and 2020 that are recorded at the Samandıra meteorological station, the nearest station to the project site (Figure 3). Temperature and precipitation data were analyzed in conjunction with elevation, utilizing the Lapse Rate formula (Barry & Chorley, 2003), which estimates a decrease in temperature of 1°C for every 200 meters of elevation, and the Schreiber formula, which predicts an increase in precipitation of 54 mm for every 200 meters of elevation (Demircan et al., 2014). According to these calculations, the highest temperature, observed in July, is 34.19°C, while the lowest temperature, observed in January, is -5.56°C. The annual average precipitation is 177.68 mm, and the average wind speed is 3.3 km/h. The prevailing wind direction is from the north-northeast (Table 1).

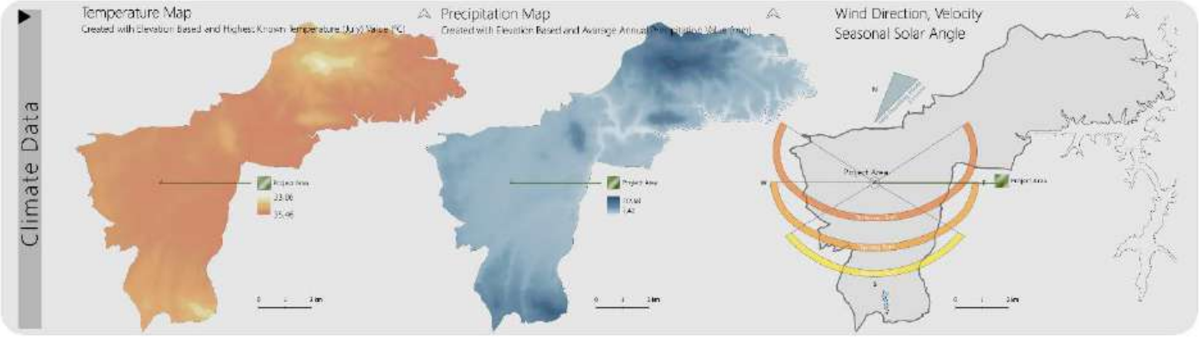


Figure 3. Climatic Analysis of Sancaktepe District.

Table 1. The hottest and coldest monthly temperatures, prevailing wind direction, and wind speed of Samandıra and Paşaköy Meteorological Stations for the period 2011-2020

Station Name	Latitude	Longitude	July	January	Prevailing Wind Direction
Samandira	40.986.581	29.213.521	34,19	-5,56	North-Northeast (NNE) 3.3 km/sa
Pasakoy	41.008.611	29.282.222	35,68	-5,55	

Based on the landscape character classification of the district, the project site has the following characteristics: According to the hydrology map, it is described as a semi-permeable granular medium. The soil is classified as alluvial, which indicates low water infiltration capacity and rate but high water retention and storage capacity. The soil depth is less than 20 cm, and it is characterized as saline-alkaline. The soil has a granular structure with rock-like properties, and this granular composition is interpreted to consist of gravel. In terms of soil classification, it is defined as high mountain meadow soil (Figure 4).

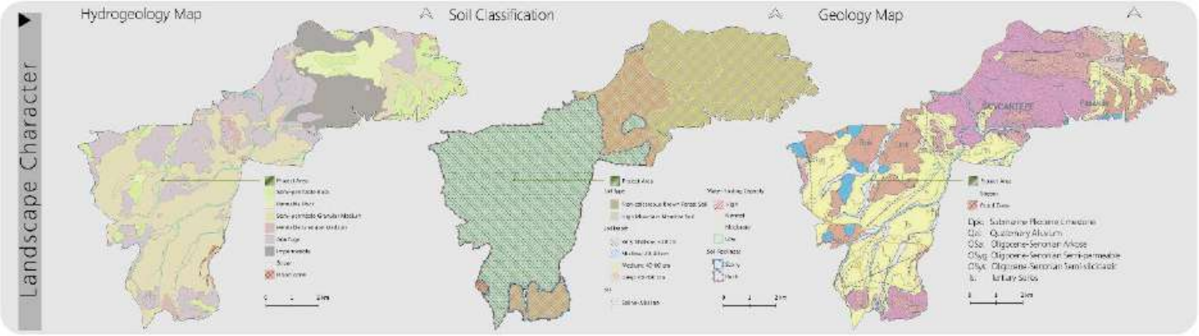


Figure 4. Landscape Character Analysis of the Sancaktepe District

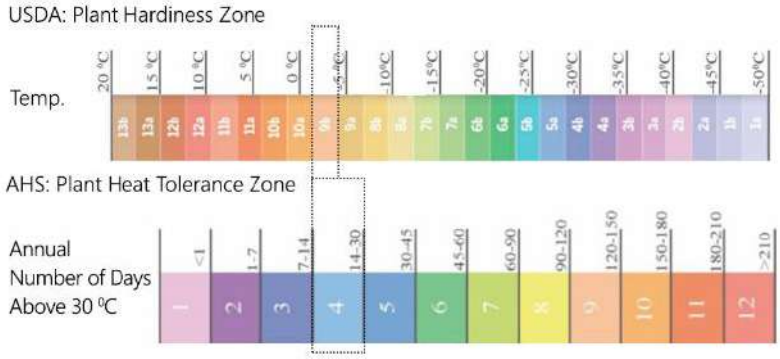
The semi-permeable granular structure of the area indicates limited water permeability, allowing plants to maintain access to surface water for longer periods. This characteristic promotes the lateral spread of roots near the soil surface but may hinder deep root penetration and restrict water movement to lower soil layers. The alluvial nature of the soil suggests it is nutrient-rich; however, the granular texture increases the likelihood of nutrient loss due to leaching. To counter this, incorporating organic matter can improve soil fertility and enhance its nutrient retention capacity.

With a soil depth of less than 20 cm, the site is more suitable for shallow-rooted plants, while deep-rooted species may face challenges in establishing themselves. Surface-covering plants can help protect the limited soil depth, reducing erosion and preserving soil integrity. The saline properties of the soil necessitate the selection of salt-tolerant and drought-resistant species for better adaptability to these conditions.

Alkaline soil with a pH range of 7–14 is conducive to plants that thrive in calcareous environments. However, high pH levels can impede the uptake of critical nutrients such as iron, zinc, and phosphorus. To address these limitations, the inclusion of species that enhance iron absorption or the use of fertilization strategies at specific intervals is recommended. Similarly, phosphorus supplements may be necessary to mitigate the challenges of nutrient uptake associated with high alkalinity.

In addition to these factors, plant hardiness zones and heat tolerance zones are critical considerations in plant selection. These zones define the range of extreme temperature conditions that plants can endure. The plant hardiness zone indicates the lowest winter temperatures a plant can tolerate, while the heat tolerance zone reflects the number of days with temperatures exceeding 30°C. As shown in Table 2, Istanbul falls within the 9b plant hardiness zone and the 4 heat tolerance zone. This classification means that Istanbul experiences temperatures exceeding 30°C for 14 to 30 days annually, with temperature ranges between -3.9°C and -1.1°C. It is crucial to select plant species that can thrive within these extreme temperature ranges.

Table 2. Plant Hardiness Zone and Plant Heat Tolerance Zone for Istanbul



Climate change projections for Istanbul have been analyzed under different emission scenarios known as Representative Concentration Pathways (RCP). While RCP 2.6 represents the most optimistic scenario, RCP 8.5 provides projections for the most pessimistic case. According to these scenarios, Istanbul is expected to experience rising temperatures and decreasing precipitation throughout the 21st century. Simulations conducted by the ITU Eurasia Earth Sciences Institute, based on the RCP 8.5 scenario, utilized the EC-Earth model with a resolution of 3 km. Using reference years from 1986–2005, these simulations predict a temperature increase of 1.93°C between 2046–2065 and 3.71°C between 2081–2100. Additionally, precipitation is projected to decrease by 6.4% by 2081–2100, while the evapotranspiration rate is expected to rise by 10.9% (Table 3). These changes are associated with diminishing water resources and an increased risk of drought.

Table 3. Amount and Rate of Change in Temperature, Precipitation, and Evapotranspiration (İİDEP, 2021).

ISTANBUL	Amount or Rate of Change		
Parameters	1986-2005	2046-2065	2081-2100
Temperature	14,50 °C	1,93 °C	3,71 °C
Precipitation	593,5 mm	- % 5,8	-% 6,4
Evopotranspiration	346,5 mm	% 4,0	% 10,9

The Istanbul Climate Change Action Plan (2018) predicts an increase in the intensity and frequency of extreme heat events, such as heatwaves, during summer months under RCP 4.5, 6.0, and 8.5 scenarios (Figure 5). It is estimated that temperatures will exceed 40°C during these periods. By the end of the century, the daily maximum temperatures are projected to rise by an average of 1.5–4.8°C (Figure 6).

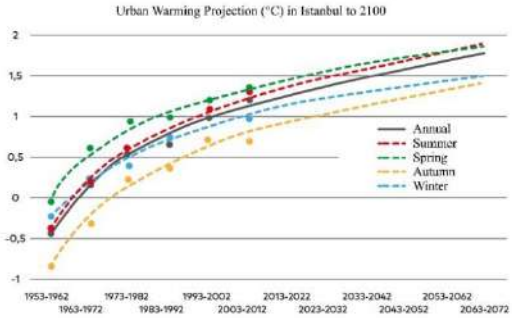


Figure 5. Urban Warming Projection (°C) For Istanbul By Seasons Until 2100 (İİDEP, 2018)

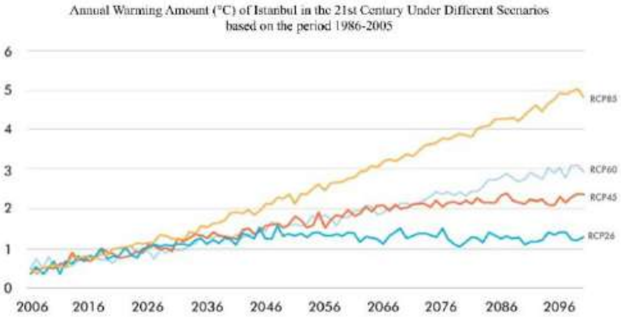


Figure 6. Annual Warming Amount (°C) of Istanbul in the 21st Century Under Different Scenarios based on the period 1986-2005 (İİDEP, 2018)

Under the RCP 8.5 scenario, total annual precipitation is expected to decrease by up to 12% (Figure 7). The reduction in the number of rainy days is anticipated in areas receiving 1 mm or less precipitation. Conversely, the number of days with heavier precipitation, ranging between 10 mm and 20 mm, is projected to increase. On such days, the total precipitation amount is expected to rise by up to 59%, with an average increase of approximately 13%. These fluctuations in precipitation patterns, combined with increased evaporation driven by rising temperatures, are expected to extend the dry season from 45 days to 57 days by the middle of the century. This shift indicates the potential for prolonged droughts and the early melting of snow in spring (İİDEP, 2021).

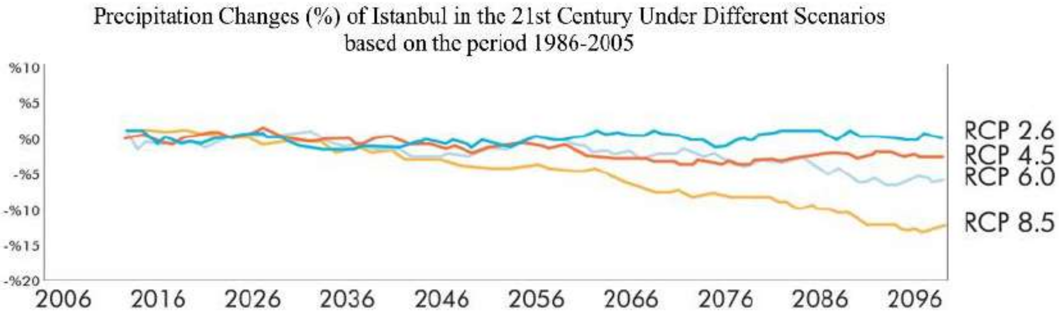
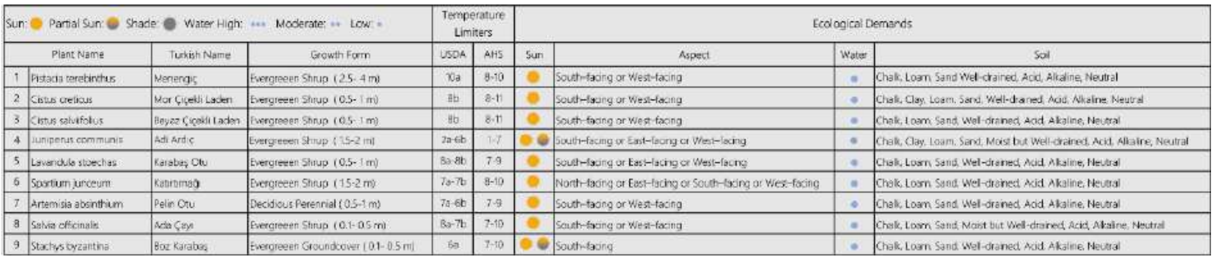


Figure 7. Precipitation Changes (%) of Istanbul in the 21st Century Under Different Scenarios based on the period 1986-2005 (İİDEP, 2018)

The plant list developed based on the analysis of the project area in terms of spatial, climate, and landscape character and Istanbul's climate change projections is presented in Table 4. The selection and placement of plants prioritize drought-resistant species whose ecological requirements align with the characteristics of the project site. These species were chosen to fit within the USDA and AHS zones corresponding to the region's minimum and maximum temperature ranges. Additionally, the selection aims to support biodiversity while reinforcing structural design decisions.

Table 4. Suggested Plant List for the Abdurrahmangazi Park in Sancaktepe / Istanbul



Sun: ● Partial Sun: ◐ Shade: ● Water High: ••• Moderate: •• Low: •				Temperature Limiters		Ecological Demands			
Plant Name		Turkish Name	Growth Form	USDA	AHS	Sun	Aspect	Water	Soil
1	Pistacia terebinthus	Menengiç	Evergreeen Shrup (2.5- 4 m)	10a	8-10	●	South-facing or West-facing	•	Chalk, Loam, Sand Well-drained, Acid, Alkaline, Neutral
2	Cistus creticus	Mor Çiçekli Laden	Evergreeen Shrup (0.5- 1 m)	8b	8-11	●	South-facing or West-facing	•	Chalk, Clay, Loam, Sand, Well-drained, Acid, Alkaline, Neutral
3	Cistus salvifolius	Beyaz Çiçekli Laden	Evergreeen Shrup (0.5- 1 m)	8b	8-11	●	South-facing or West-facing	•	Chalk, Loam, Sand, Well-drained, Acid, Alkaline, Neutral
4	Juniperus communis	Adi Ardıç	Evergreeen Shrup (1.5-2 m)	2a-6b	1-7	● ◐	South-facing or East-facing or West-facing	•	Chalk, Clay, Loam, Sand, Moist but Well-drained, Acid, Alkaline, Neutral
5	Lavandula stoechas	Karabaş Otu	Evergreeen Shrup (0.5- 1 m)	8a-8b	7-9	●	South-facing or East-facing or West-facing	•	Chalk, Loam, Sand, Well-drained, Acid, Alkaline, Neutral
6	Spartium junceum	Katırtırnağı	Evergreeen Shrup (1.5-2 m)	7a-7b	8-10	●	North-facing or East-facing or South-facing or West-facing	•	Chalk, Loam, Sand, Well-drained, Acid, Alkaline, Neutral
7	Artemisia absinthium	Pelin Otu	Decidious Perennial (0.5-1 m)	7a-6b	7-9	●	South-facing or West-facing	•	Chalk, Loam, Sand, Well-drained, Acid, Alkaline, Neutral
8	Salvia officinalis	Ada Çayı	Evergreeen Shrup (0.1- 0.5 m)	8a-7b	7-10	●	South-facing or West-facing	•	Chalk, Loam, Sand, Moist but Well-drained, Acid, Alkaline, Neutral
9	Stachys byzantina	Boz Karabaş	Evergreeen Groundcover (0.1- 0.5 m)	6a	7-10	● ◐	South-facing	•	Chalk, Loam, Sand, Well-drained, Acid, Alkaline, Neutral

As a result, the planting design decisions made for Sancaktepe Abdurrahmangazi Park are as follows:

- A total of 214 mature and healthy trees within the project area were preserved.
- It is widely recognized that the coexistence of different age groups within the same tree species significantly increases the risk of disease transmission among individuals. Therefore, Pistacia terebinthus, a species previously absent from the area, has been recommended to mitigate this risk.This species was selected for its ecological compatibility, tolerance to the region's temperature limits, and adaptability to local conditions.
- To enhance biodiversity, perennials and shrubs with low water requirements, strong adaptability, and minimal maintenance needs were chosen for their compatibility with the region's climate and soil structure. These plants were strategically placed in clusters at specific points (Figure 8).

Figure 8. Designed Project for Sancaktepe Abdurrahmangazi Park

5. Conclusion

This study developed a methodology for addressing the design of Abdurrahmangazi Park in Sancaktepe District through a climate-sensitive landscape design model. The study proposes a planning process that incorporates climate, spatial, and landscape character analyses to address both current and projected impacts of climate change. Utilizing geographic information systems (GIS) tools such as QGIS, a site-specific climate map was created to provide an objective foundation for the design process. Environmental factors, including plant hardiness zones, heat tolerance zones, soil composition, geology, hydrology, topography, and aspect, were evaluated as critical determinants in species selection.

The study also highlights the importance of selecting plant species capable of adapting to local climate conditions to overcome environmental challenges such as drought and salinity, as identified through future climate change simulations. Furthermore, the study emphasizes the feasibility of adaptive and sustainable design approaches in the context of climate change impacts.

This approach not only aims to create a sustainable urban landscape but also seeks to optimize microclimate parameters and enhance ecosystem services. The climate-sensitive landscape design model offers an innovative example that is both environmentally and urban-contextually applicable.

Note

This article is derived from the poster presentation titled *"Green Space Intervention Proposal for Climate-Sensitive Landscape Design"* presented at IFLA 2024. The original poster can be found in Figure 9.

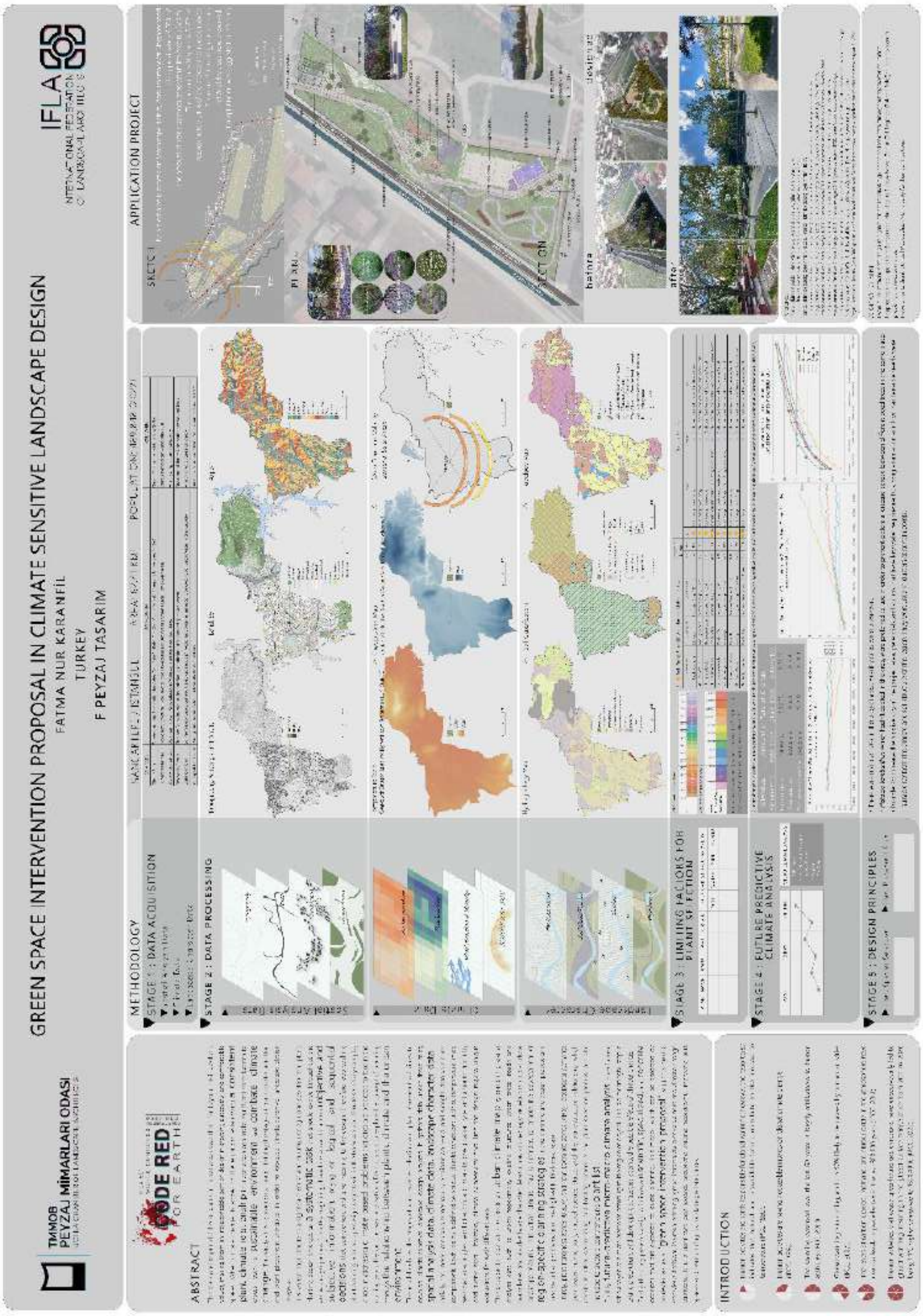

GREEN SPACE INTERVENTION PROPOSAL IN CLIMATE SENSITIVE LANDSCAPE DESIGN
FATMA NUR KARANFIL
TURKEY
F PEYZAJ TASARIM

Figure 9. Poster Presentation for IFLA 2024

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Landscape Design for Earthquake Resistant Cities: Bakırköy Example

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Abstract

The swift urbanization process in Türkiye has led to the metamorphosis of unplanned urban areas into zones of urban decay. The concomitant rapid urbanization has resulted in the degradation of urban open and green spaces. The inadequacy of recognizing the pivotal role of open-green spaces and urban infrastructure in poorly developed urban areas has emerged as an apprising issue. The seismic event of February 6th, centered on Kahramanmaraş, served as a stark reminder of the criticality of urban open and green spaces, shedding light on their qualitative and quantitative deficiencies. In response to these observations, two central inquiries have crystallized, constituting the foundational framework of this inquiry: Are we undertaking sufficient planning to alleviate the deleterious impacts of post-disaster scenarios? How can we seamlessly integrate open and green spaces into the urban landscape, considering their functionality and importance during disasters, and to what extent are current designs efficacious in augmenting disaster resilience? This study addresses these queries and discerns the functions urban open and green spaces in the earthquake-prone Istanbul-Bakırköy district would shoulder during and after a seismic event. Additionally, the research strives to delineate urban open and green spaces available for the populace post-disaster and assess their adequacy concerning gathering, evacuation, and temporary shelter functions, employing a comprehensive approach encompassing literature review, observation, and analytical methodologies.

Keywords: Disaster, disaster management, earthquake resistant, resilient city.

1. Introduction

In Türkiye, within the scope of disaster management in urban areas, it is observed that the existing reserves of urban open and green spaces are insufficient to serve as gathering and temporary shelter areas during and after disasters. The immense number of human losses and significant damages caused by disasters in cities are attributed not only to faulty urbanization, the vulnerability of buildings to disasters, and inadequate infrastructure but also to the lack of safe urban open and green spaces where individuals can seek refuge from the effects of the disaster or secondary hazards that may arise (Balta, 2013).

The design of park landscapes significantly contributes to urban resilience against earthquakes by incorporating features such as open spaces, modular and adaptable layouts, shaded areas, access to water, and essential infrastructure like sanitation facilities. These spaces not only support emergency response efforts but also serve as temporary shelters and community gathering points during and after seismic events (Balta, 2013; Jayakody et al., 2018; Park & Jang, 2018; Başkaya, 2018; TMMOB PMO, 2023; Şahin et al, 2024).

Türkiye is known as one of the most seismically active regions all over the world due to its special tectonic setting, characterized by the interaction of Eurasian, African, and Arabian tectonic plates. Because of this complex geological environment, shifts in plates leads to significant tectonic stress and frequent seismic activity, making Türkiye particularly vulnerable to earthquakes (Fotiou, 2023; Raykova, 2024). Earthquakes caused by compression, tension, or bending in the Earth's crust have historically resulted in significant loss of life and property in

Türkiye, turning into major events over time. To exemplify, including the devastating 1999 İzmit earthquake, which had a magnitude of 7.4 (Kalafat et al., 2021; Türker & Bayrak, 2016) and the recent earthquakes in February 2023, which registered magnitudes of 7.8 and 7.5 (Fotiou, 2023; Mavroulis, 2023; Tan & Eyidoğan, 2019) resulted in substantial loss of life and property.

Given Türkiye's tectonic position and the societal memory of recent devastating earthquakes, it is evident that future seismic events are inevitable. The 2023 Kahramanmaraş Earthquake highlighted the nation's inadequate preparedness for a potential earthquake. In this context, it is predicted that the North Anatolian Fault Line, which passes directly under the Sea of Marmara, will cause great destruction in Istanbul that has a population exceeding 15 million. In addition to that, the historical pattern of seismic activity in Istanbul suggests a recurrence interval for significant earthquakes approximately every 100 to 500 years, with the potential for future events to reach magnitudes between 7.1 and 7.4 (Kalaycioglu et al., 2022; Kundak, 2017). Also, research indicates that there is a 62% probability (±15%) of a major earthquake with a magnitude of 7 or greater occurring in the vicinity of Istanbul before 2030. (Tekeli-Yeşil et al., 2011; Murru et al., 2016; Vries, 2023).

Among Istanbul's districts, Bakırköy is notable for its seismic vulnerability, with its proximity to the Sea of Marmara and specific soil conditions amplifying potential earthquake impacts. Bakırköy is situated in the Istanbul province on the European side of the city. It is located on the northeastern coasts of the Marmara Sea on the Çatalca Peninsula, which is the western part of Istanbul. The district shares borders with Zeytinburnu to the east, Güngören to the northeast, Bahçelievler to the north, Küçükçekmece to the west, and the Marmara Sea to the south. Bakırköy is made up of 15 neighborhoods and has a total area of 29 km² (Karabacak, 2019). 229,239 people are living in the district, according to TÜİK (2019) data (Karabacak, 2019). Because the region is in a first-degree seismic zone and is expected to sustain more damage than other districts in the case of an earthquake and related tsunami, it was chosen as the study site. Furthermore, Bakırköy, one of Istanbul's oldest districts, has a comparatively older building stock than other districts, which makes it even more seismically vulnerable (İBB, 2020).

2. Material and Method

The study utilized official data on the seismic conditions of the building stock, ground characteristics, transportation network, accessibility, usability, ownership status, dimensions, and the presence of public open and green spaces. The data was gathered from a number of reliable sources, such as the Istanbul Metropolitan Municipality's Bakırköy Possible Earthquake Loss Estimation Report, the Bakırköy Municipality Parks and Gardens General Directorate, the Department of Earthquake and Ground Investigation, the Kandilli Observatory and Earthquake Research Institute, and the Istanbul Metropolitan Municipality's Earthquake Risk Management and Urban Improvement Department. These extensive datasets offered a strong basis for catastrophe risk reduction planning and vulnerability assessment of the district.

The method of the study is to superimpose the obtained data on the ArcGIS program and determine the risk score in line with the opinions received from experts. In line with the information obtained, it is aimed to reveal the earthquake-related impact scenario of urban open and green areas. The study is currently ongoing and the selected district is still being studied in detail.

3. Findings and Discussion

The study employed a comprehensive seven-step process to assess the seismic risks and their impact on urban open and green spaces of Bakırköy. The first step is the analysis of natural and seismic data of Istanbul, Bakırköy district. The data's, which is taken from Istanbul Metropolitan Municipality (IBB) and the Kandilli Observatory, on soil characteristics, fault proximity, and seismic activity were collected from official reports.

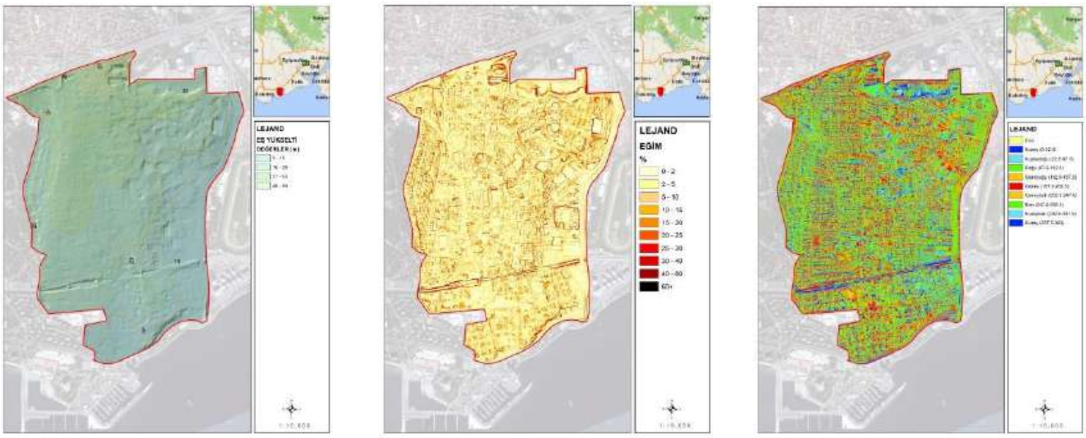


Figure 1. Examination of the natural data (IBB, Şehir Planlama Müdürlüğü, 2022)

The second step is the classification of building stock especially in the Bakırköy district. The classification process completed based on buildings height such as buildings with 1-4 floors, buildings with 5-8 floors, and buildings with 9-19 floors, construction type such as wooden buildings, reinforced concrete buildings, steel buildings, tunnel form buildings, prefabricated buildings, masonry buildings, and age to evaluate their seismic vulnerability.

Figure 2. Classification of the existing building stock (IBB,Deprem Zemin Müdürlüğü, 2020)

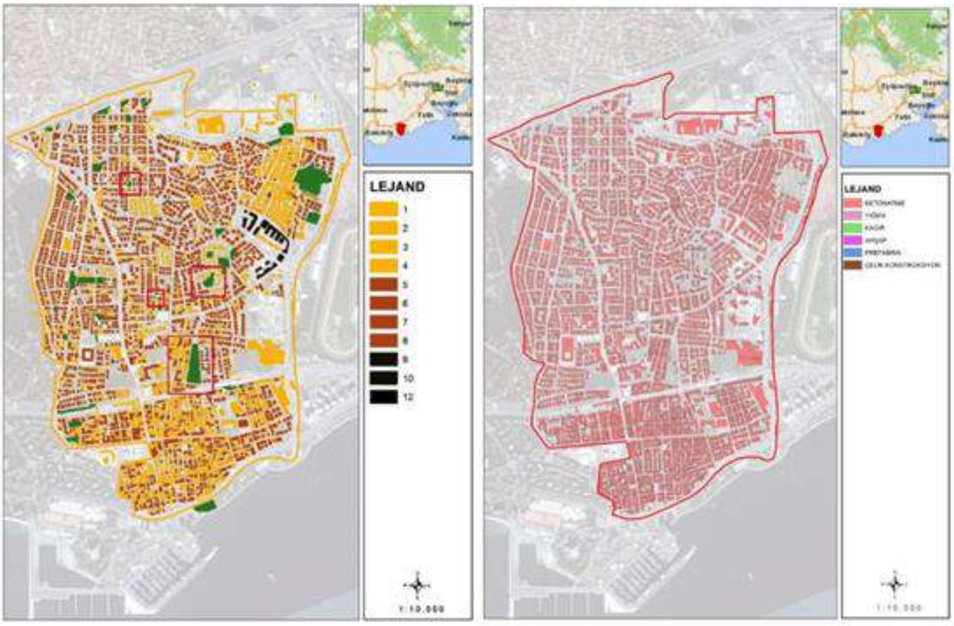
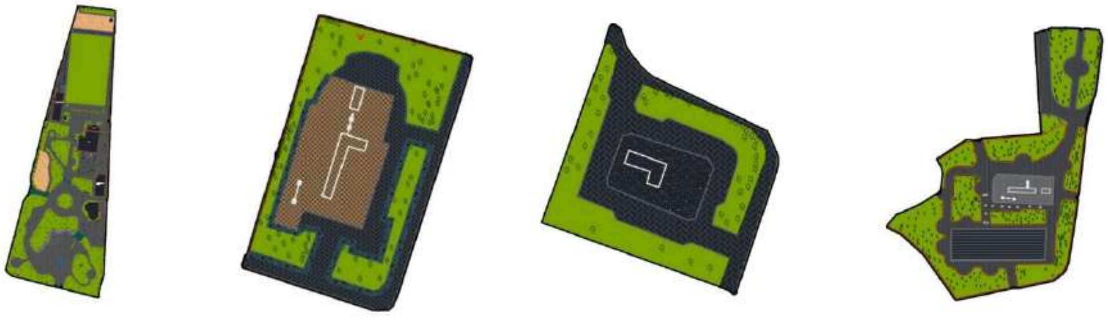


Figure 3. Classification of the existing building stock (IBB,Şehir Planlama Müdürlüğü, 2022)

The third process is related to the identification of urban open and green spaces. In this step, the district's open and green spaces, including 64 assembly areas and four designated earthquake parks, were mapped and evaluated. The selection process for parks considered variations in size and differences in infrastructure to ensure a comprehensive analysis and it has been investigated whether the parks would be sufficient or not in the sudden event of an earthquake.

Table 1. Identification of open and green spaces according to infrastructure conditions

NO	DISTRICT	NEIGHBORHOOD	NAME	TYPE	SIZE	INFRASTRUCTURE CONDITIONS									
						Signs	Electricity	Water	Toilet	Generator	Camera	Earthquake Containers	Accessibility	Helicopter Pad	Phone/Internet
1	BAKIRKÖY	KARTALTEPE NEIGHBORHOOD	MİLLET GEZİ PARKI	PARK	14165 m2	🟩	🟩	🟩	🟩	🟥	🟥	🟩	🟩	🟥	🟩
2	BAKIRKÖY		BAŞARI SOKAK PARKI	PARK	680 m2	🟩	🟩	🟥	🟥	🟥	🟥	🟥	🟩	🟥	🟥
3	BAKIRKÖY		PANCARLI SOKAK PARKI	PARK	135 m2	🟥	🟩	🟥	🟥	🟥	🟥	🟥	🟩	🟥	🟥
4	BAKIRKÖY		ABDULLAH CÖMERT PARK	PARK	3019 m2	🟩	🟩	🟩	🟥	🟥	🟥	🟥	🟩	🟥	🟥



Millet Gezi Park Başarı Street Park Pancarlı Street Park Abdullah Cömert Park

Figure 4. Identification of open and green spaces as a gathering area

The next step is the risk assessment of buildings with expert opinions and IBB's seismic studies to score buildings based on vulnerability parameters. In connection with the previous step, the debris volume estimation that refers to the assessment and management of debris generated during construction and demolition activities. The debris likely to result from building collapses was calculated using formulas that consider building volume and material density.

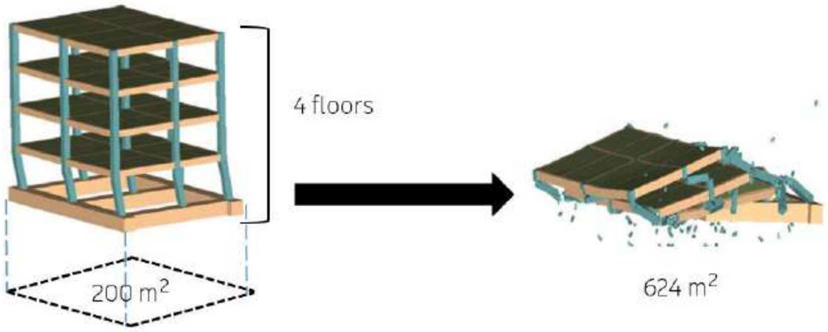


Figure 5. Identification of risky buildings and the allocation of a damage radius based on the anticipated collapse.

The following step is, assessment of damage to urban open and green areas that is correlated with the impact of debris on green spaces. To exemplify, depending on the collapse direction, a building may cause a loss of 80 to 93 m² of green space, or it may have no impact at all.

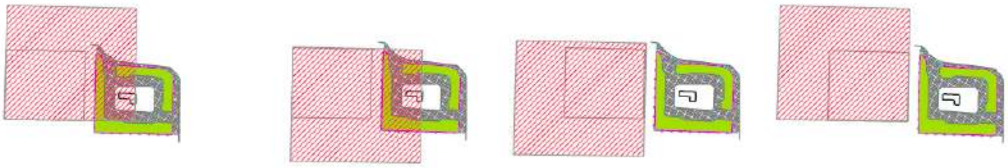


Figure 6. Loss of open space due to building collapse for Pancarlı Sokak Park

All these analysis processes reveals that a considerable portion of the buildings in Bakırköy are at high seismic risk. Particularly, older buildings and those constructed with less robust materials are more susceptible to collapse. The debris from these buildings could lead to the substantial loss of open and green spaces, further limiting emergency gathering areas.

4. Conclusion

In conclusion, this study underscores the pivotal role of landscape architecture in designing urban spaces that are resilient to seismic disasters, particularly within highly vulnerable districts like Bakırköy. By employing a comprehensive multi-step methodology, this research highlights the critical need for integrated planning that prioritizes the dual functionality of urban open and green spaces as both community amenities and vital components of disaster management strategies. Findings from Bakırköy illustrate the potential for significant damage to open spaces caused by building collapse and secondary disaster impacts, further emphasizing the necessity of resilient design.

In this context, landscape architecture plays a key role in designing disaster-resilient spaces. By planning urban open and green areas that serve multiple functions, such as emergency gathering, shelter, and resource distribution, the risk of earthquake can be minimalized. The designers and the designed spaces should be accessible, environmentally sustainable, and adaptable to different post-disaster needs. The integration of nature-based solutions with well-planned infrastructure facilitates the development of spaces that support recovery efforts and strengthen community resilience against natural disasters.

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SUSTAINING LIFE

Biodiversity and Sustainability in Cities: The Role of Landscape Architects

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Abstract

Urbanization is rapidly increasing worldwide, leading to a significant loss of biodiversity in urban environments. This decline adversely impacts human well-being and the sustainable management of urban ecosystems. Research demonstrates that the richness and abundance of fauna in cities largely depend on the spatial distribution of urban vegetation, including forests, woodlands, parks, and gardens. Thus, integrating strategic green infrastructure—such as urban parks, forests, green belts, and protected areas—into urban landscapes is essential for conserving biodiversity and enhancing urban ecosystem functionality.

Urban parks are vital components of cities, offering spaces for biodiversity conservation, social interaction, and physical activity. However, biodiversity considerations are often overlooked in park design. Floristic diversity, in particular, significantly enhances ecosystem resilience. Therefore, urban park designs should prioritize native plant species and floristic diversity to support biodiversity. This approach is crucial for achieving sustainable urban development.

Biodiversity plays a key role in sustainable cities by providing ecosystem services, including improved air and water quality, climate regulation, and disaster mitigation. Ecological planning, which emphasizes the efficient use of natural and cultural resources, is integral to sustainable urban planning. Landscape architects must lead in designing urban spaces that prioritize ecological and economic interrelations. This study underscores the importance of biodiversity in urban park design and advocates for incorporating ecological principles into urban planning to create sustainable, resilient cities.

Keywords: Biodiversity, sustainable cities, ecological planning

1. Introduction

The increasing pace of urbanization globally has created significant challenges for biodiversity conservation in urban environments. Urbanization transforms natural landscapes, leading to habitat fragmentation, degradation, and loss, which adversely impact species richness and ecosystem functionality (McKinney, 2008). Biodiversity loss in cities not only diminishes ecological resilience but also undermines the ecosystem services critical to human well-being, such as air purification, water regulation, and climate stabilization (Elmqvist et al., 2013). These issues underscore the urgent need for sustainable urban planning that integrates ecological principles and prioritizes biodiversity.

Urban parks play a pivotal role in addressing these challenges, as they serve as vital refuges for biodiversity while simultaneously providing spaces for social, cultural, and recreational activities (Chiesura, 2004). However, urban park designs often prioritize aesthetic and recreational functions over ecological considerations, neglecting the role of floristic diversity in enhancing ecosystem resilience. Floristic diversity, particularly the use of native plant species, is a cornerstone for sustaining urban biodiversity, as it supports faunal populations and improves the functionality of urban ecosystems (Niemelä, 1999). Research highlights the importance of diverse vegetation patches, including urban forests, green belts, and gardens, in promoting biodiversity within cities (Aronson et al., 2017).

Sustainable urban planning must adopt an integrative approach that incorporates green infrastructure to enhance biodiversity conservation. The incorporation of ecological planning principles is imperative to harmonize urban development with natural systems. By embedding biodiversity-focused strategies within urban park designs, cities can ensure resilience against environmental stressors while maintaining ecosystem services that support urban populations (Beatley, 2016). Landscape architects, as pivotal stakeholders in this process, are uniquely positioned to lead efforts in designing sustainable urban spaces that balance ecological, social, and economic dimensions.

2. Biodiversity and Urbanization: A Complex Relationship

Urbanization has profoundly altered the natural environment, creating fragmented and isolated habitats that significantly challenge biodiversity. The homogenization of urban landscapes often results in a reduction in native species richness, replaced by a few generalist and invasive species adapted to urban conditions (McKinney, 2006). This phenomenon, known as "biotic homogenization," reduces the ecological uniqueness of urban areas and their capacity to support diverse ecological functions (Olden et al., 2004). Furthermore, the loss of biodiversity compromises ecosystem services, such as carbon sequestration, soil stabilization, and water regulation, which are essential for urban sustainability (Seto et al., 2012).

Despite these challenges, urban areas also hold unique opportunities for biodiversity conservation. Research demonstrates that urban vegetation patches, such as parks, greenways, and urban forests, can function as critical habitats for flora and fauna, particularly when designed to mimic natural systems (Aronson et al., 2017). The strategic integration of green infrastructure into urban planning can significantly mitigate the negative impacts of urbanization on biodiversity (Beninde et al., 2015). These elements provide ecological corridors that enhance habitat connectivity, support species migration, and improve genetic exchange among populations (Müller et al., 2010).

3. The Role of Urban Parks in Biodiversity Conservation

Urban parks serve as multifunctional landscapes, providing recreational, social, and ecological benefits. However, their potential to conserve biodiversity is often underutilized. Studies show that the design and management of urban parks directly influence their capacity to support native species and maintain ecological resilience (Pauleit et al., 2005). For example, parks with diverse vegetation structures, including a mix of trees, shrubs, and groundcovers, are more effective in supporting bird and insect populations than parks dominated by monocultures (Goddard et al., 2010). The inclusion of native plant species is particularly critical, as they are better adapted to local climatic conditions and support a wider range of native fauna compared to exotic species (Tallamy, 2007).

Moreover, the size, shape, and connectivity of urban parks play crucial roles in biodiversity outcomes. Larger parks tend to support higher species richness due to their ability to host a variety of habitats (Soga et al., 2014). Additionally, connecting parks through greenways or ecological corridors can enhance species movement and mitigate the effects of habitat fragmentation (Naveh 2006). These strategies underscore the need for ecologically informed park designs that prioritize biodiversity alongside other urban functions.

4. Ecological Planning and Landscape Architecture: Toward Sustainable Cities

The integration of ecological principles into urban planning is essential for creating sustainable cities. Ecological planning emphasizes the preservation and enhancement of natural systems within urban areas, balancing development needs with ecological integrity (Steiner, 2008). This approach aligns with the broader goals of sustainability, which require the efficient use of natural and cultural resources while minimizing environmental impacts (Beatley, 2016).

Landscape architects play a critical role in operationalizing these principles, as they bridge the gap between ecological science and urban design. By incorporating biodiversity considerations into park designs, landscape architects can create spaces that are not only aesthetically pleasing but also ecologically functional. For instance, designing with native plants, creating habitat zones, and integrating water-sensitive urban design can significantly enhance the ecological performance of urban parks (Thompson & Sorvig, 2018).

Furthermore, public engagement and education are vital components of ecological planning. Urban parks can serve as platforms for raising awareness about biodiversity and sustainability among urban residents. Programs that involve communities in park management, such as citizen science initiatives, can foster a sense of stewardship and promote long-term conservation efforts (Krasny & Tidball, 2012).

5. Measuring Floristic Diversity in Urban Areas

Accurate measurement of floristic diversity is essential for understanding the structure, composition, and functionality of urban ecosystems. Effective management of floristic diversity requires precise methods to evaluate the richness, distribution, and density of plant species in urban areas (Faeth et al., 2011; Szlávecz et al., 2011; Doğan & Eroğlu 2024). This evaluation provides the necessary data for designing sustainable landscapes and planning green infrastructure. A range of methodologies has been developed for this purpose, combining traditional fieldwork with advanced technological tools (Morgenroth et al., 2016).

Field surveys

Field surveys are a cornerstone of biodiversity assessment, involving systematic observations and sampling of vegetation to determine species presence, abundance, and distribution. These surveys are particularly valuable for generating detailed vegetation maps and assessing localized biodiversity patterns (Stohlgren, 2008). The direct nature of this method allows for comprehensive data collection, which can then inform species conservation strategies and urban park designs (Wang et al., 2024). For example, vegetation surveys are often employed to identify species composition in areas undergoing urban development, ensuring that local flora is considered in planning processes.

Imaging and remote sensing

Imaging and remote sensing techniques offer a scalable solution for assessing vegetation diversity across large urban areas. Utilizing satellite imagery and aerial photography, these methods enable researchers to analyze vegetation cover, spatial distribution, and temporal changes in biodiversity (Wang et al., 2024). Remote sensing is particularly effective in detecting habitat loss, urban expansion, and the impact of climate change on urban ecosystems (Hedblom and Mörtbeg 2011). Advanced technologies, such as LiDAR and hyperspectral imaging, enhance the precision of these analyses, making them indispensable for monitoring urban biodiversity dynamics.

Biological indicator measurements

Biological indicators provide an indirect yet powerful approach to evaluating floristic diversity. Indicators such as the presence of specific species, functional groups, or community traits serve as proxies for broader ecological conditions (Bull et al., 2013). Quantitative tools like the Shannon-Wiener diversity index and Simpson's diversity index are widely used to measure species richness, evenness, and heterogeneity in urban ecosystems (Kohsaka et al., 2013). These metrics facilitate comparative analyses across different urban landscapes, highlighting areas of conservation priority and ecological value.

6. Conclusion

Urbanization has fundamentally reshaped natural landscapes, posing significant challenges to biodiversity conservation while offering opportunities for sustainable development. This review underscores the indispensable role of biodiversity in urban park design as a cornerstone for creating resilient and sustainable cities. Urban parks, when designed with ecological principles, serve as multifunctional spaces that integrate biodiversity conservation, ecosystem service enhancement, and human well-being. The prioritization of floristic diversity, native species, and habitat connectivity fosters ecological resilience, enabling urban ecosystems to adapt to environmental changes and continue delivering critical ecosystem services such as air and water purification, climate regulation, and disaster mitigation.

The accurate assessment and management of urban biodiversity are essential to achieving these goals. A combination of methodologies—including field surveys, advanced imaging technologies, and biological indicators—offers a comprehensive framework for evaluating floristic diversity and informing sustainable urban planning. These methods provide both localized insights and large-scale perspectives necessary for effective biodiversity management in urban contexts.

Central to this process is the leadership of landscape architects and urban planners, whose expertise in integrating ecological, social, and cultural dimensions is critical for creating multifunctional and inclusive urban spaces. By adopting adaptive management strategies, fostering community engagement, and incorporating economic considerations, these professionals can ensure the long-term success of urban biodiversity initiatives. Moving forward, a holistic approach to urban park design—rooted in ecological planning and supported by public participation—is imperative for addressing the complex challenges of urbanization and harmonizing human development with natural systems. This integrative framework paves the way for resilient, equitable, and ecologically sound cities that thrive alongside nature.

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Integrating Multi-Species Justice into Climate Adaptation: A Coastal Habitat Projection Framework

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Abstract

Protecting biodiversity and natural habitats, a vital component of the Sustainable Development Goals (SDGs), faces escalating threats from climate change. As policymakers, researchers, and practitioners increasingly shift from engineering-oriented approaches to nature-based solutions (NBS) to safeguard human habitats from climate threats, a critical question remains underexplored: Do these NBS promote environmental justice by equitably distributing their co-benefits and costs among human communities and other species? In response, this research introduces a framework to project sea-level rise (SLR) impacts on coastal habitats, which NBS use as natural buffers against SLR. Combining remote sensing, supervised image classification, and the Sea Level Affecting Marshes Model (SLAMM), the framework projects habitat conditions under various SLR scenarios. Collaborating with the New Jersey Wetlands Institute, the framework projected suitable habitats for the endangered Diamondback Terrapin, an indicator species in New Jersey's shorelines. Results reveal that if the terrapin's habitat continues to be relied upon as a natural buffer for mitigating SLR impacts without appropriate intervention, the suitable habitat area within the research site will decrease by nearly 40% by 2069, with an accelerated loss from 2039 to 2069. This research underscores the need for integrating multi-species justice into NBS to ensure equitable solutions, advancing SDG targets.

Keywords: Multi-species justice, *nature-based solutions*, *sea-level rise*, habitat perservation

1. Introduction

Achieving the Sustainable Development Goals (SDGs) of protecting biodiversity and natural habitats is increasingly challenged by the externalities of human activities, which are further intensified by the impacts of climate change (Hoffmann, 2022). According to the Intergovernmental Panel on Climate Change (IPCC), this is a decisive decade for keeping climate change within manageable limits (IPCC, 2022). The actions taken now will have profound implications for the future. To more effectively reduce greenhouse gas emissions and adapt to climate change, policymakers, researchers, engineers, and designers are increasingly shifting from engineering-focused approaches to nature-based solutions (NBS) to protect human habitats from climate-related threats (Herrmann-Pillath et al., 2023).

However, current approaches to nature-based solutions (NBS), which leverage natural resources such as wetlands to mitigate the impacts of climate change, primarily addressing storm surges from sea-level rise (SLR) and increasing flooding events, are often anthropocentric (Thorslund et al., 2017). They tend to overlook a critical question: do these NBS promote environmental justice by equitably distributing their co-benefits and costs among human communities and other species? Therefore, achieving the SDG target of protecting biodiversity necessitates rethinking the concept of justice in NBS, shifting from a focus solely on humans to one that includes other species. This requires the full integration of biodiversity and its diverse values into policies, regulations, planning, and development processes.

This research contributes to the discourse by introducing an innovative framework to analyze and assess the impact of SLR on both human and animal habitats. By integrating remote sensing data, supervised image classification, and the Sea Level Affecting Marshes Model (SLAMM) (Warren Pinnacle Consulting, Inc.), the proposed framework enables the projection of land cover scenarios for both present conditions and long-term future conditions, accounting for projected SLR along the American Eastern Coastline.

In collaboration with the Wetlands Institute in New Jersey, this framework is applied to assess the climate impacts on the Diamondback Terrapin (Figure 1, left), a key indicator species in New Jersey's low-lying coastal areas and an endangered species listed on the IUCN Red List of Threatened Species (IUCN). Spartina grass (Figure 1, middle), a critical component of Diamondback Terrapin habitats, also plays a vital role in mitigating the increasingly severe impacts of flooding caused by SLR through NBS (Baptist et al., 2021; U.S. Department of Agriculture). The research goal is to support the development of resilient planning strategies for nearby coastal communities while creating habitat protection scenarios for this critical species. The following section outlines the materials and methods used in this research, providing a detailed explanation of the proposed framework. The third section then presents our findings.

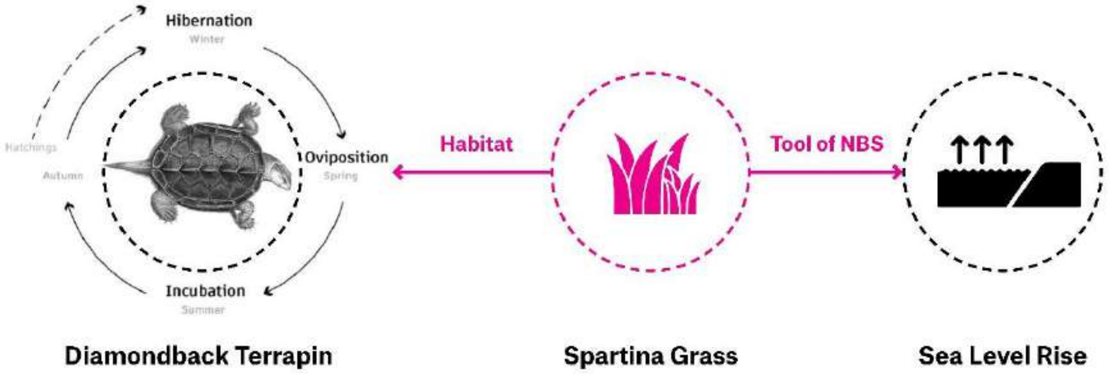


Figure 1. Relationship between Diamondback Terrapin, Spartina Grass, and SLR (Zhu & Zhang, 2024)

The results reveal that while natural wetlands, as a key component of nature-based solutions (NBS), can effectively enhance the resilience of human communities, they may pose significant risks to animal habitats if not managed with appropriate interventions to ensure a more equitable distribution of benefits between humans and other species. This research provides valuable insights into integrating multi-species justice into NBS, contributing to the advancement of Sustainable Development Goals (SDGs).

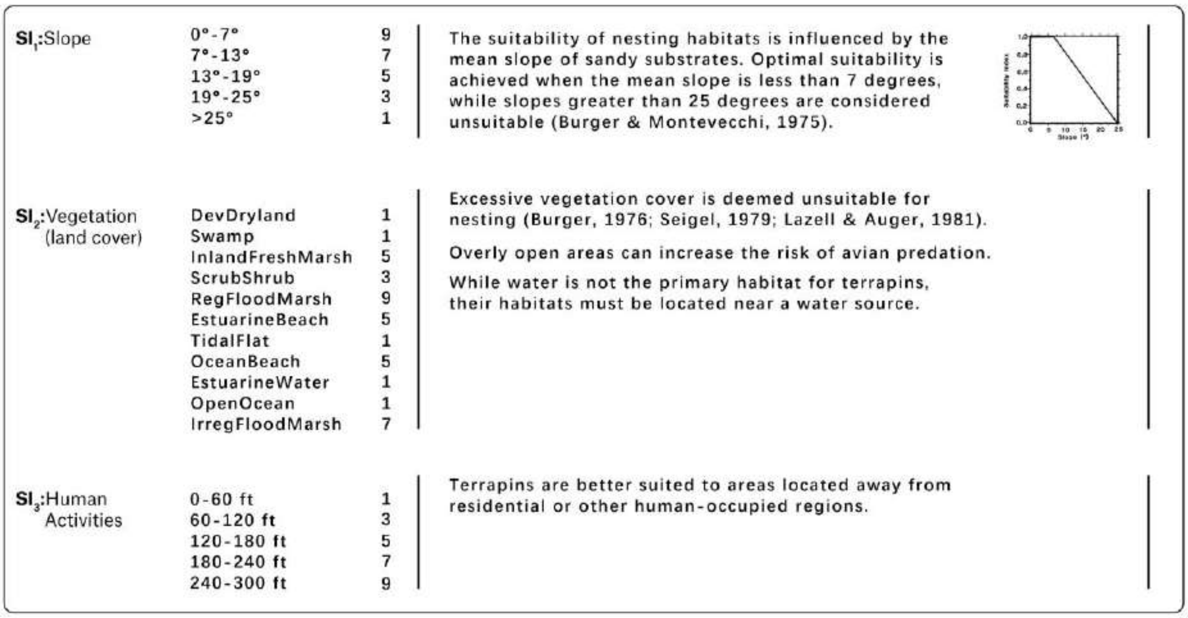
2. Material and Method

The proposed framework comprises three key components (Figure 2). First, to create a high-resolution and up-to-date wetland inventory map, a supervised image classification model was developed within the ArcGIS platform. This model utilized multi-spectral remote sensing data, digital elevation models (DEM), and spatial analysis outputs such as slope data. This approach addresses the limitations of the National Wetlands Inventory managed by the U.S. Fish & Wildlife Service, which is updated infrequently and provides relatively low-resolution data.

Figure 2. The proposed framework (Zhu, 2024)

Secondly, the Sea Level Affecting Marshes Model (SLAMM), combined with local sea-level rise projections, is utilized to forecast land cover changes over a predefined time period using the wetland inventory map generated in the first component. Next, the projected land cover data is integrated into an updated habitat suitability index (HSI) model (Figure 3), built upon previous research on the same species within the same geographical context (Burger & montevecchi, 1975; Burger, 1976; Seigel, 1979; Lazell & Auger, 1981; Hart & Lee, 2006). The Habitat Suitability Index (HSI) incorporates three key factors: slope, vegetation (land cover), and human activities (1). Finally, the projected habitat suitability map was evaluated, and habitat loss was quantified. Areas requiring intervention were identified to inform targeted conservation efforts.

$$HSI = (SI_1 \text{ x } SI_2 \text{ x} SI_3)^{1/3} \qquad (1)$$



SI_1:Slope	0°-7°	9	The suitability of nesting habitats is influenced by the mean slope of sandy substrates. Optimal suitability is achieved when the mean slope is less than 7 degrees, while slopes greater than 25 degrees are considered unsuitable (Burger & Montevecchi, 1975).
	7°-13°	7	
	13°-19°	5	
	19°-25°	3	
	>25°	1	
SI_2:Vegetation (land cover)	DevDryland	1	Excessive vegetation cover is deemed unsuitable for nesting (Burger, 1976; Seigel, 1979; Lazell & Auger, 1981). Overly open areas can increase the risk of avian predation. While water is not the primary habitat for terrapins, their habitats must be located near a water source.
	Swamp	1	
	InlandFreshMarsh	5	
	ScrubShrub	3	
	RegFloodMarsh	9	
	EstuarineBeach	5	
	TidalFlat	1	
	OceanBeach	5	
	EstuarineWater	1	
	OpenOcean	1	
	IrregFloodMarsh	7	
SI_3:Human Activities	0-60 ft	1	Terrapins are better suited to areas located away from residential or other human-occupied regions.
	60-120 ft	3	
	120-180 ft	5	
	180-240 ft	7	
	240-300 ft	9	

Figure 3. Habitate Suitability Index (HSI) Model (Zhu, 2024)

The datasets utilized in this research and their sources are detailed in Table 1. Key datasets include multi-spectral remote sensing data from Landsat 8, digital elevation model (DEM) data from National Oceanic and Atmospheric Administration (NOAA)'s Digital Coast dataset (National Oceanic and Atmospheric Administration), and SLR projection data from the New Jersey Climate Change Resource Center at Rutgers University (Rutgers New Jersey Climate Resource Center, 2020).

Table 1. Key Datasets and Sources

Dataset Name	Data Specification	Data Sources
Multi-spectral remote sensing	Band 3-Green Band 4-Red Band 5-Near Infrared	Landsat 8
Digital Elevation Model (DEM)	Raster format	NOAA)'s Digital Coast dataset
New Jersey Sea-level rise projection	0.5 to 1.1 feet (2000-2030) 0.9 to 2.1 feet (2000-2050)	New Jersey Climate Change Resource Center

3. Findings and Discussion

The framework's outputs for 2019, 2039, and 2069 are illustrated in Figure 3. The suitable areas for Diamondback Terrapins across these three time periods are overlaid on a single map to highlight the dynamics of potential habitat changes. A significant decrease in suitable habitat is evident when comparing the areas between 2019 and 2069.

We measured the percentage of suitable habitat relative to the total area of the research site and compared these percentages over time. The results show that the loss of suitable habitat occurs at a slower rate during the first two decades, with a decline of 0.035 percentage points per year. However, the rate of decline accelerates significantly between 2039 and 2069, reaching 0.1 percentage points per year. By 2069, nearly 40% of the suitable habitat area from 2019 is projected to be inundated due to rising sea levels. Additionally, not only does the total area of suitable habitat shrink over time, but the remaining suitable habitat also becomes increasingly fragmented, as illustrated in Figure 4.

Table 2. Change in Suitable Habitat Area Over Time

Year	Percentage of suitable habitat relative to the total site area	δ
2019	10.0%	n/a
2039	9.3%	-0.7 percentage point -0.035 percentage point per year
2069	6.2%	- 3.1 percentage point (to 2039) -0.1 percentage point per year

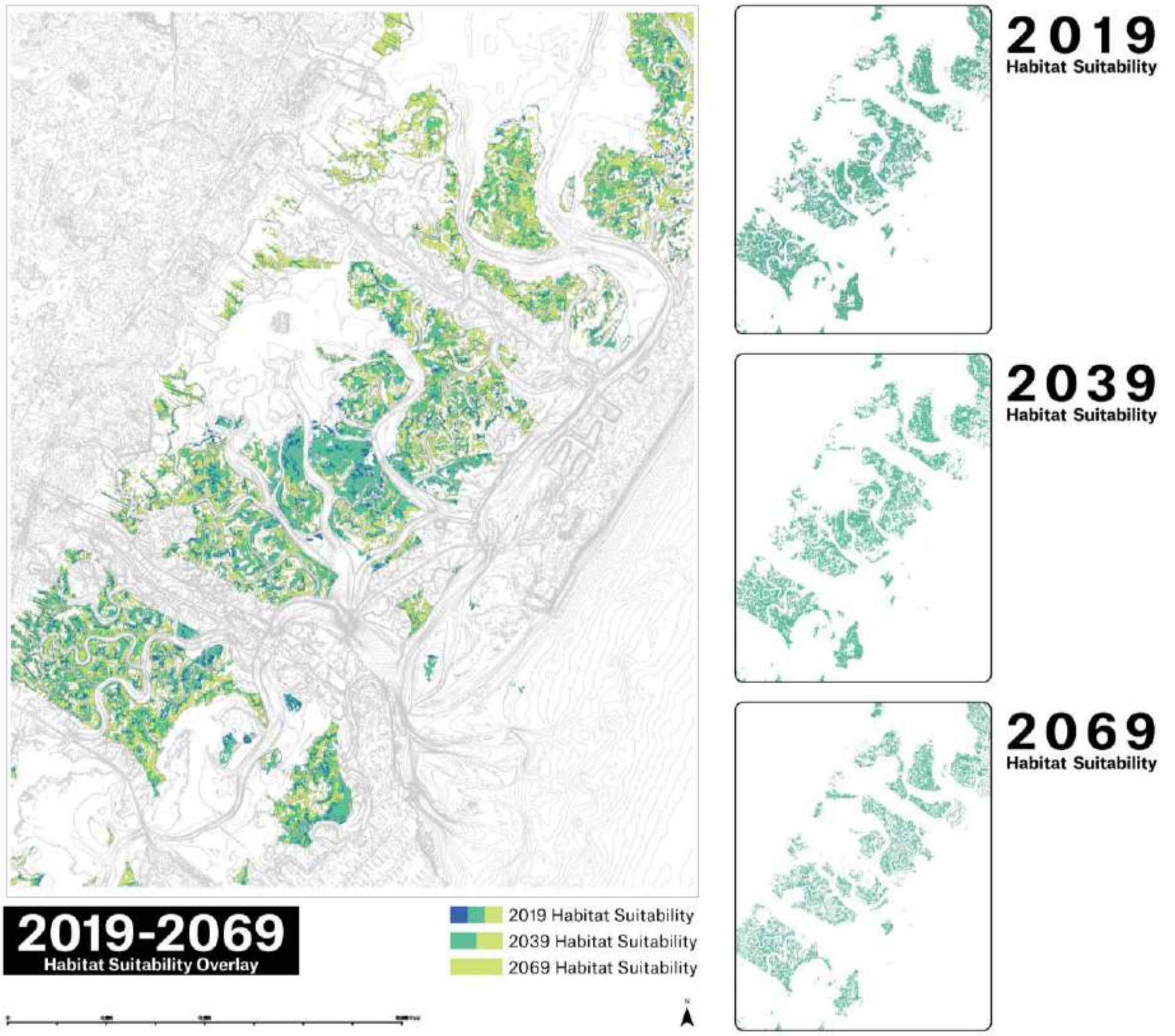


Figure 4. 2019, 2039, 2069 Results (Zhu, 2024)

4. Conclusion

To address the issue of multi-species justice in current NBS that leverage coastal natural resources to mitigate the impacts of climate change, particularly SLR, this research proposes an innovative framework for assessing potential habitat loss for coastal species using state-of-the-art technologies. A real-world case study is then utilized to demonstrate the application of this framework. The results not only quantify the loss of suitable habitat area for Diamondback Terrapins over time but also pinpoint specific locations where these losses are expected to occur, providing valuable insights to guide future preservation interventions.

This research highlights that climate change poses threats not only to human communities but also to the habitats of other species. Relying on other species' habitats to protect human communities raises concerns about justice and impedes progress toward achieving the SDGs of protecting biodiversity and natural habitats. The proposed framework offers new insights for developing approaches to assess and equitably distribute the co-benefits and costs of NBS across multiple species, advancing multi-species justice and supporting the realization of the SDG goals of protecting biodiversity.

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Urban Afforestation Against Biodiversity Loss Integrating Design in Science Experimentation

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Abstract

In 1992, the United Nations held the Conference on Environment and Development in Rio de Janeiro, laying the groundwork for international cooperation to halt the escalating biodiversity loss on the planet. However, over the past 30 years, biodiversity loss has increased, triggering a growing sense of urgency. Among various approaches addressing this issue, afforestation is one of the most widespread. This is evident in the European Green Deal's Biodiversity Strategy, which aims to plant 3 billion trees in Europe by 2030 among its various objectives.

This "Red code" condition calls for the expertise of professionals capable of proposing efficient and effective solutions, often prioritizing performances and correspondence to a given set of parameters and, consequently, overshadowing less tangible, more difficult-to-quantify aspects, such as diversity of uses or fruitful relationships with the contexts. This tends to render afforestation projects mainly technical operations. This strategy may find resonance in projects away from human fluxes; however, operating in urban contexts represents a crucial opportunity to enhance public awareness of environmental issues. This would benefit from the expertise in landscape architecture, a discipline that is used in navigating the tools of aesthetics, communication, and human experience.

In Italy, the "Urban Biodiversity" spoke of the National Biodiversity Future Center (NBFC), funded by the European Union Next Generation EU, is a research center working on the increase of biodiversity in urban areas. It involves several universities and public and private entities. One of the research groups (task 6.3), which includes the authors of this contribution, has addressed these issues through a multidisciplinary team conducting an afforestation and biodiversity increase experiment in three areas of the metropolitan city of Milan (the focus of this contribution) and in other parts of Italy.

While incorporating the necessary measures for obtaining scientific data - the core of the experiment - such as repetition, standardization, and randomization, the project has integrated considerations of spatial quality, such as composition, aesthetics, and relationship with the context. This was achieved within a multidisciplinary environment, through composition, a reorganization of planting layouts in line with botanists' needs, and through the relations of the plantation schemes with the surrounding urban features, such as rural areas, residential zones, and schools and warehouses. Additionally, the need for mechanized maintenance of the afforested areas was considered, by allowing easy maneuvers for vehicles and maintenance without sacrificing spatial quality.

This contribution will describe how landscape architecture has collaborated in a multidisciplinary field and identified several opportunities to generate interesting spaces from a design perspective while also responding to the technical-scientific goals. The primary focus of this contribution will be to outline the possible role of landscape architecture and the communicative potential of composition and aesthetics for urban afforestation projects, indicating possible developments and critical points to focus on given the significant and growing interest in this type of intervention in the years to come.

Keywords: Biodiversity loss, afforestation, urban biodiversity, landscape architecture, multidisciplinary collaboration

1. Introduction

In 1992, the United Nations Conference on Environment and Development in Rio de Janeiro marked a pivotal moment in global efforts to combat biodiversity loss. However, despite decades of international cooperation, biodiversity continues to decline at alarming rates, creating a scenario that calls for urgent and effective solutions.

This urgency often translates into legislative frameworks or approaches that tend to reduce interventions aimed at enhancing an area's ecological value to their "technical" performance and quantifiable ecological parameters. This reduction, presented as a linear and sound rationale, obscures the complexity of environmental issues, which cannot be separated from the heterogeneous and intricate contexts that produced them in the first place. As a result, projects intended to enhance an area's ecological and environmental "score" are seldom recognized as complex, holistic transformations that influence multiple domains—cultural, aesthetic, social, and economic—beyond ecology alone.

Among the interventions aimed at increasing biodiversity, afforestation has emerged as one of the most widely implemented strategies. It is supported by initiatives like the European Green Deal's Biodiversity Strategy, which aims to plant 3 billion trees across Europe by 2030. Afforestation projects fit well within quantitative frameworks because forests appear as discernible clusters of individual trees: tree species can be counted, measured, and observed, so afforestation is easily interpreted as a "technical" project, a standardized, productive infrastructure.

While there may be debate over the relative importance of this issue for projects in remote areas, urban contexts offer a rich opportunity to view such initiatives as complex devices capable of exerting a wide variety of influences on their surroundings.

The project
A concrete example of this issue was addressed by the Italian National Biodiversity Future Center (NBFC) through an afforestation project led by the Spoke 5 "Urban Biodiversity" – Ecological Restoration unit ("task 6.3"). This initiative was carried out by a multidisciplinary team[1] of botanists, technical operators, zoologists, and landscape architects (including the authors of this paper).

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[1] The research team of task 6.3, "Restoration ecology" (NBFC, Spoke 5 Urban Biodiversity) regarding the activities on the sites located in the metropolitan areas of Milan (Corbetta, Albairate, Abbiategrasso) and Pistoia is composed as described below. M. Labra, Università degli Studi di Milano Bicocca (Scientific Director of the NBFC and former Principal Investigator of the Spoke 5); A. Galimberti, Università degli Studi di Milano Bicocca and M. C. Pastore, Department of Architecture and Urban Studies, Politecnico di Milano (Principal Investigators of Spoke 5); R. Gentili, Università degli Studi di Milano Bicocca (Coordinator of the task 6.3, Botany); C. Geroldi, M. U. Poli, T. Cabai, Department of Architecture and Urban Studies, Politecnico di Milano (Landscape Architecture); G. Gaiani, E. Simoni, E. Alghisi, M. Bertini, ERSAF Lombardia (Construction documents, implementation, manteinance of the sites in the metropolitan area of Milan); F. Ferrini, E. Lo Piccolo, A. Maltoni, B. Mariotti DAGRI Università degli Studi di Firenze, F. Salbitano, Università di Sassari (Developing the project in the site in Pistoia in collaboration with GEA); A. Arcidiacono, A. De Toni, S. Ronchi, S. Salata, Department of Architecture and Urban Studies, Politecnico di Milano (Analysis of the recent afforestation interventions in the areas of the project sites); P. Digiovinazzo, Freelance (Collaboration in the species selection); C. Panigada, M. Rossini, L. Vignali (Remote sensing analysis), R. Resemini, S. Citterio (Botany, species monitoring), Università di Milano-Bicocca. Moreover, the sites of the Task 6.3 experimentations in the metropolitan area of Milan also involved Task 6.1 "Urban Bio-Phyto-remediation": S. Castiglione, F. Guarino, Università di Salerno, W. Guidi Nissim, Università degli Studi di Milano Bicocca (Phytoremediation); and Task 6.4 "Enhancement of functional biodiversity and mitigation of stressors": P. Biella, R. Ranalli, Università degli Studi di Milano Bicocca, Department of Biotechnology and Biosciences - ZooPlantLab, L. Bani, O. Dondina, V. Orioli, Università degli Studi di Milano Bicocca, Department of Earth and Environmental Sciences, E. Caprio, Università di Torino, Department of Life Sciences and Systems Biology, V. Fiorilli, A. Genre, Università di Torino, Department of Earth and Environmental Sciences (Experimentation with strips for flowers, shrubs and nests for wildlife).

Task 6.3 Projects in Rome and tree seed planted plots: M. Del Monte, M. De Sanctis, G. Capotorti, C. Blasi, Francesca Vergari, Università di Roma Sapienza. Task 6.3 Project in Molise: Cesar I. Alvites Diaz, M. Marchetti, M. Ottaviano, F. Parisi, L. Sallustio, G. Santopuoli, R. Tognetti, D. Tonti, E. di Pirro, V. Garfì, B. Lasserre Università del Molise.

The team developed an experimental afforestation project that addressed both technical and contextual aspects of ecological restoration simultaneously. The scientific component sought to measure specific botanical parameters of the planted forest, while the landscape architecture component aimed to integrate the intervention into the unique characteristics of the site, all while ensuring that the scientists' data collection needs were met. The interaction between these oftenconflicting values revealed subtle and unexpected ways to synthesize opposing methodologies, offering a new perspective on how to interpret ecological transformations amid the current biodiversity crisis.

2. Methodology

Scientific experimentation

The NBFC afforestation project involved creating three small forests, each roughly one hectare in size, within the metropolitan area of Milan[2]. These sites, located in the western part of the city, were subject to various botanical constraints on permissible species due to numerous pests introduced from diverse bioregions via Malpensa Airport.

The scientific goal of the project was to identify the most efficient and rapid planting scheme for forest ecological restoration in the Po Valley. The botanists selected three criteria for species choice: they had to be native, resistant to climate change, and not listed as prohibited by the involved municipalities. These conditions underscored the scarcity of species available to enhance biodiversity in highly urbanized areas and constrained tree selection largely to the genus *Quercus*, while allowing more flexibility in choosing shrubs.

Four experimental plots were established across three sites, each reflecting a distinct combination of trees and shrubs. Plot 1 (Conventional Forestation) was tree-dominated, with 70% trees and 30% shrubs. Plot 2 (Shrub-Dominated) emphasized understory growth, allocating 70% shrubs. Plot 3 ("*Macchia seriale*") resembled the popular Miyawaki method, featuring high density and a progression of climax species from the edges toward the center. Plot 4 (Control) was left to natural regeneration and served as a baseline for comparison.

The scientific team monitored growth rates, survival rates, and ecological interactions of the planted species to evaluate the success of the afforestation efforts. By collecting and analyzing data over time, the team aimed to refine future methodologies and contribute to developing guidelines for similar projects in other urbanized regions.

Landscape architecture

The plot design incorporated replication and randomization to ensure statistical rigor, enabling researchers to isolate the effects of planting configurations from external variables like soil heterogeneity and microclimatic conditions—factors that designers conventionally define as "the context." It was at this point that a methodological clash emerged. While the scientific component sought abstract configurations independently from the context, the landscape architecture component[3] aimed to contextualize the intervention.

An attempt was made to accommodate both requirements by maintaining plots as standard, recurring elements, while arranging them contextually. In the three sites, the plots took on distinct configurations. In Corbetta—the most urbanized area, located near residences, schools, a cemetery, and municipal parks—the plots leveraged existing movement patterns and were arranged to resemble a public park.

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[2] Other areas in Italy were also addressed by the research team of the "task 6.3 Restoration Ecology", Spoke 5, Urban Biodiversity NBFC.

[3] The authors of this paper.

The site was divided into two parts: one facing the city and the other facing the countryside. Each area was thematically distinct, with a more public configuration on the city side and a denser, more ecologically focused configuration on the countryside side. In the more urban area, the plots were circular and spaced to encourage fluid circulation and spatial variety, offering a succession of "rooms" for future uses. On the countryside-facing side, a woodland edge was established along the road, guiding visitors from the cemetery to the park. This introduced a less domesticated, more imposing woodland form bridging the urban and rural realms.

In Abbiategrasso, the project area formed part of a larger compensation-driven afforestation initiative at the edge of an industrial zone dominated by warehouses. This linear site, adjacent to a secondary road, could potentially serve as the start of a trail system extending from the urban area into the countryside. Here, the concept was to treat the road as an exhibition gallery and the afforestation site as the exhibit. The plots were arranged to create visual variety along the road frontage, establishing a "forest facade", an elevation that introduced compositional discontinuities with the existing hedge. Standard afforestation schemes in Lombardy often employ sinuous lines to mimic natural forms; instead, the decision was made to emphasize the artificiality of this intervention, thereby fostering curiosity and engagement.

At Albairate, the site lay within an industrial area containing a small residential cluster of cottages, isolated from the urban fabric and surrounded by fields and a high-speed road. As in Corbetta, the Albairate site was split in two: one part oriented toward the road, and the other toward the countryside, the residential cluster, and a farmhouse. Here, spatial and regulatory constraints limited the possible configurations. On the countryside-facing side, a greater variety of plots was possible, while the industrial side featured dense, square plots that softened the boundary wall. On the side facing the road, the plots were arranged repetitively due to limited space, creating a structured edge in front of the prefabricated warehouses.

All three interventions considered maintenance and technical operations, such as ensuring irrigation in the early years. Regulatory requirements—like maintaining certain distances from boundaries or avoiding planting above underground utilities—were also integrated. These practical constraints were transformed into design features, such as the empty "rooms" within the dense Abbiategrasso plantations.

3. Conclusions

These observations highlight the potential for landscape architecture to enhance the communicative and experiential dimensions of afforestation, transforming technical-oriented interventions into more holistic undertakings, within a multidisciplinary context.

From this experience, we confirmed the tangible possibility of adding spatial quality to scientific experiments, viewing them not only as scientific endeavors but also as spatial projects enriched with cultural, social, and pedagogical potential. Implementing these considerations can make projects more recognizable as opportunities for on-site education, fostering a shared imaginary that considers temporal evolution—an aspect often overlooked in scientific experiments.

Moreover, the project demonstrated the possibility of introducing a subtle, sensitive layer of public space into biodiversity-enhancing initiatives, suggesting a more integrated relationship between human and non-human life.

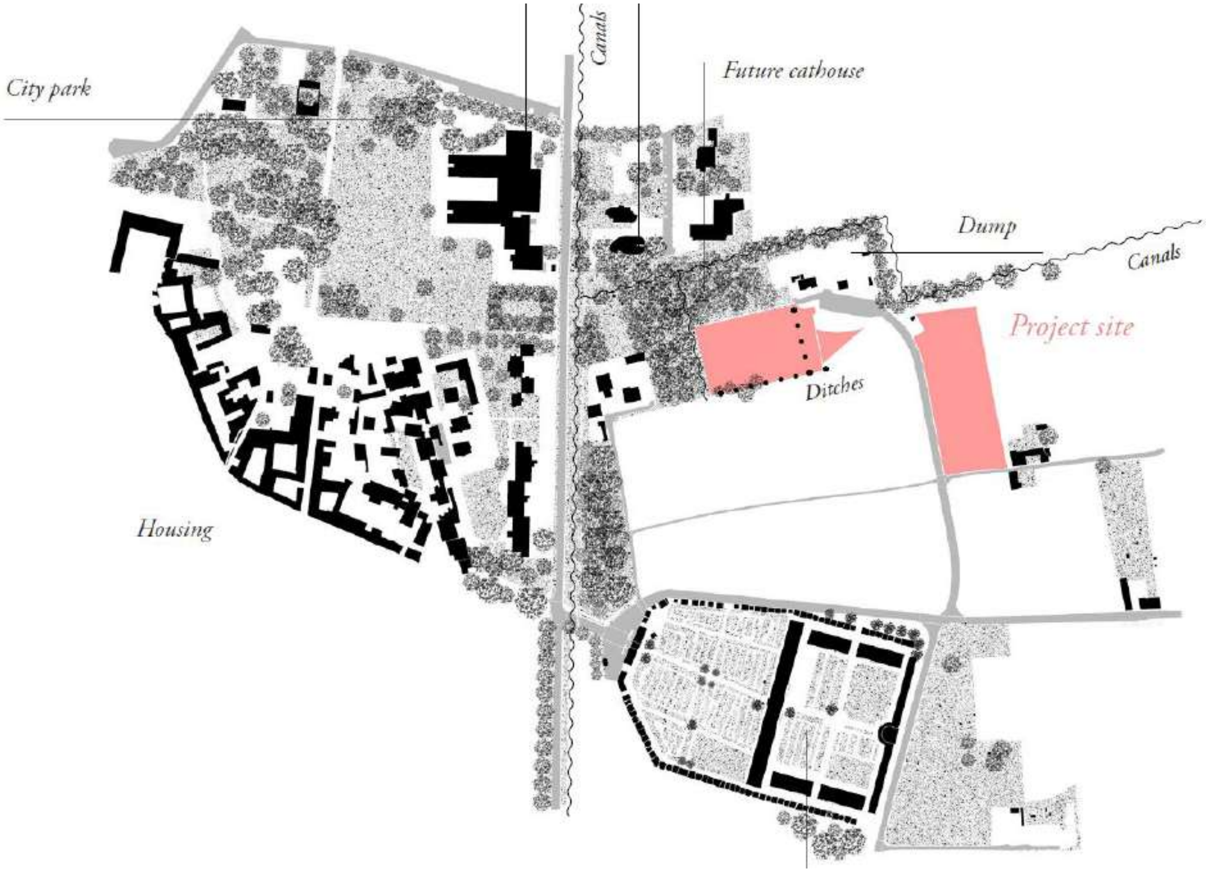

Figure 1. Corbetta's urban and agricoltural context (drawing by the landscape research team, Cabai, Geroldi, Poli)

Figure 2. Corbetta's plot configuration (drawing by the landscape research team, Cabai, Geroldi, Poli)

Figure 3. Corbetta's plot configuration (Photo by Thomas Cabai)

Figure 4. Abbiategrasso's plot configuration (drawing by the landscape research team, Cabai, Geroldi, Poli)

Figure 5. Abbiategrasso’s plot configuration (Photo by Rodolfo Gentili, coordinator of the task 6.3)

Figure 6. Albairate’s plot configuration (drawing by the landscape research team, Cabai, Geroldi, Poli)

Figure 7. Albairate's plot configuration (Photo by Rodolfo Gentili)

All figures were created by the author.

Notes

Funder

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Empirical Study of the Canopy Leaf Area Index Across Seasons

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Abstract

Various disasters triggered by extreme weather events due to global warming have occurred in recent years. To mitigate the occurrence of extreme weather conditions, it is crucial to engage in research on utilizing planting design to create ecologically friendly microclimate environments. Leaf Area Index (LAI) is a paramount parameter for reducing radiative heat, providing practical insights for selecting and arranging plantings in landscape design.

This study focuses on the crown structure parameters of 15 tree species planted within the Wenshui Visitor Center area of Shei-PaNational Park, Taiwan. Among these, 8 are evergreen trees, and 7 are deciduous trees. The AccuPAR model LP-80, a canopy analyzer, was utilized to measure the Leaf Area Index (LAI) of the 15 tree species during both summer and winter. Subsequent analysis and comparisons were conducted to examine the LAI variations among the different species.

The results indicate that during the summer season, the Leaf Area Index (LAI) ranged from 7.37 to 2.05, while in the winter season, it varied from 4.12 to 0.67. For effective shading during the summer, recommended plant species with the highest LAI include Prunus armeniaca, Erythrina crista-galli, Machilus thunbergii, Zelkova serrata, and Ficus microcarpa. Additionally, among evergreen tree species, the average difference in LAI between summer and winter seasons was 1.49, whereas among deciduous tree species, this difference averaged 3.30.

The findings of this study can serve as design references for microclimate adjustments in humid and hot climatic regions. Achieving human comfort requirements aside, it offers a deeper understanding of the translucent environment in the context of multi-layered planting design.

Keywords: Leaf area index, multi-layered planting, microclimate

1. Introduction

1.1 Research motivation

Studies indicate that the impacts of global warming on Earth are now evident through events such as rising sea levels, ocean acidification, ice sheet melting, changes in flowering and plant blooming patterns, and extreme weather events (Mickaele et al., 2022). With increasing urban populations and rising population density, the phenomenon of urban heat islands as a localized climate effect has emerged (Saaroni et al.,2018). Heat is primarily generated by impervious surfaces, lack of greenery, and energy consumption, which can directly or indirectly impact urban ecosystems and affect the thermal comfort, health, and well-being of city residents (Prabhasri et al., 2024, Xiang et al., 2023). Therefore, mitigating climate change and reducing energy consumption are significant challenges facing society today (Fabiana et al., 2020).

Urban vegetation—such as lawns, shrubs, trees, green roofs, and green walls—is widely regarded as an effective strategy for mitigating urban heat islands and adapting to climate change (Zhao et al., 2024). Trees are crucial in urban biodiversity, sustainability, and climate resilience. Through evaporative cooling and radiation shielding effects, they contribute to mitigating urban heat environments (Deng et al., 2021, Yang et al., 2023).

Research indicates that trees can mitigate highly high temperatures and reduce incoming solar radiation and outgoing terrestrial radiation (Ben et al., 2023). By shielding infrastructure and buildings in urban areas, trees can prevent heat accumulation and reduce surface temperatures (Alessandro et al., 2021).

1.2 Research objectives

The main objective is to explore the variations in leaf area index (LAI) of common landscape plants in a subtropical humid climate during summer and winter and to investigate the differences in LAI among different plant species.

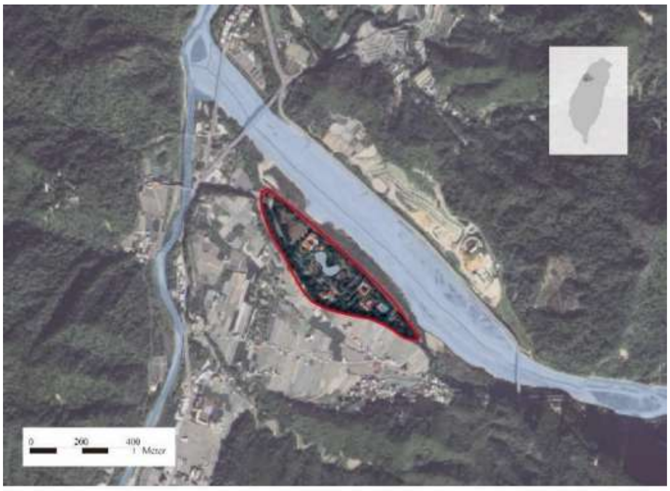
Therefore, this study used the Wenshui Visitor Center within Shei-Pa National Park as the measurement base. The park contains rich and healthy ecological resources, and 34 trees from 15 different species were selected for field measurement, comprising 8 species of evergreen trees and 7 species of deciduous trees. Measurements were conducted using the AccuPAR model LP-80 to obtain the necessary data to understand the impact of different plants on the outdoor microclimate, which will serve as a reference for sustainable urban landscape design.

2. Research Methods

2.1 Research scope and objectives

This study conducted multiple field measurements at the Wenshui Visitor Center (24°44’ N 120°87’ E). Situated at an elevation of approximately 241 meters, the visitor center is surrounded by mountains in a valley, making it a habitat for diverse flora and fauna.

The Wenshui Visitor Center is a long-shaped site roughly oriented in a northwest-southeast direction, divided into three main zones: the front, middle, and back areas. The front section, located at the entrance, primarily consists of a large grassy lawn environment. The middle section, comprising the visitor center area, features lawns with layered plantings and ecological ponds, impervious surfaces, and children's play areas. The rear section is dominated by building structures and serves as the office area. To investigate the basic information of trees for screening and analysis, the Wenshui Visitor Center was divided into four zones. (Figure 1).



(a) Research Location and Scope

(b) Experimental Study Area Division & Microclimate Monitoring Station Locations

Figure 1. Research Site of Field Measurements (a)(b)

Divide the Wenshui Visitor Center in Shei-Pa National Park into four zones labeled A-D, and map out the tree measurement points in each zone. The tree species and details for each area are provided in Table 1.

Table 1. Tree species in each zone

Zone	Scientific Name
A	*Araucaria heterophylla, Koelreuteria elegans, Fraxinus griffithii, Melia azedarach, Erythrina crista-galli, Ficus microcarpa, Cinnamomum camphora*
B	*Calocedrus formosana, Machilus thunbergia, Melia azedarach, Bischofia javanica, Liquidambar formosana*
C	*Koelreuteria elegans, Prunus armeniaca, Ficus microcarpa, Cinnamomum camphora, Zelkova serrata, Terminalia catappa*
D	*Morella rubra, Ficus microcarpa*

2.2 Measurement procedure and instruments used

This study selected 15 commonly used landscape plant species that were not shaded by nearby environments, comprising a total of 34 trees. Measurements were taken for these 34 trees in May and December using the AccuPAR model LP-80 plant canopy analyzer, with each tree species sampled six times during both summer and winter for subsequent research analysis. To understand the local microclimate, this study employed a Professional Wireless Internet Weather Station to measure background meteorological data for record-keeping. The product specifications and equipment details are referenced in the attached Table 2.

Table 2. Instrumentation and Specifications

	Instrument Name/Model	Measurement Parameters	Measurement Range	Accuracy
	Professional Wireless Internet Weather Station	air temperature	-30℃-65℃	±1℃
		relative humidity	1%-99%	±5%
		wind speed	0-50m/s	±1m/s(<5m/s) ±10%(>5m/s)
		sunlight exposure	0-400k Lux	±15%
		ultraviolet index	-	-
	AccuPAR model LP-80	PAR LAI	0-2500μmol m-2 s-1	1μmol m-2 s-1

The microclimate measurement stations were established in three different landscape environments in unshaded areas. Measurement point G was situated on a large lawn, point P was located on the impervious surface of a children's play area, and point W was positioned by an artificial ecological lake southeast of the visitor center, as shown in Figure 2.

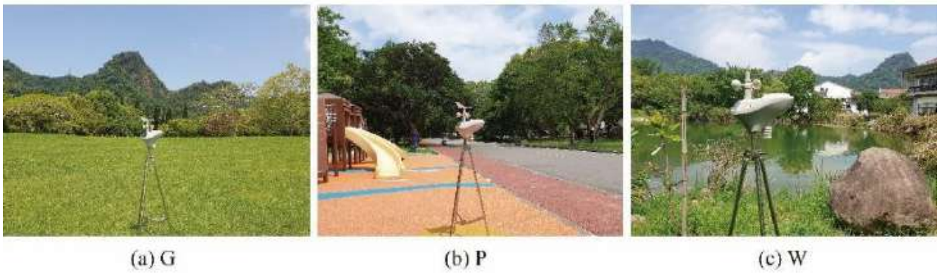

(a) G (b) P (c) W

Figure 2. Diagram of microclimate measurement stations at three different locations (a)(b)(c)

AccuPAR is a linear quantum sensor composed of 80 photodetectors that measure photosynthetically active radiation (PAR) in the wavelength range of 400-700 nm (Garrigues et al., 2008, Fang et al., 2014, Li et al.,2021). PAR values were measured by placing the sensor below and above the canopy (Fang et al., 2018). The measurement method involved using a handheld AccuPAR model LP-80 to measure the upper canopy (in this study, modified to measure in unshaded areas) and the lower canopy. During data collection, measurements were taken once in the four cardinal directions (east, west, south, and north) to ensure data accuracy. The measurement method is detailed in Figure 3.

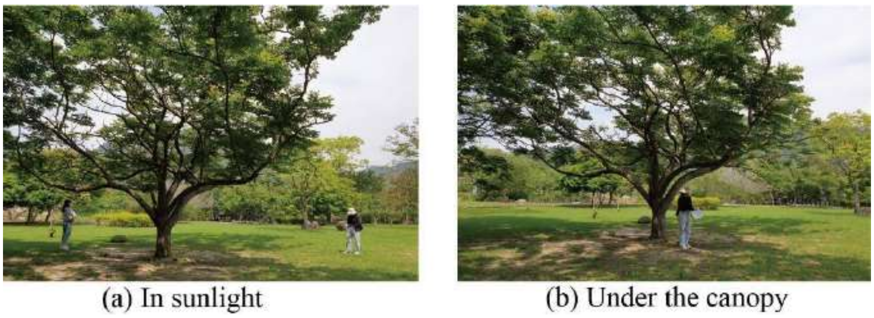

(a) In sunlight (b) Under the canopy

Figure 3. Measurement methods and field measurement overview (a)(b)

3. Measured Results and Analysis

This study conducted field measurements on May 3, May 10, May 17, December 12, December 18, December 19, and December 25, taking the average for subsequent analysis. May and December were selected as measurement months: May marks the early summer season when foliage is dense and less affected by rainfall, while December represents mid-winter, with most deciduous leaves fallen, making it an ideal time to measure both evergreen and deciduous trees. Measurements were taken between 10:00 AM and 2:00 PM during peak sunlight hours to avoid low-angle sunlight (high solar altitude and optimal azimuth) and ensure accurate readings.

3.1 Microclimate parameters in different landscape environments

This study collected microclimate parameters (temperature, humidity, wind speed, solar radiation, and UV index) from three measurement stations as background data for subsequent analysis of shielding effects.

3.1.1 Temperature analysis

By averaging the temperature readings at the same measurement point and time interval on each measurement day, the average temperature for different landscape environments can be obtained. A comparison of each measurement point yields Figure 4.

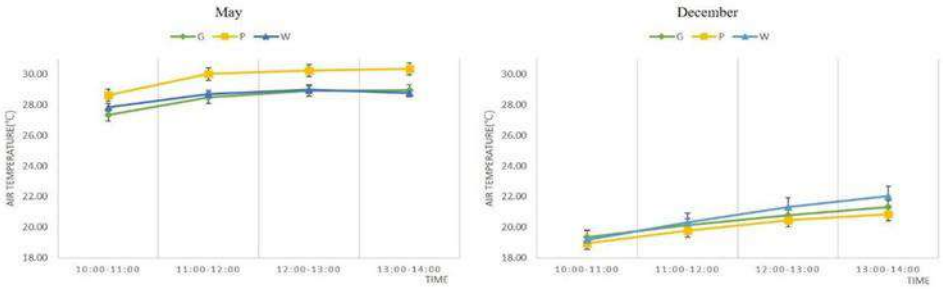


Figure 4. Average air temperature at the three measurement stations during summer and winter

As shown in Figure 4, the average temperature at 10:00 a.m. across the three measurement stations in May is relatively similar, with an average temperature of 27.9°C ± 0.7°C. After 11:00 a.m., temperatures at all three stations show an upward trend, with station P experiencing a more significant increase than G and W. The average temperature at 10:00 a.m. across the three stations is also similar in December, averaging 19.2°C ± 0.2°C. After 11:00 a.m., temperatures at all stations gradually rise, with station W showing a more pronounced increase after noon than stations G and P.

In May, the average temperature across the three stations from highest to lowest is P > W = G, while in December, the order is W > G > P.

3.1.2 Humidity analysis

The average relative humidity for each point can be obtained by averaging the relative humidity at the same measurement point and time interval on each measurement day. A comparison of each measurement point yields Figure 5.

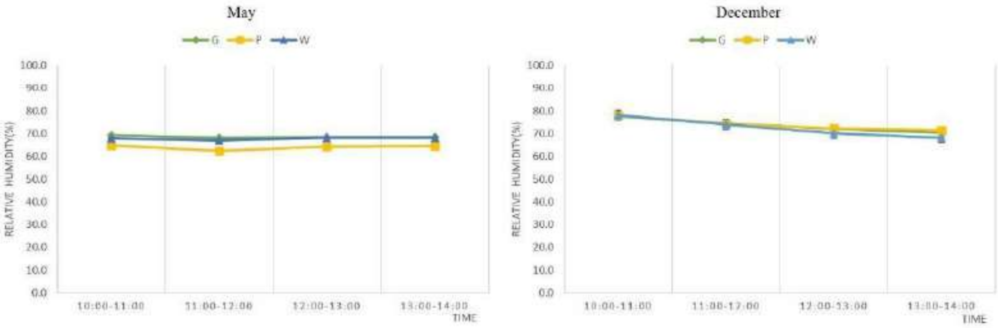


Figure 5. Average relative humidity at the three measurement stations during summer and winter

As shown in Figure 5, in May, the average relative humidity across the three stations varies little across time intervals. Still, the relative humidity at station P is noticeably lower than at stations G and W. In December, the average relative humidity at the three stations from 10:00 a.m. to 12:00 p.m. is very similar, with a gradual decline in relative humidity from 10:00 a.m. to 2:00 p.m.

In May, the average relative humidity across the three stations was 66.8% ± 1.8%, with the stations ranked from highest to lowest relative humidity as G > W > P. The average relative humidity in December was 73.4% ± 0.8%, with the stations ranked P > G > W.

3.1.3 Wind speed analysis

The average wind speed and maximum gust speed at the same measurement point and period on each measurement day were calculated and compared across the different points, resulting in Figure 6.

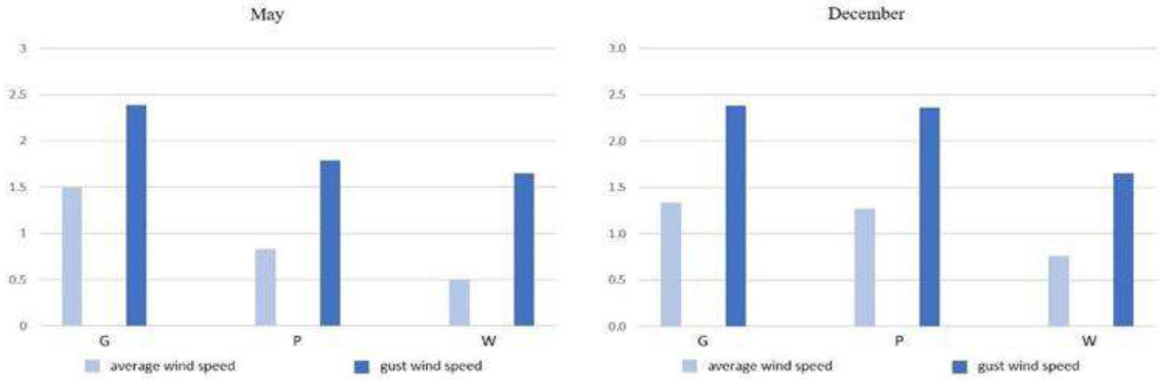


Figure 6. Comparison of Wind Speeds at Three Stations in Summer and Winter

As shown in Figure 6, in May, the average wind speed and maximum gust speed at Station G were higher than at Stations P and W. In December, the average wind and maximum gust speeds at Stations G and P were higher than at Station W.

The average wind speed at Station G decreased from 1.5 m/s in May to 1.3 m/s in December, while at Station P, it increased from 0.8 m/s in May to 1.3 m/s in December. At Station W, the average wind speed increased from 0.5 m/s in May to 0.8 m/s in December. Station P showed the most significant difference in average wind speed between May and December among the three stations.

3.1.4 Sunlight exposure analysis

The average exposure at the same measurement point and period on each measurement day was calculated to obtain the average exposure across different landscape environments. Figure 7 compares each measurement point.

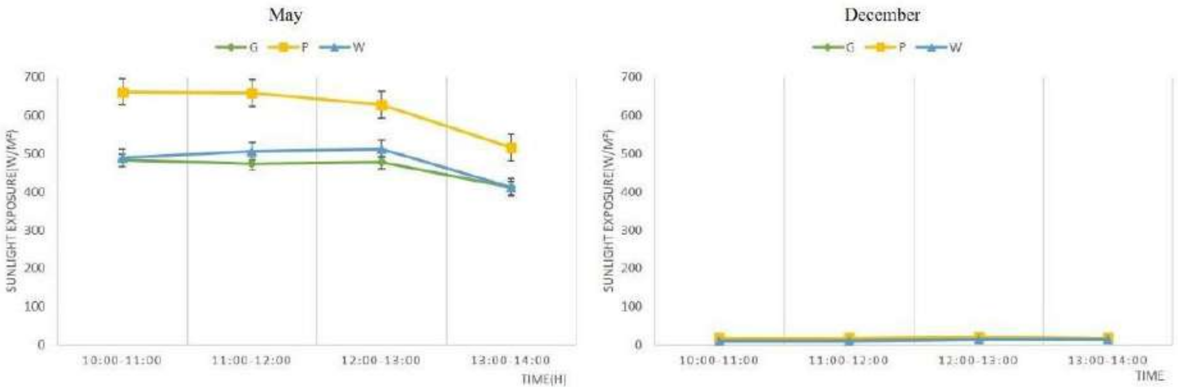


Figure 7. Average sunlight exposure at the three measurement stations during summer and winter

As shown in Figure 7, in May, the average solar radiation at the three stations from 10:00 to 13:00 remained relatively consistent, with a decreasing trend after 13:00. Among the three stations, Station P showed the most noticeable decline in solar radiation. In December, the solar radiation data across the three stations showed minimal variation and remained generally stable.

In May, the average solar radiation across the three stations was 518.8 W/㎡ ± 57.9 W/㎡, with average solar radiation highest to lowest at Stations P > W > G. In December, the average solar radiation was 16.8 W/㎡ ± 2.1 W/㎡, with average solar radiation highest to lowest at Stations G > P > W. The difference in average solar radiation between the summer and winter seasons was 502 W/㎡.

3.1.5 UV index analysis

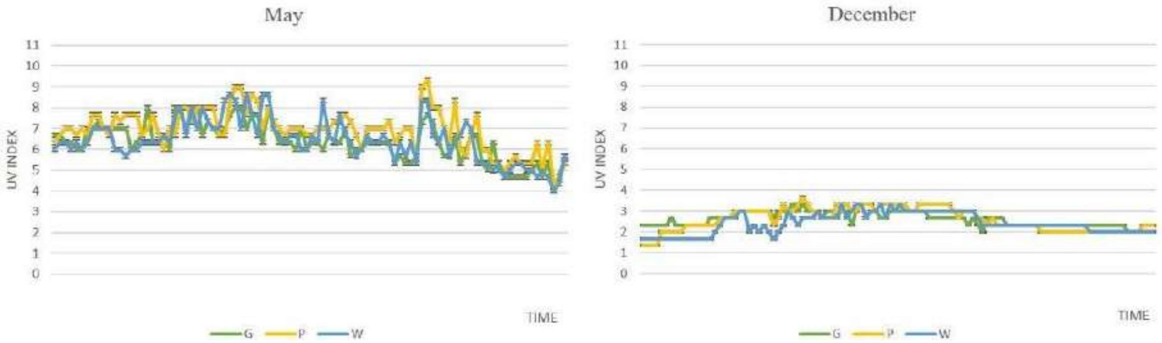


Figure 8. Comparison of UV Index at Three Stations in Summer and Winter

As shown in Figure 8, the highest UV index recorded in May was 10, observed at Station P from 11:00 to 13:00 on May 3 and at Stations P and W during the same hours on May 17. The highest UV index on May 10 reached 9, classified as a very high exposure level (red category), which occurred at Station P from 12:00 to 13:00. Due to the lack of shading at all three stations, the differences in UV index readings were insignificant.

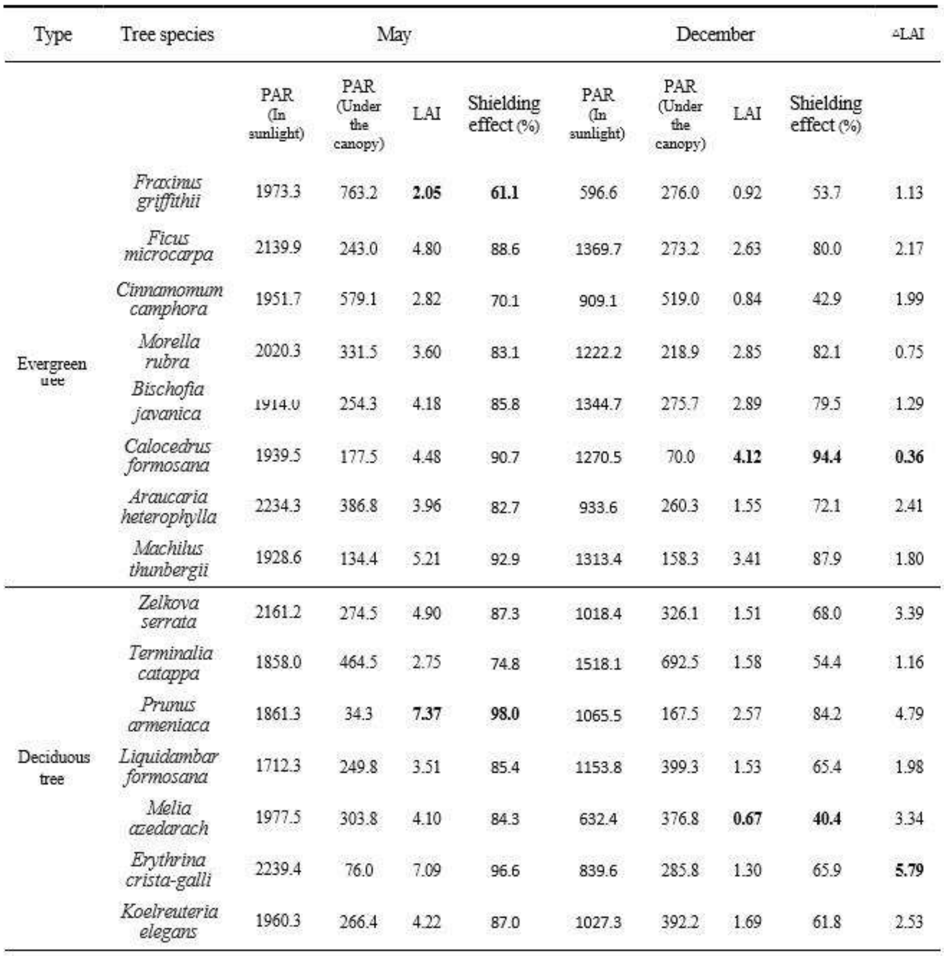
In December, the highest UV index recorded over three measurement days was 6, observed at Station P from 11:00 to 12:00 on December 19. This index falls within the orange category of high exposure levels.

3.2 Calculation of radiation shielding effects for different tree species

The AccuPAR model LP-80 was utilized to measure plantings in various areas. Similar to the measurement method employed in Ying's master's thesis using the AccuPAR model LP-80. Subsequently, by subtracting the PAR value under the tree canopy from the PAR value in direct sunlight and dividing it by the PAR value in direct sunlight, the average shading effect for each measured tree species was obtained, as represented by Equation (1) Integrating the data obtained for the same tree species provides the average measurement values for the 20 tree species, as shown in Table 3.

The average shading effect (%) = (PAR in sunlight - PAR under the canopy) / PAR in sunlight (%) *(1)*

Table 3. Average PAR Values, LAI, and Average Shielding Effects of Each Tree Species



Type	Tree species	May				December				ΔLAI
		PAR (In sunlight)	PAR (Under the canopy)	LAI	Shielding effect (%)	PAR (In sunlight)	PAR (Under the canopy)	LAI	Shielding effect (%)	
Evergreen tree	*Fraxinus griffithii*	1973.3	763.2	**2.05**	**61.1**	596.6	276.0	0.92	53.7	1.13
	Ficus microcarpa	2139.9	243.0	4.80	88.6	1369.7	273.2	2.63	80.0	2.17
	Cinnamomum camphora	1951.7	579.1	2.82	70.1	909.1	519.0	0.84	42.9	1.99
	Morella rubra	2020.3	331.5	3.60	83.1	1222.2	218.9	2.85	82.1	0.75
	Bischofia javanica	1914.0	254.3	4.18	85.8	1344.7	275.7	2.89	79.5	1.29
	Calocedrus formosana	1939.5	177.5	4.48	90.7	1270.5	70.0	**4.12**	**94.4**	**0.36**
	Araucaria heterophylla	2234.3	386.8	3.96	82.7	933.6	260.3	1.55	72.1	2.41
	Machilus thunbergii	1928.6	134.4	5.21	92.9	1313.4	158.3	3.41	87.9	1.80
Deciduous tree	*Zelkova serrata*	2161.2	274.5	4.90	87.3	1018.4	326.1	1.51	68.0	3.39
	Terminalia catappa	1858.0	464.5	2.75	74.8	1518.1	692.5	1.58	54.4	1.16
	Prunus armeniaca	1861.3	34.3	**7.37**	**98.0**	1065.5	167.5	2.57	84.2	4.79
	Liquidambar formosana	1712.3	249.8	3.51	85.4	1153.8	399.3	1.53	65.4	1.98
	Melia azedarach	1977.5	303.8	4.10	84.3	632.4	376.8	**0.67**	**40.4**	3.34
	Erythrina crista-galli	2239.4	76.0	7.09	96.6	839.6	285.8	1.30	65.9	**5.79**
	Koelreuteria elegans	1960.3	266.4	4.22	87.0	1027.3	392.2	1.69	61.8	2.53

3.2.1 Analysis of shielding effects in summer and winter seasons

Among the measured tree species are 8 evergreen trees and 7 deciduous trees. The average shielding effect from summer to winter decreased for evergreen trees from 81.9% to 74.1%,

representing an average reduction of 7.8%. In contrast, deciduous trees showed an average decrease from 87.6% to 62.9%, resulting in an average reduction of 24.7% in the shielding effect. Even in winter, deciduous trees can still reduce over half of the radiation.

Taking Erythrina crista-galli and Calocedrus formosana as examples, the annual average Leaf Area Index (LAI) of Erythrina crista-galli is 4.04, while that of Calocedrus formosana is 4.30. Based on the yearly average LAI, Erythrina crista-galli is lower than Calocedrus formosana. However, during the summer, the LAI of Erythrina crista-galli reaches 7.09, while the summer LAI of Calocedrus formosana is 4.48, indicating that Erythrina crista-galli surpasses Calocedrus formosana in terms of summer LAI.

Thus, it can be concluded that for the assessment of the shielding effect, summer data should serve as the primary reference contribution. Following the winter measurements, the integration and comparison of data will enable a more focused selection of plantings for shading during the summer.

3.3 The relationship between lai in summer and winter

The measured and integrated LAI was categorized into summer and winter for analysis, allowing for examining the relationship between LAI across different tree species in both seasons, as illustrated in Figure 11.

As shown in Figure 11, the summer LAI of all plant species is higher than the values measured in winter. The most minor difference in LAI between summer and winter is 0.36, observed in the evergreen tree *Calocedrus formosana*, while the most significant difference is 5.79, found in the deciduous tree *Erythrina crista-galli*. During summer, the highest LAI is 7.37 for *Prunus armeniaca*, while the lowest is 2.05 for *Fraxinus griffithii*; in winter, the highest LAI is 4.12 for *Calocedrus formosana*, and the lowest is 0.67 for *Melia azedarach*. Among the 15 tree species, the average LAI difference between summer and winter for evergreen species is 1.49, while for deciduous species, it is 3.30.

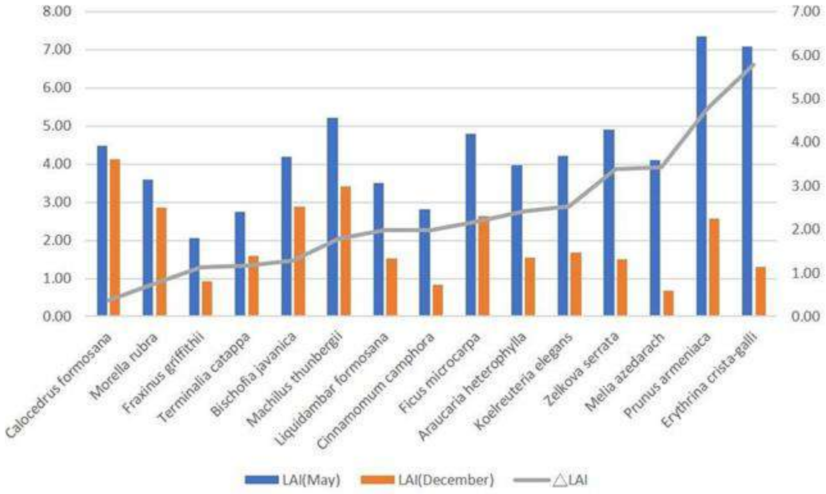


Figure 9. Difference Relationship Diagram of Summer and Winter LAI

3.4 Classification of LAI

As shown in Table 4, the measured LAI values were classified into eight groups, ranging from LAI = 0 to LAI = 8. Table 4 clearly illustrates the significant differences in leaf area index (LAI) among plants due to seasonal variations. Notably, only the evergreen tree *Calocedrus formosana* maintains LAI in the range of 4 to 5 during summer and winter.

In summer, when the average LAI is 2.54, the tree species within this range include *Fraxinus griffithii*, *Cinnamomum camphora*, and *Terminalia catappa*. At an average LAI of 3.69, the species include *Morella rubra*, *Araucaria heterophylla*, and *Liquidambar formosana*. When the average LAI reaches 4.45, the species present include *Ficus microcarpa*, *Bischofia javanica*, *Calocedrus formosan*, *Zelkova serrata*, *Melia azedarach*, and *Koelreuteria elegans*. At an average LAI of 5.21, the species present is *Machilus thunbergii*, and when the average LAI reaches 7.22, the species include *Prunus armeniaca* and *Erythrina crista-galli*.

In winter, when the average LAI is 0.81, the tree species in this range include *Fraxinus griffithii*, *Cinnamomum camphora*, and *Melia azedarach*. At an average LAI of 1.53, the species are *Araucaria heterophylla*, *Zelkova serrata*, *Terminalia catappa*, *Liquidambar formosana*, *Erythrina crista-galli*, and *Koelreuteria elegans*. When the average LAI reaches 2.73, the species present include *Ficus microcarpa*, *Morella rubra*, *Bischofia javanica*, and *Prunus armeniaca*, and at an average LAI of 3.41, the species is *Machilus thunbergii*. When the average LAI reaches 4.12, the species is *Calocedrus formosana*.

In summer, the LAI ranges from levels 2 to 8, with the highest average LAI being 7.22 and the lowest being 2.54. In winter, the LAI ranges from levels 0 to 5, with the highest average LAI being 4.12 and the lowest being 0.81.

Table 4. LAI Classification Table

LAI range	May		December	
	Tree Species	Average LAI	Tree Species	Average LAI
0~1	-	-	*Fraxinus griffithii, Cinnamomum camphora, Melia azedarach*	0.81
1~2	-	-	*Araucaria heterophylla, Zelkova serrata, Terminalia catappa, Liquidambar formosana, Erythrina crista-galli, Koelreuteria elegans*	1.53
2~3	*Fraxinus griffithii, Cinnamomum camphora, Terminalia catappa*	2.54	*Ficus microcarpa, Morella rubra, Bischofia javanica, Prunus armeniaca*	2.73
3~4	*Morella rubra, Araucaria heterophylla, Liquidambar formosana*	3.69	*Machilus thunbergii*	3.41
4~5	*Ficus microcarpa, Bischofia javanica, Calocedrus formosana, Zelkova serrata, Melia azedarach, Koelreuteria elegans*	4.45	*Calocedrus formosana*	4.12
5~6	*Machilus thunbergii*	5.21	-	-
6~7	-	-	-	-
7~8	*Prunus armeniaca, Erythrina crista-galli*	7.22	-	-

4. Conclusion

This study analyzed the differences and relationships of leaf area index (LAI) between summer and winter through actual measurements of trees. Fifteen common landscape plant species were measured and recorded, with summer LAI ranging from 2 to 8 and winter LAI ranging from 0 to 5.

The summer average LAI of the plants ranges from 2.05 for the *Fraxinus griffithii* to 7.37 for the Prunus armeniaca. In winter, the average LAI ranges from 0.67 for the chinaberry to 4.12 for the *Calocedrus formosana*. Among these, the most negligible difference in LAI between summer and winter is 0.36, associated with the evergreen *Calocedrus formosana*, while the most significant difference is 5.79, associated with the deciduous *Erythrina crista-galli*.

The Leaf Area Index (LAI) of deciduous trees decreases when averaged across summer and winter; however, summer data plays a predominant role regarding the shielding effect. Therefore, it is not necessarily appropriate to rely solely on the annual LAI; rather, the summer LAI should be used as a reference.

Furthermore, the climate background data obtained from actual measurements indicated that the ultraviolet index exceeded level 6 for 72% of the measurement periods during summer, categorizing it within the orange high exposure level and above. Tree species with an LAI of 4 or higher are suitable for planting in summer when shading effects are needed. This study demonstrates that plants exhibiting a shading effect of over 90% in summer include *Calocedrus formosana*, *Machilus thunbergii*, *Erythrina crista-galli*, and *Prunus armeniaca*, all of which have an LAI greater than 4. The findings of this study can serve as a reference for microclimate regulation in landscape design.

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Endemic Species Conservation in Uludağ National Park: Ecological Niche Mapping and Habitat Expansion

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Abstract

Human activities and climate change have significantly harmed biodiversity, making ecosystems more fragile. Türkiye faces similar challenges, as it hosts around 12,000 plant taxa with an endemism rate above 30%, due to its diverse climate, topography, and geology. This study aims to protect 11 endemic species through ex-situ conservation in Uludağ National Park (UNP) and the Uludağ Area Presidency (UAP), designated in 2023. First, the endemic and endangered species within the area were identified. Using species location coordinates, data on habitat, elevation, aspect, slope, soil, rock structure, and rainfall were transferred into ArcGIS. This involved digitising topographic data and incorporating information from existing research. A suitability analysis was conducted using the 'Weighted Overlay' method to identify the best habitats for ex-situ conservation. The analysis determined suitable habitats within UNP, revealing nine species could thrive outside the UAP. However, Galium olympicum and Achillea multifida were found only within the UAP. This research is significant as it helps prevent the extinction of these 11 endemic species, expands vegetation areas, and promotes sustainability. The study's findings offer valuable guidance for future conservation efforts, ensuring the long-term protection of Türkiye's unique biodiversity.

Keywords: Biodiversity, Uludağ Area Presidency, endemic, ecological niche, ex-situ conservation

1. Introduction

Anthropogenic land use and climate change pose significant threats to terrestrial biodiversity. Empirical evidence indicates that these human-induced pressures have markedly exacerbated terrestrial biodiversity decline. Given the likelihood of continued environmental changes in the future, it is crucial to assess their impacts on biodiversity to effectively prioritize conservation efforts (Record et al., 2020). According to Körmeçli & Ceylan (2023), biodiversity is defined as the diversity observed among living organisms within an ecosystem, encompassing both species richness and genetic diversity within the same species' living space. Plant biodiversity spans ecosystem level, species diversity, and genetic diversity within species (Ebert & Engels, 2020).

Approximately 340,000 seed plant species and 60,000 tree species exist globally, with 1 in 5 seed plants and 1 in 6 tree species facing threats. Species vulnerability varies due to physiological differences and proximity to threats (Cavender-Bares et al., 2020). Türkiye, a biodiversity hotspot, hosts about 12,000 vascular plant taxa, with 4,000 being endemic (over 30% endemism rate). In contrast, the entire European continent, 15 times larger than Türkiye, harbors around 2,547 endemic plants (Gözcü et al., 2024; Adıgüzel & Solmaz, 2023). Recent studies report 167 families, 1,320 genera, and 9,996 species in Türkiye, with 3,649 being endemic (Adıgüzel & Solmaz, 2023). The Mediterranean region boasts the highest density of endemic plants in Türkiye. Moreover, with 9,677 plant locations across Türkiye, an average of 1.24 locations per 100 km^2 underscores the country's biodiversity richness (Aydoğdu, 2023).

Türkiye rich biodiversity stems from its geographical location, climate, geological structure, soil and water resources, and bird migration routes (Gözcü et al., 2024; Adıgüzel & Solmaz, 2023). With 37 distinct flora regions globally, Türkiye hosts three phytogeographic regions: European-Siberian, Iran-Turanian, and Mediterranean, contributing to its floristic richness (Aydoğdu 2023). The Mediterranean, encompassing Türkiye, holds the highest plant diversity in Europe (Adıgüzel & Solmaz, 2023). Moreover, Türkiye lies at the confluence of two significant gene centers, the Near East and the Mediterranean (Adıgüzel & Solmaz, 2023). Its strategic position and ecological diversity make Türkiye a crucial gene center for many cultivated plants. The country boasts five microgene centers with over 100 plant species exhibiting extensive variation (Erat & Balık, 2022).

The Uludag Mt, known as "Bithynian Olympus" in mythology or "Keşiş Dağı" in the Ottoman period, is the highest mountain of West Anatolia. It is situated between 39°04' – 40°04' N and 28°13' – 29°13' E in the Bursa province. Its range is 40 km long and 15–20 km wide. The altitude of the mountain is 250–300 m southwards of the city of Bursa, and 2543 m at the summit. The Uludag Mt is one of the 122 Important Plant Areas (IPA No: 18) in Türkiye defined by Özhatay et al. (2003), with an "Emergency" status for conservation priorities (Daşkın, 2008; Sakar & Güleryüz, 2024; Akın et al., 2014). The climate of the mountain changes gradually from low altitudes to the summit. While the lower slopes facing Bursa city have a subtype of the Mediterranean climate, in the upper parts the climate is very cold and icy. Owing to these changes in its climate and the geomorphologic structure, six vegetation belts can be distinguished in the Uludag (Daşkın, 2008). In 1961, an area of 11 338 ha in the northern part of the Uludag Mt was declared a national park, owing to its rich biological diversity, different habitats, zonation of its plant communities at various altitudes, and unique geomorphological structure. The boundaries of the Uludag National Park were extended to 12 732 ha in 1996. (Daşkın, 2008). Mt Uludağ has rich plant diversity and one of the major winter sports centres in Türkiye. 1309 taxa of 488 genera belonging to 102 families were identified in the area. One hundred sixty-nine of these taxa are endemic to Türkiye and the endemism rate is 12.9 %. Thirty-one taxa are also known only from Mt Uludağ (Daşkın & Kaynak, 2010a,b).

The primary concern revolves around extensive construction for winter tourism, notably in the foothills and the First and Second Tourism Development Centers within the National Park. Areas such as Sarıalan, Kirazlıyayla, Çobankaya, Kırkpınarlar District, Hotels District, Fatin Hill, Şahinkaya, Kuşaklıkaya, Rasatdüzü, Tungsten Mine, Lakes District, and Alaçam are utilized for both winter sports and summer recreational activities. Unfortunately, these areas also harbor dense populations of endemic plants (Daşkın & Kaynak, 2010a, b). Another potential threat to the area is the establishment of the Area Presidency within the borders of Uludağ National Park. Established on 26.01.2023 under the Ministry of Culture and Tourism, the Directorate functions as a public legal entity with a summarized budget. Its primary purpose is to oversee the protection, preservation, development, promotion, planning, management, and supervision of natural protected areas, including geological and biological assets, water resources, and other protected areas within the Uludağ region. (Mumcu, 2023).

This study focuses on providing ex-situ protection for 11 endemic taxa situated within the area designated as the UAP in 2023 by relocating them to the most suitable habitats within the borders of UNP. The study will begin by identifying plant species categorized as endemic and endangered within the boundaries of the designated area. Once identified, the ecological requirements of these species will be determined using literature data and the digitized database of the area. Suitability analyses will then be conducted utilizing ArcGIS software to identify the most suitable habitats within UNP for these plant species. Indeed, this study holds significant importance for Uludağ, a region renowned for its rich biodiversity. By focusing on the ex-situ protection of 11 endemic taxa within the UAP, this study contributes to the preservation of the region's unique plant species. Additionally, by identifying the most suitable habitats within UNP for these taxa, the study aims to ensure their continued survival and conservation. Ultimately, the findings of this study will not only benefit Uludağ's biodiversity but also serve as a model for conservation efforts in other regions with similar ecological significance.

2. Material and Method

2.1. Material: plants material and study area

UNP is located between 29° 03′ 16″- 29° 16′ 34″ eastern longitudes and 40° 03′ 28″ and 40° 10′ 17″ northern latitudes and covers an area of 12,762 ha. The study area is located within the UNP within the borders of the "Uludağ Regional Directorate" (UAP) in Bursa province (Figure 1) and this area are lived 11 endemic plants. The reason why 11 plants are chosen is that species are threatened. Plants is categorized by International Union for Conservation of Nature (IUCN) danger levels, is as follows: 3 CR (Critically Endangered), 2 EN (Endangered), 5 VU (Vulnerable), and 1 NT (Near Threatened) (Daşkın & Kaynak, 2011a, b; Özbek et al., 2011, Table 1). These plants are shown in Table 1. Besides, the study area is characterized by alpine zone (elevation ranging from 1900 m to 2543 m). The study area is also one of the areas where Türkiye most important winter sports are performed. Therefore are many hotels in the area and in the past ten years, there has been more building of ski slopes in Uludağ. Studies on the plants in the area have shown environmental issues caused by winter tourism and other developments on the mountain (Güleryüz et al., 2011).

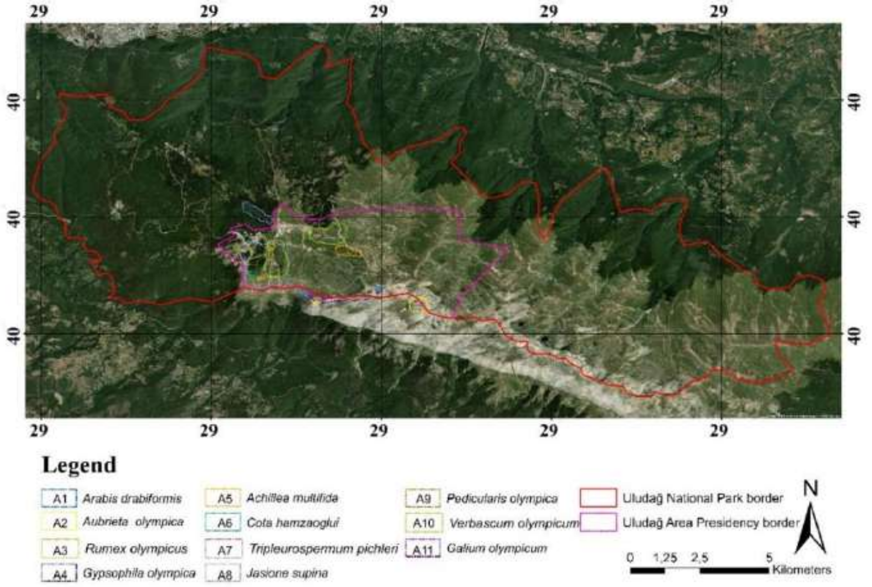

Figure 1. 11 endemic plant species located in and around the study area and UAP; *Arabis drabiformis* (1), *Aubrieta olympica* (2), *Rumex olympicus* (3), *Gypsophila olympica* (4), *Achillea multifida* (5), *Cota hamzaoglui* (6), *Tripleurospermum pichleri* (7), *Jasione supina* subsp. *supina* (8), *Pedicularis olympica* (9), *Verbascum olympicum* (10), *Galium olympicum* (11)

Table 1. Endemic Species Present in the UAP and their distribution areas in hectares according to IUCN categories of endangerment

Code	Latin name	IUCN Category	Area (ha)
A1	*Arabis drabiformis*	EN (Endangered)	3,4
A2	*Aubrieta olympica*	VU (Vulnerable)	25,7
A3	*Rumex olympicus*	EN (Endangered)	1,7
A4	*Gypsophila olympica*	CR (Critically Endangered)	18,2
A5	*Achillea multifida*	VU (Vulnerable)	21,7
A6	*Cota hamzaoglui*	CR (Critically Endangered)	3,1
A7	*Tripleurospermum pichleri*	CR (Critically Endangered)	52,6
A8	*Jasione supina* subsp. *supina*	VU (Vulnerable)	221,5
A9	*Pedicularis olympica*	VU (Vulnerable)	1,2
A10	*Verbascum olympicum*	NT (Near Threatened)	124,6
A11	*Galium olympicum*	VU (Vulnerable)	3,0

2.2 Data collection

We optained data from Digital Elevation Model (DEM), herbarium records, climate stations, soil and geology maps and literature research. We gathered information on threatened species from the IUCN category, drawing from multiple sources such as the 'Flora of Türkiye' by Davis (1965-1985), the Red Book of Turkish Plants, TÜBİVES, Özbek et al. (2011), Daşkın and Kaynak (2011a,b), and Daşkın (2008). Then determined the habitat, elevation, and coordinates of these species. Habitats of the study area were obtained from Urban Atlas (2018) data. To understand the habitat environment better, we used Digital Elevation Model (DEM) data to calculate elevation, aspect, and slope values. DEM data for the study area were acquired from topographic data with a resolution of 10 x 10 m. For temperature data, we relied on the General Directorate of Meteorology (MGM), specifically from the Uludağ Teleferik station numbered 19915. We analyzed the soil structure at the locations where the species live by using information from the Türkiye Soil Map. This helped us identify the main types of soil in those areas. Additionally, we looked at the geological map of Türkiye to understand the rock formations within UNP and the Area Presidency. We recorded all this data, including details about soil and rock structures, in Table 2. We also created maps in Figure 2 to show all the information we used in our study.

Table 2. Habitat, elevation, aspect, slope, soil, rock structure and minimum temperature data of 11 endemic species within the UAP

Code	Habitat	Altitude	Aspect	Slope	Big soil groups	Rock structure	Minimum temperature
A1	Stony-rocky slopes	1800-2307 m	North, Northwest	%43-69	Bare rock and rubble	Granoite	(-11,5)-(-10˚C)
A2	Stony-rocky slopes	200- 2120 m	West, Northwes, South West	%6-25	Bare rock and rubble	Granoid,Marble	(-11,5)- (-9˚C)
A3	Watersides, roadsides and open areas - beech and pine forest clearings	1600-1850 m	North, East	%6-25	Limeless Brown Forest soil	Granoid	(-9˚C)-(-8˚C)

A4	Rock crevices - among *Juniperus communis communities*	2000-2500 m	South, West, Southwest	%6-25	Bare rock and rubble	Granoid	(-11,5)- (-9˚C)
A5	Water edges-alpine stony slopes-alpine meadows-roadside	1610-2278 m	North, Northeast, South	%16-25, %34-43	Bare rock and rubble, High mountain meadow soil, Limeless Brown Forest soil	Granoid	(-10˚C)-(-8˚C)
A6	*Juniperus* ssp. and *Vaccinium* ssp. among subalpine shrubs	2050-2100 m	Northeast, East	%16-25, %25-34	Bare rock and rubble	Granoid	(-9˚C)-(-8˚C)
A7	Moist forest clearings, roadsides, fir-pine forest clearings	1500-1950m	West, Southwes, Northwest	%0-25	Limeless Brown Forest soil	Granoid, Gneiss	(-8˚C)-(-7˚C)
A8	Rocky slopes and moving cliffs	1900-2000m	North, Northeast, East, South, Southwest	%6-25, %25-43, %54-69	Bare rock and rubble, High mountain meadow soil, Limeless Brown Forest soil	Granoid	(-10˚C)-(-7˚C)
A9	River banks, wet places	1600-2300m	North, Northeast	%6-16, %43-54	Limeless Brown Forest soil	Granoid	(-9˚C)-(-8˚C)
A10	*Abies nordmanniana* woodland, meadows	300-1800m	North, West, Northwes, Southwest	%6-25, %25-43	High mountain meadow soil, Limeless Brown Forest soil	Granoid	(-10˚C)-(-8˚C)
A11	Rock cracks, crevices	2300-2500m	West, Southwest	%43-54, %69-98	Bare rock and rubble	Granoid	(-10˚C)-(-9˚C)

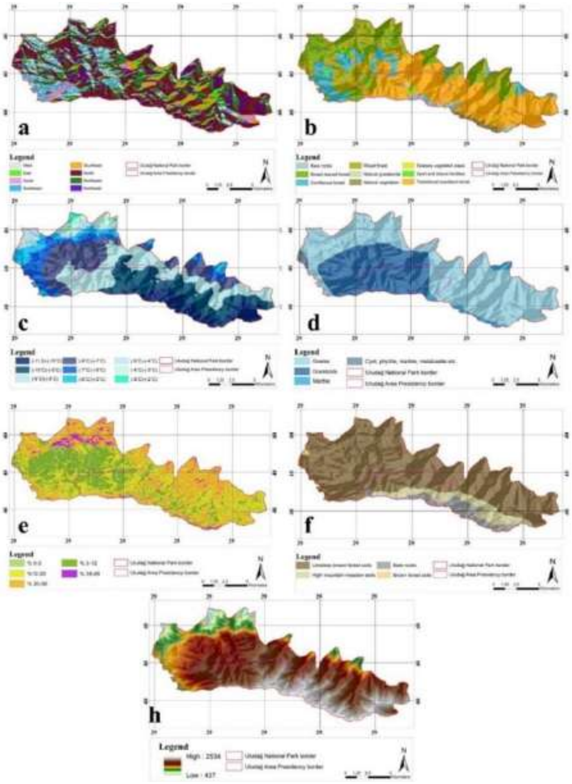

Figure 2. Aspect map (a), land cover map (b), minimum temperature map (c), rock structure (d), slope map (e), large soil groups map (f), and elevation map in the coordinates where the species planned to be transported are located

2.3 Method

We first started working with problem identification. The main problem in the study area is that 11 endemic species remaining in the area transferred to the UAP are in danger due to excessive construction and winter sports. Later, in order to solve this problem, we wanted to transfer 11 endemic plant species in the area to potentially suitable habitats in UNP using the 'Weighted overlay model'. We overlaid 7 different layers (altitude, aspect, slope, rock structure, minimum temperature and land cover) (Figure 3) to identify potentially suitable habitats. Since the station from which the minimum temperature data was taken is located in the northwest of the study area, the 'Lapse Rate' method was used to determine the minimum temperatures in other areas. Then, weighted overlay analysis was performed. In order to determine the weights of the layers used in the analysis, a survey was conducted taking into account expert opinions.

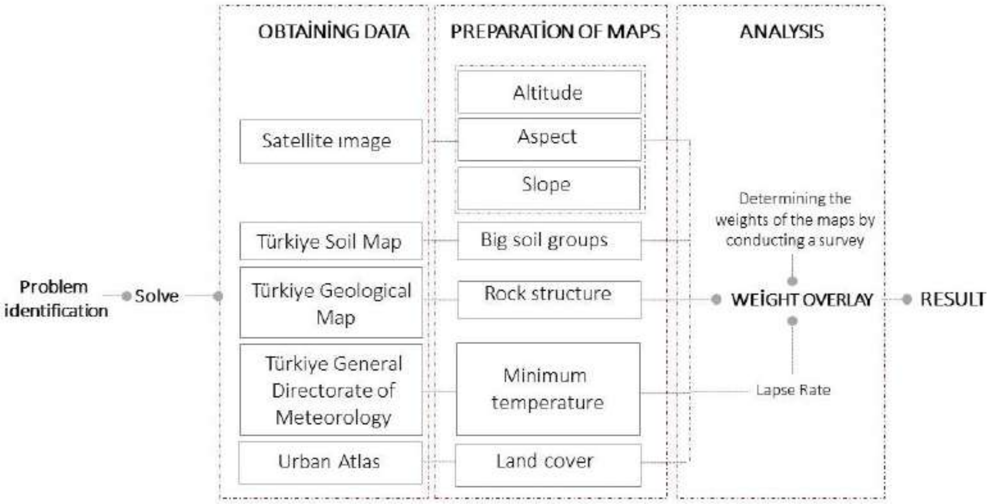

Figure 3. Method scheme

2.3.1. Modeling potential distribution of minimum temperature

The lapse rate method is used to estimate the distribution of minimum temperatures at other locations, considering a climate station with known coordinates and elevation. This method helps fill in gaps in climatic data for higher points that are not directly available from sources like the MGM. Vertical lapse rates typically average around 6°C per kilometer in the free troposphere, though there can be seasonal and geographical variations (Agnew & Palutikof, 2000). This study, temperature data were focused on February, considering it as the month with the lowest average temperature recorded for Uludağ (1.7 ˚C) (Öztürk, 2010). The lowest temperature measured at Uludağ Teleferik station on 03.02.2024 was recorded as -8 ˚C (MGM, 2024). Then, we generated 500 random points in the area using the 'Create Random Point' extension. The minimum temperatures at these points were determined by applying the Lapse rate formula in the 'Raster Calculator' command, considering the elevation data at the points. We used the Inverse Distance Weighting (IDW) extension to interpolate minimum temperature distribution at these points, providing minimum temperature distributions within the National Park borders. After determining the distribution, we classified minimum temperatures using the 'Reclassify' extension to facilitate the 'Weighted Overlay' analysis. Minimum temperature data in the habitats where the species thrived were digitized in the ArcGIS environment and recorded in Table 2. Additionally, the Lapse rate formula utilized to estimate temperatures at other points in the ArcGIS environment is represented in Equation 1.

Td = Ti + (hi * 0.005) **(Equation 1)**

Td = Temperature reduced to sea level

Ti = Average temperature of the station

hi = Height of the station (Demircan et al., 2014).

2.3.2. Distribution of endemic plants using the weighted overlay model (WOM)

The weighted overlay technique involves creating a map by layering multiple raster images, with each layer weighted according to its importance (Saaty, 1990). The weighted overlay method is a straightforward and effective technique (Shit et al., 2016). All numerical data for our study were imported into the ArcGIS environment. Before conducting the 'Weighted Overlay' analysis, we converted vector data to raster format. Existing raster maps for slope, elevation, minimum temperature, and aspect were directly analyzed without preprocessing. Habitat, soil, and rock structure data in vector format were converted to raster format using the 'polygon to raster' command. Once all parameters were converted to raster format, we determined weight values for parameters using the 'Weighted Overlay' command, guided by expert opinions. We identified suitable areas within the National Park borders for species classified as threatened according to both endemicity and IUCN category. The weight values assigned by experts for the parameters used in the study are presented in Figure 4. In the study, we surveyed a total of 10 experts, asking them, "Which parameters are more important for a species to thrive in an environment other than its natural habitat?" We then determined the weights of their responses as percentages and inputted these values into the ArcGIS software.

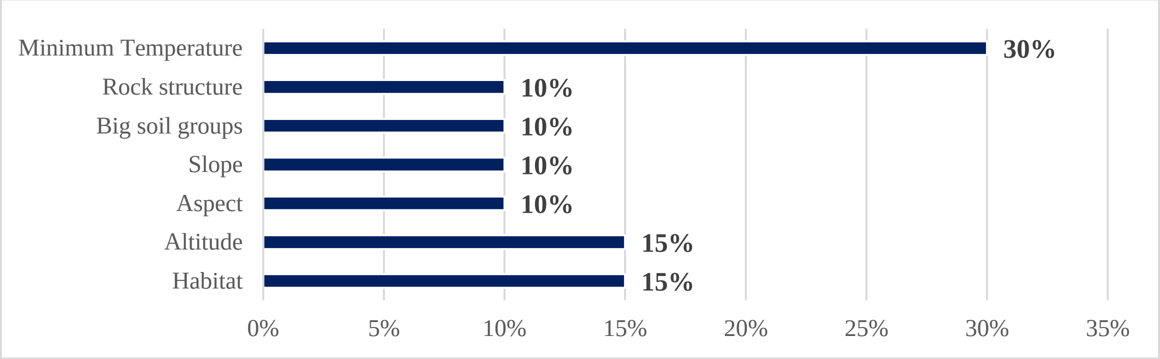

Figure 4. Weight values of habitat, elevation, aspect, slope, soil, rock structure and minimum temperatures used within the scope of the study

3. Findings and Discussion

A total of 7 parameters were overlaid, each with different weights, for the 11 endemic species within the UAP. Then, suitability maps were created using 'Weighted Overlay' analysis and suitable areas for modeling potential distribution of habitat within the Uludağ Nation Park were determined (Figure 4). The results of the weighted overlay analysis are examined, and it is determined that some of the 11 endemic species grew within the UNP and outside the UAP. However, *Cota hamzaoglui* and *Galium olympicum* species are located within the borders of the UAP, (Table 3) which is under pressure from winter sports. After conducting a suitability analysis for the *Gypsophila olympica* species, which occupies an area of 18.2 hectares within the region and is categorized as "CR" (Critically Endangered) by the IUCN, we found that there is potential for development in an area spanning 379.3 hectares outside the jurisdiction of the UAP. Another species, Arabis drabiformis, covers an area of 3,4 hectares within the region and is classified as "EN" (Endangered) according to the IUCN. After conducting the suitability analysis, we found that there could be a potential development area spanning 485.1 hectares outside the jurisdiction of the UAP. Similarly, for the *Rumex olympicus* species, which occupies an area of 1.7 hectares within the region and is also classified as "EN" by the IUCN, our analysis revealed a potential development area of 1.945,2 hectares outside the UAP.

Table 3. Total suitable areas (ha) within the Area Presidency, outside the Area Directorate and within the borders of UNP for endemic and threatened species according to IUCN category within the UAP

Species	Suitable areas within the Area Presidency (ha)	Suitable areas outside the Area Presidency (ha)	Total suitable areas within the National Park (ha)
Arabis drabiformis	119,6	485,1	604,7
Aubrieta olympica	649,1	357,3	1.006,4
Rumex olympicus	545,5	1.945,2	2.490,7
Gypsophila olympica	285,2	379,3	664,5
Achillea multifida	1.717,5	3.695,8	5.413,3
Cota hamzaoglui	18,9	0,0	18,9
Tripleurospermum pichleri	43,0	2.617,6	2.660,6
Jasione supina Sieber ex Spreng. subsp. *supina*	1.380,1	2.771,1	4.151,2
Pedicularis olympica	718,6	2.339,4	3.058
Verbascum olympicum	976,0	1.571,8	2.547,8
Galium olympicum	66,9	0,0	66,9

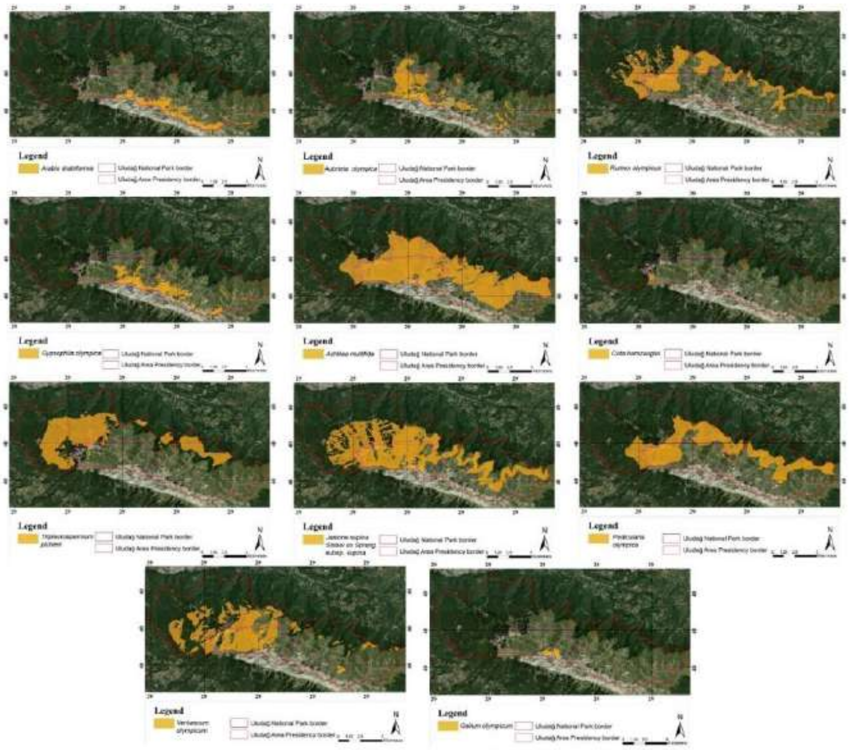

Figure 4. Areas found suitable as a result of the 'Weighted Overlay' analysis for endemic and threatened species according to IUCN category within the UAP

As a result of the study, suitable areas is identified within the UNP area border, except for only two of the 11 species examined. Within the borders where the analysis was carried out, *Conta hamzaoğlu* and *Galium olympicum* species grow only within the borders of UAP. The protection of these species is more important than other plant species. Because these species develop only in the habitats where they currently exist. Apart from these species, it is possible that the 9 species examined develop in different habitats within the UNP area border. This situation poses a risk for the area to which UAP was transferred in 2023 and which is exposed to anthropogenic interventions as a result of tourism activities. In this context, the protection status of the area will need to be reviewed. This study has a few limitations. Firstly, we only looked at potential habitats within UNP, ignoring areas outside the park that could also be suitable. Expanding our analysis to cover the whole of Türkiye could give us a better picture. However, it's tough to rely on these programs entirely when dealing with species that are only found in small areas, as we don't have much data to work with. Also, there's not a lot of existing research on the 11 species we studied, which makes it hard to find information and analyze it. Getting hold of things like seeds or live plants for these species is another big challenge, which slows down our research. Additionally, if sufficient information about the species is provided, programs based on future projections such as the Maximum Entropy MaxEnt can be used. These limitations show why it's important for different experts to work together and come up with new ways to tackle the problems we face in conserving biodiversity.

4. Conclusion

This study provides comprehensive analyzes for the conservation of 11 endemic taxa within the UAP. A thorough 'Suitability Analysis' was conducted within the confines of UNP for these taxa, which face endangerment due to winter sports activities. The results revealed suitable areas for all taxa except A6 (*Cota hamzaoglui*) and A11 (*Galium olympicum*), which exhibited suitable areas solely within the UAP borders.

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Examining Dynamic Urban Open Spaces: The Case of Museum Gazhane

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Abstract

In the contemporary era, individuals residing in urban environments require access to locations that facilitate social interaction and engagement. It is therefore evident that urban open spaces are of significant importance. The quality of urban open spaces in high-density areas directly impacts key issues like quality of life, sustainability, and urban welfare. In this context, the reuse of disused industrial heritage has the potential to make a significant contribution to the city. This study examines the Museum Gazhane, which occupies a significant position in Istanbul's industrial heritage and has been transformed through the process of adaptive reuse, situated within the context of urban open space. This study employs a behaviour-based assessment to investigate the impact of the Gazhane Museum's historical and cultural value, social diversity and community engagement on the vitality, diversity, and utilisation of open spaces. In the case study, data on open spaces and users were collected through observation, interviews, videographing, and behavioural mapping. By examining the role of the Museum Gazhane's transformation over time, this study highlights the importance of reused spaces in the design of quality urban open spaces and the diversity, vibrancy, and diverse uses they offer, which should be considered in creating liveable cities.

Keywords: Urban open space, industrial heritage, adaptive reuse, place-making, place identity

1. Introduction

As urban populations continue to grow rapidly, the need for spaces where individuals from diverse cultural backgrounds can express themselves is becoming increasingly critical. In this context, urban open spaces hold a key role in fostering social interaction and accommodating a variety of activities. According to Woolley (2003), urban open spaces are defined as areas that provide opportunities for various activities, including necessary, optional, and social activities. However, Istanbul, a metropolis with a population of approximately 16 million, lacks sufficient urban open spaces to meet the needs of its dense population. To address this deficiency, new open spaces are being introduced for public use daily.

One notable example in this regard is Museum Gazhane, which was opened to the public in 2021. Formerly known as Hasanpaşa Gasworks, this site was established as an industrial facility in the late 19th century but was decommissioned in the late 20th century due to its inability to meet contemporary demands. Following its closure, the site was recognized as industrial heritage through local advocacy efforts and was subsequently repurposed as a public space. Today, Museum Gazhane functions as a cultural open space, supporting social and cultural activities with its diverse range of functions. With its historical depth and adaptive reuse process, Museum Gazhane stands out as a significant case study. This study aims to evaluate the various functions and open spaces of the site and analyze their effects on the area's vitality, usage patterns, and user diversity. The hypothesis of this research is that repurposed industrial heritage sites play a crucial role in urban open space use and social interaction, while also enhancing user diversity and the vibrancy of such spaces. Through a comprehensive analysis of Museum Gazhane, this study seeks to explore the intricate dynamics between public open spaces and their users, offering significant contributions to urban planning, heritage conservation, and social cohesion.

Placemaking, as defined by Gehl (2010), involves a collaborative approach to designing and revitalizing public spaces to enhance their functionality, aesthetics, and appeal. This participatory process engages various stakeholders, including residents, businesses, and urban planners, to transform neglected areas into vibrant spaces fostering social interaction, cultural expression, and community identity (Gehl & Svarre, 2013). Effective placemaking emphasizes community engagement, cultural integration, and sustainable design, ensuring urban spaces are both functional and reflective of local identity (Cresswell, 2004; Hester, 2006). Urban open spaces, such as parks, squares, and streetscapes, play a pivotal role in placemaking. These spaces are shaped by key elements, including community engagement, which ensures designs reflect local needs (Project for Public Spaces, n.d.); design and activation, enhancing both functionality and aesthetics (Whyte, 1980); and the incorporation of cultural and historical significance, fostering a unique sense of place (Cresswell, 2004). Moreover, programming events and activities promote social interaction, while addressing safety and accessibility ensures inclusivity (Carmona et al., 2010).

In the context of **industrial heritage**, placemaking extends beyond revitalizing urban spaces to preserving and reimagining structures emblematic of the industrial era, such as factories, railways, and warehouses. Industrial heritage embodies the social, economic, and technological transformations of the past, offering a tangible connection to history. Adaptive reuse—a key strategy for repurposing such spaces—transforms them into functional hubs for contemporary use while preserving their unique character. This approach balances the conservation of cultural heritage with the needs of modern urban life (Hester, 2006).

Adaptive reuse aligns closely with placemaking principles. For example, industrial sites can be transformed into community hubs, integrating public spaces with cultural and social activities. This transformation is guided by design and activation that honors historical narratives while fostering new uses, community engagement to ensure the spaces resonate with local identities, and programming to animate these hubs with events and activities. Safety and accessibility considerations further ensure inclusivity and usability.

The concept of **urban open spaces** is crucial in placemaking, as these areas serve as platforms for social interaction and community engagement. Observational studies by Whyte (1980) and Gehl & Svarre (2013) reveal how design elements—such as seating arrangements and spatial configurations—shape human interaction. These spaces act as community hubs, strengthening social bonds and fostering shared experiences. By integrating placemaking principles into the adaptive reuse of industrial heritage, cities can create dynamic, inclusive spaces that celebrate history while addressing contemporary urban needs. This holistic approach fosters cultural continuity, community vitality, and sustainable development, ensuring urban spaces remain vibrant and relevant for future generations.

2. Material and Method

2.1. Study area: Museum Gazhane

Museum Gazhane, located within the borders of Kadıköy district of Istanbul province, is a cultural facility that serves different functions today. However, the area went through different processes until it came to its current use. The complex, located in Hasanpaşa District and has survived to the present day, was established in 1892 as a gas production facility. This function appears as the largest gas production facility on the Anatolian Side. The building, which continued its industrial function until 1993, lost its function and was closed with the transition to natural gas use in Istanbul during this period.

Figure 1, 2. Pre-project view of Gasworks (Altınsay, 2021),
Post-project view of Hasanpaşa Gasworks (IBB)

History of Museum Gazhane

The Hasanpaşa Gasworks, one of three gasworks established in Istanbul in the late 19th century alongside Dolmabahçe and Yedikule, began as a sprawling, low-density industrial facility. Over time, it evolved to accommodate the growing gas demands of the city, gradually becoming more compact with the addition of new structures. However, the gasworks ceased operations in 1993 due to obsolescence. The period following its closure, crucial to our analysis, spanned 28 years and marked a significant chapter in Türkiye's architectural preservation and urban rights movements. Starting with documentation efforts by Istanbul Technical University (ITU) students in 1996 and the formation of the Gazhane Çevre Gönüllüleri (Gazhane Environmental Volunteers) in 1997, the site's preservation struggle gained momentum. This advocacy ultimately led to its registration by the conservation board and designation for public use in 2014. In 2021, after extensive transformation, the site reopened as 'Müze Gazhane', symbolizing a successful shift from industrial use to cultural heritage preservation and public accessibility.

In 1994, the concept of industrial heritage was still developing in Türkiye, and the preservation of Hasanpaşa Gasworks stands as a key example of local community efforts to prevent its commercialization. Through the organization of Gazhane Festivals and the work of the Gazhane Environmental Volunteers, the area was successfully reimagined and repurposed as a public space. Ultimately, the transformation of the site from an industrial facility to an urban wasteland and, eventually, to a vibrant open space highlights the role of local residents in preserving this cultural landmark.

Site analysis

This study conducted higher-level analyses to better understand the relationship between Museum Gazhane and its immediate surroundings. As shown in Figure 5 the green spaces in the Kadıköy Hasanpaşa neighbourhood are particularly inadequate. Therefore, the green and open spaces within Museum Gazhane are of great importance to the residents of the neighbourhood. The accessibility of Museum Gazhane by public transport is illustrated in Figure 6. Due to the proximity of bus, metrobus and Marmaray stops, Müze Gazhane is used not only by local residents but also by many individuals from different parts of Istanbul.

Figure 3. Green Space Analysis

Figure 4. Accessibility Analysis

The land use analysis presented in Figure 7 highlights that Museum Gazhane is located in the midst of dense residential and educational areas. The proximity to educational institutions ensures active use of the social and working areas within Museum Gazhane by students from these institutions. In addition, Museum Gazhane is used as a shortcut by residents going to the well-established Tuesday market in Kadıköy. The analysis of open spaces in Figure 8 shows that all the open spaces in the densely populated residential area are private and therefore restricted to the use of property owners. However, the educational units in the vicinity of Museum Gazhane can be used by the public on certain days and at certain times, thus contributing to wider community use.

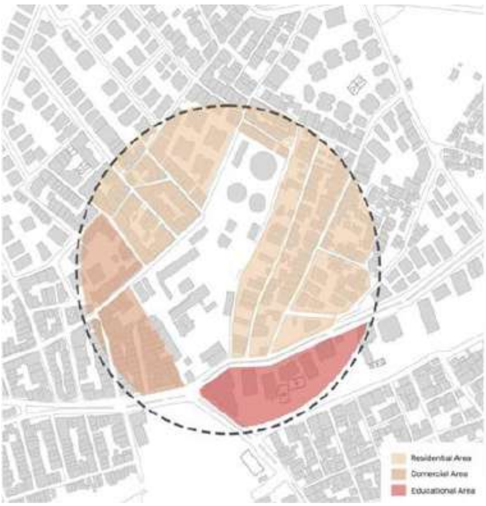

Figure 5. Land-use Analysis

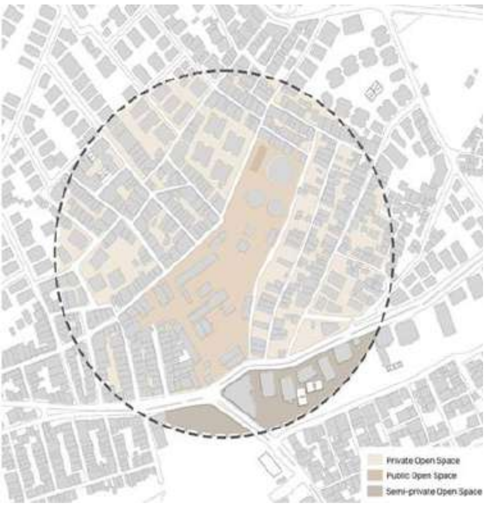

Figure 6. Open space Analysis

After the re-functioning, the industrial and historical traces of the gasworks were preserved and the buildings in the area were given the functions of a restaurant, cafeteria, sound/silent work areas, library, bookshop, theater hall, open-air exhibition, workshop, and museum. In the site plan in Figure 9 the existing functions and function distributions after the transformation are expressed.

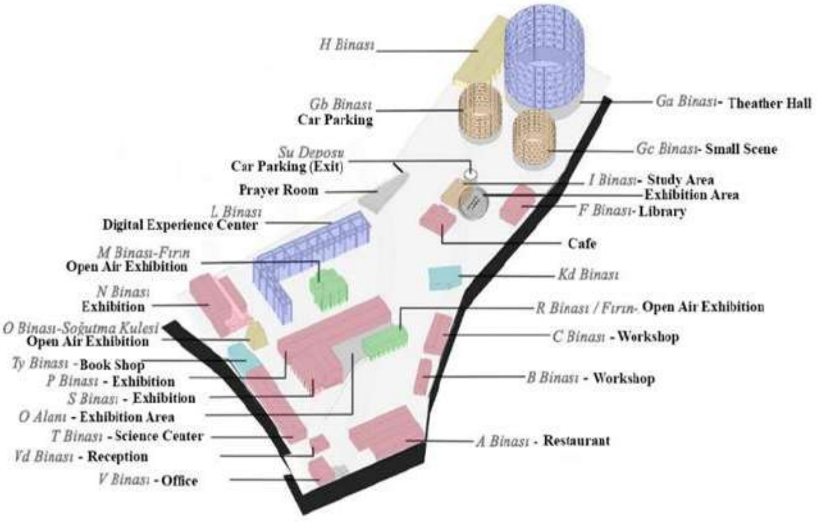

Figure 7. Functions of the Museum Gazhane (Ayvaz and Halaç, 2023)

During the transformation of the building into a public space, areas that can perform functions such as concerts, open-air cinemas, and exhibitions have been designed for the use of open spaces by the user. In addition, the open area includes various sculptures produced with techniques that do not conflict with the historical identity of the building, and green areas that allow the area to be used with different functions for users.

2.2. Research question and hypothesis

The research aims to evaluate the site by examining the Museum Gazhane in the context of the placemaking concept. In this context, it is aimed to examine the multifaceted effects of different functions and open spaces in the Museum Gazhane on the liveliness of the area, usage patterns, and user diversity, by considering the historical and cultural identity of the area together with the placemaking concept. Within the scope of the study, it is assumed that the different functions and uses of open spaces in the Museum Gazhane contribute significantly to the vitality and dynamism of the area. The hypothesis suggests that diversity in functions, ranging from historical exhibitions to contemporary cultural events, combined with the spatial layout that accommodates different activities, fosters a livelier and more engaging environment. Additionally, this multifunctional and diverse spatial design is anticipated to not only influence usage patterns but also attract a more diverse user demographic by promoting a sense of inclusivity and community participation in the Gazhane area.

2.3. Methods

In this study, the functionality of the open spaces in Museum Gazhane and the user-open space relationship were analyzed. For this purpose, observational mapping, tracking, videography, and survey methods were employed to evaluate the vitality, usage patterns, and user diversity of the area. These methods, supported by a literature review, provided a comprehensive basis for testing the hypothesis.

Placemaking, a collaborative and participatory approach to designing and reshaping public spaces to enhance their functionality, aesthetics, and overall appeal, was the focus of this research. The concept of place was analyzed through four key dimensions: sociability, uses and activities, comfort and image, and access and linkages, alongside their associated intangible qualities. Within this framework, placemaking was utilized as a method to evaluate Museum Gazhane, an urban open space, in terms of its liveliness, usage patterns, and user diversity.

Table 1. Categories, Variables, and Questions

CATEGORIES	VARIABLES	QUESTIONS
OPEN SPACE	FUNCTIONS AND ACTIVITIES	How is the historical identity of the place perceived by the user?
		What are the effects of the changing functions of the Gazhane over time on the open space?
	RELATIONSHIP WITH INTERIOR SPACES	What is the relationship between the use of undefined areas and open spaces around closed spaces?
		How do the functions of closed spaces affect the use of open spaces?
	SURFACES (SOFT/HARD)	Are the existing green areas sufficient for the users of the Gazhane?
		How do different types of surfaces affect the use of open space?
USER	ACTIVITES	How is the Museum Gazhane used when periodic events are not held?
		How does the use of open spaces at Museum Gazhane change on specific event days?
	DEMOGRAPHIC	How and by whom is the Museum Gazhane used when periodic events are not held?
		How the cultural and demographic factor affect the utilization of open and closed spaces in Museum Gazhane?
	USAGE PATTERNS	How are the open spaces at the Museum Gazhane used at different times of the day?
		Does the fact that Museum Gazhane is an industrial heritage affect the use of space?
	LOCALITY	Does Museum Gazhane meet the open space needs of the residents?
		Does the Gazhane Environmental Volunteers have an impact on the use of open spaces, and if so, how?
		For what purposes do residents use the space?

In this context, the area was examined in two categories: open areas and users. Under the title of open spaces, the functions and activities, the relationship with interior spaces, and surface variables were measured by utilizing the questions presented in Table 1**.** However, under the title of users, activities, demographic data, usage patterns, and locality variables were measured with the questions shown in Table 1. These measurements were made using observational mapping, tracking, videography, and survey methods. These observations made within the scope of the research could only be made on Sundays between 10.00 and 18.00 due to the limitations of the study and seasonal conditions. Therefore, while these methods, which were used for a limited period, were used in the evaluation process of the area, they were used as data regarding the use of the area at noon hours on the weekend rather than the general use of the area. It is aimed to express user activities and the open-closed space relationship with the observational mapping method. By using the observational mapping method, the users, activity types, and activity locations of the Museum Gazhane were visually recorded. The usage pattern of open areas is expressed with the map created with this method. Using the tracking method, it is aimed to observe the diversity of usage, the directional preferences of the users, and which entrance is used by which users. Videographing, another method used, aims to identify user activities and observe the relationship between open space and public life. Finally, a qualitative survey was conducted with users. This survey aimed to collect demographic data of the users, to learn who uses the area, and to find out the users' thoughts about the area. Within the scope of this survey, the following questions were asked of users:

- What is your gender/age/occupation/place of residence?
- Have you ever been to Museum Gazhane before? If yes, how often do you visit this place?
- What brings you to the Museum Gazhane?
- Did you know/do you know that the Museum Gazhane is of historical value?
- Does the historical value of the site mean anything to you? If yes, what does it mean?
- Do you think the open green areas in the Museum Gazhane are sufficient?
- Do you think the Museum Gazhane meets the open space needs of the users?

With these methods and observation methods used in the study, it is aimed to collect data on how and by which users the Museum Gazhane is used. The field will be evaluated with this collected data. In addition, it will be revealed how the different functions and open spaces in the Museum Gazhane affect the liveliness of the area, usage patterns, and user diversity.

3. Findings and Discussion

Throughout the study, various findings were obtained by using observational mapping, tracking, videographing, and survey methods to reveal how the different functions and open spaces in the Museum Gazhane affected the liveliness, usage patterns, and user diversity of the area and to evaluate the area. These findings will be presented in this section and the study will end by expressing our observations and thoughts during the study on the Museum Gazhane. Thirty-eight volunteers participated in the survey, which is one of the methods used in this context. 15 of them (39.4%) are women and 23 (61.6%) are men. 8 of these users (21.0%) are students, 11 (29.0%) are visitors, 9 (25.0%) are employees and 9 (25%) are between the ages of 18 and 60. 0) is defined as local user. Additionally, 20 (52.7%) of the survey participants are under the age of 30, and the remaining 18 (47.3%) are over the age of 30. The surveys conducted within the scope of the study were divided into 4 main user categories: locals, students, visitors and workers, and the data obtained as a result of the qualitative survey study was tried to be expressed. Among these users, visitors refer to people who use the area for sightseeing, while students can be defined as people who use the area to study. However, workers can be defined as people who perform the services provided in the area, and locals can be defined as people who frequently use the area for various activities and live close to the area. When the locations of the surveys (Figure 10**)** were examined, some usage patterns were observed. With the categorization made in the surveys, an observation was made about which user type uses which area more frequently. In this context, while the locals are mostly located around the cafe, which is in the most central location of the area, a concentration of usage was observed among the students around the cafe, study area, and library. However, visitors who come to visit the area and workers who provide services in the area are located throughout the area.

Figure 8. Locations of the Surveys

Museum Gazhane emerges as a multifaceted and welcoming space that intricately addresses the diverse needs of its users. This includes students and families with children who find the open layout conducive to their activities. Operating as a Social-Hub, the site draws individuals from various corners of the city, fostering a rich tapestry of user diversity. The open spaces within Museum Gazhane are not merely utilitarian but serve as key gathering spots that fulfill the varied open space requirements of Kadıköy. Remarkably flexible in design, the open areas in the vicinity can be adapted to a range of purposes, reflecting an inherent versatility. Despite the presence of security measures, such as personnel and cameras, the true sense of security emanates from the active engagement of the users themselves, highlighting the participatory nature of the space. Beyond their role as active zones, these open areas also double as convenient passages, with the Tuesday market users frequently utilizing the space for transit and abbreviation. The success of the restoration and refunctioning efforts is particularly acknowledged by users who possess a keen awareness of the historical texture of the area. The integration of green spaces within the site goes beyond aesthetic considerations, creating a positive impact not only on the local Kadıköy community but also resonating more broadly in the city of Istanbul.

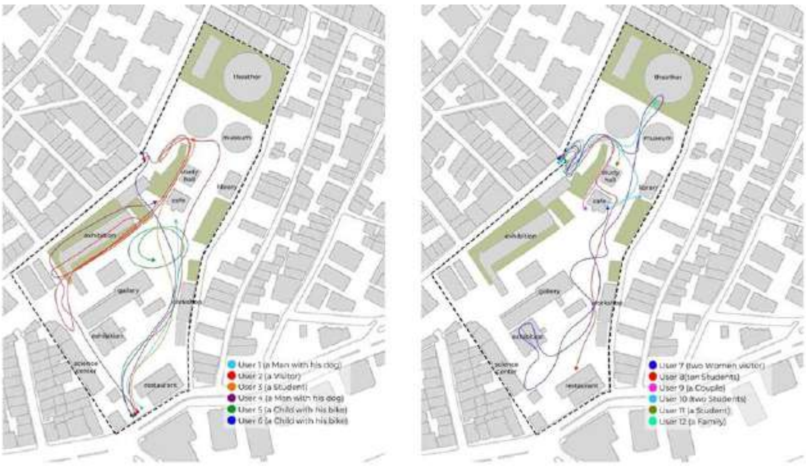

Figure 9. Museum Gazhane's various user routes

The utilization patterns at Museum Gazhane vary among different groups. While employees tend to avoid the space on non-working days, families with children and dog owners use it as an informal park for recreational activities. The site's squares are diverse, reflecting the variety of functions and activities hosted within, with local users, workers, and students engaging with its services, while visitors explore its different aspects. Ultimately, Museum Gazhane stands as a dynamic, adaptive urban space that blends historical preservation, community engagement, and versatile functionality.

4. Conclusion

This study highlights the significant social benefits of adaptive reuse when applied to industrial heritage sites, with Museum Gazhane serving as a compelling case study. The museum's multi-layered spatial structure not only embodies its rich historical depth but also illustrates the evolution of industrial heritage preservation while maintaining its historical significance. By employing a comprehensive methodological approach that includes observation, behavioral mapping, tracking, videography, and surveys, the research provides valuable insights into usage patterns and the role of open spaces in enhancing the vitality of Museum Gazhane. As a versatile and accessible urban space, Museum Gazhane effectively facilitates social interaction among diverse user groups, thereby fostering community engagement. This study underscores the critical importance of repurposing and conserving industrial heritage sites to improve urban quality of life. By promoting social interaction and raising awareness of cultural heritage, such initiatives contribute to a more sustainable and socially cohesive urban environment.

Note

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How to Achieve Sustainable Natural River Recreation?

- Learning from Case Studies

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Abstract

Recreation is one of the most important ecosystem services provided by river corridors. As a significant form of outdoor recreation, a large number of tourists worldwide participate in outdoor river recreations every year. However, with the reduction of free-flowing rivers globally due to the process of urbanization and other human behaviors, there is an urgent need to address the issue of how to make natural river recreation more sustainable.

This paper selects internationally representative rivers in national parks that provides recreation activities as case study areas, including the Colorado River (Grand Canyon National Park section) in the USA, the Whanganui River (Whanganui National Park section) in New Zealand, the Zambezi River (Zambezi-Victoria Falls National Park section) in Africa, and the Amazon River (Amazon National Park section) in Brazil.

Through literature review, this paper examines important natural river recreation management practices to follow in spatial planning, visitor management and facility and sites management, and threats to be wary of in collaborative management, environmental impact control, visitor experience management, new recreational equipment and activities, and monitoring and assessment.

Keywords: Natural river, recreation, sustainable, management

1. Introduction

As the pace of urbanization accelerates and the quality of life for residents improves, natural river recreation is increasingly becoming a popular choice for people to connect with nature and relax their minds. However, the frequent occurrence of recreational activities also poses significant challenges to the ecological environment of natural rivers. How to meet the public's demand for natural river recreation while ensuring the integrity and sustainability of river ecosystems has become a key issue in landscape planning, environmental protection, and tourism management.

Based on an overview of concepts of sustainable tourism, river recreation, ecotourism, alternative tourism, nature tourism, outdoor tourism, protective tourism, and adventure tourism, we define sustainable natural river recreation as: a type of in-river or riverfront leisure activity that focuses on less disturbed river corridors and related cultural landscapes, with education, learning, and appreciation of the river ecosystem as the basis of activities. It emphasizes visitor responsibility, river environmental education, and the controllability of the impact of tourism activities.

Sustainable natural river recreation focuses on the following points: a. emphasizing less disturbed natural river corridors as the primary draw for tourists. b. visitors taking on corresponding responsibilities. c. emphasizing natural education, with the appreciation, learning, and protection of the river ecosystem as the main activity content. d. controlling the environmental impact of tourism activities to promote the ecological, economic, and social-cultural sustainability of tourist destinations. In short, sustainable natural river recreation aims to achieve three goals: controlling the impact on the ecological environment, providing high-quality visitor experiences, and bringing economic benefits to the community.

Globally, some areas have taken the lead in sustainable natural river recreation due to the uniqueness of their river resources or advanced regional development. How do they manage natural river recreation? What measures have they taken to achieve these three goals? What insights do these experiences offer for the global development of sustainable natural river recreation? This paper will explore and answer these questions through case studies.

2. Material and Method

2.1 Case study

We choose for typical natural river recreation areas and read through their management plans related to river creation (Figure 1): Colorado River (Grand Canyon National Park section) in the USA, the Whanganui River (Whanganui National Park section) in New Zealand, the Zambezi River (Zambezi-Victoria Falls National Park section) in Africa, and the Amazon River (Amazon National Park section) in Brazil. Some core river recreation management strategies were copied out and organized from the official management plan. Then we make a contraction of the four cases.

In this study, we selected representative natural riverine recreational areas and conducted a thorough review of their management plans with a focus on river recreation. The selected rivers include the Colorado River within the Grand Canyon National Park in the United States, the Whanganui River in the Whanganui National Park in New Zealand, the Zambezi River in the Zambezi-Victoria Falls National Park in Africa, and the Amazon River in the Amazon National Park in Brazil (refer to Figure 1). We extracted and categorized key river recreation management strategies from the respective official management plans. Subsequently, we synthesized a comparative analysis of the management strategies across these four cases.

Figure 1. Cases' locations (National Administration of Surveying, Mapping and Geoinformation of China, 2008)

3. Findings and Discussion

The following outlines the core management strategies for river recreation across the four case studies. It is evident that among the three overarching goals of sustainability, the control of ecological impact and the enhancement of visitor experience are the primary foci, whereas there is a relative paucity of strategies aimed at promoting community benefits.

Of the four cases, the Colorado River appears to have the most comprehensive strategies related to river recreation. Moreover, it boasts the most detailed river recreation management plan, which may be related to the fact that the USA has built the Wild and Scenic Rivers System. This suggests a greater emphasis on the importance of river systems within the country.

Table 1. Core Management Strategies for River Recreation in the Colorado River (Grand Canyon National Park Section), USA

Managers		
The Office of Planning and Compliance and the National Park Service		
Main River Recreation Activities		
Rafting, Canoeing, River Hiking, and River Camping		
Core River Recreation Management Measures		**Corresponding Sustainable Goals**
River Focused Plan	Developed the Colorado River Management Plan (2006) for detailed planning of river recreation activities.	EVC
River Segmentation Management	Implemented the River Opportunity Spectrum (ROS) framework for segmented and zoned management of the river, including detailed regulations for boat numbers, types (motorized and non-motorized), trip type (commercial and non-commercial), number of people, time, and trip length.	EVC
Adaptive Management	Update the planning scheme approximately every 20 years based on monitoring and assessment results.	EVC
Recreation Impact Control Special Plan	Implemented the Research and Monitoring Mitigation Plan: Constructed a concept model of recreational impact based on ROS zoning; applied the LAC (Limits of Acceptable Change) theory, through monitoring and feedback mechanisms for adaptive management.	EVC
Collaborative Management	Managed in partnership with indigenous tribes, concessionaires, and other government departments.	EVC
Visitor Management	Managed visitor capacity through a reservation system and weighted lottery; implemented “soft” visitor behavior guidelines for safety and security; conducted regular water quality monitoring to ensure visitor safety.	EV
Infrastructure Management	Constructed recreational facilities following ecological design principles and requiring pre-approval; managed motorized and non-motorized boats in different areas.	EV
Educational Promotion	Used multimedia education, such as websites and DVDs, to convey the importance of river protection to the public.	EV
Clear Responsibilities	Different management measures were overseen by specific departments to ensure clear division of responsibilities.	EV
Administrative Visit Management	Established separate management methods for administrative river visits, requiring administrative river assessments and approval processes, including Minimum Requirements Analysis (MRA), before the trip.	EV

Note: “EVC” in the table stands for “Ecological Impact Control, Visitor Experience Enhancement, and Community Benefit Promotion”.

Table 2. Core Management Strategies for River Recreation in the Whanganui River (Whanganui National Park Section), New Zealand

Managers		
Department of Conversation (DOC)		
Main River Recreation Activities		
Canoe or kayak Whanganui water tour, jet boat, river hike, river camping		
Core River Recreation Management Measures		Corresponding Sustainable Goals
Special Chapter	Section 6.3 of the Whanganui National Park Management Plan 2012-2022 specifically addresses river recreation management planning.	EVC
Legal Framework	Management of recreational activities is governed by legally enforceable regulations.	EVC
Adaptive Management Strategy	Plans are updated periodically based on monitoring and assessment results to adapt to new challenges, including adjusting visitor capacity and addressing new issues.	EVC
Collaborative Management	Management is carried out in partnership with indigenous tribes, concessionaires, and other government departments.	EVC
Visitor Management and Monitoring	Visitor capacity and usage are managed through a reservation system, including water travel, accommodation, and camping sites. A "soft" approach to visitor behavior is used for safety and behavioral guidance.	EV
Visitor Experience Survey	In collaboration with other agencies, a visitor experience survey is conducted at least every five years to enhance service quality.	V
Infrastructure Management	Requirements for camping sites are established; DOC is responsible for the construction and maintenance of essential recreational facilities such as toilets, shelters, and access points. Due to issues with river management ownership, DOC cannot restrict the number or type of boats.	EV

Table 3. Core Management Strategies for River Recreation in the Zambezi River (Zambezi-Victoria Falls National Park Section), Africa

Managers		
Zimbabwe Parks and Wildlife Management Authority (ZPWMA)		
Main River Recreation Activities		
Riverboat Cruise, Canoeing, Kayaking, Helicopter River Flight, River Hiking, Whitewater Rafting		
Core River Recreation Management Measures		**Corresponding Sustainable Goals**
Visitor Management	"Soft" visitor behavior guidelines are used for safety and behavioral management; there are no clear visitor capacity limits.	EV
Visitor Monitoring	Monitoring of boat numbers and visitor flow, in conjunction with ecosystem monitoring, to assess the ecological impact of recreation.	EV
Collaborative Management	Management in partnership with local communities, international organizations, and concessionaires.	EVC
Adaptive Management	The park continuously adjusts and optimizes river recreation management measures based on monitoring data and assessment results.	EVC

Table 4. Core Management Strategies for River Recreation in the Tapejara River (Amazon National Park Section), Brazil

Managers		
Brazilian Institute of Biodiversity Conservation (ICMBio)		
Main River Recreation Activities		
Canoe or Rafting Tours, Whitewater Rafting, Kayaking, Snorkeling, Riverside Camping, Cultural Experiences, Surfing		
Core River Recreation Management Measures		**Corresponding Sustainable Goals**
Visitor Management	Established a “Visitor Number Balance Point” (NBV) to control visitor capacity; “soft” visitor behavior guidelines for safety and behavioral management.	EV
Facility Management	Construction of recreational facilities using low-impact technology.	E
Monitoring	Utilizes a variety of monitoring methods to track visitor numbers, sources, and purposes of visit.	EV
Promotion	Developed promotional strategies to enhance the attractiveness of the recreation area.	C
Cooperative Management	Managed in partnership with local communities, concessionaires, and international organizations.	EVC

4. Conclusion

Table 5. Natural river recreation management strategies for reference

	United States Case	**New Zealand Case**	**Brazil Case**	**Africa Case**
River Recreation Special Planning	√	√		
River Segmentation Management	√			
Emphasis on Adaptive Management	√	√		√
Clear Departmental Responsibilities	√			
Legal Regulations for Management		√		
Visitor Reservation System	√	√		
Collaborative Management	√	√	√	√
Visitor Capacity Management	√	√	√	
Facility Management	√	√	√	
River Special Interpretive Education	√			
Administrative Trips Managed Separately	√			
Visitor Experience Survey		√		

Note: The “√” indicates that the corresponding management measure is in place in the respective case study area.

Table 6. A structured overview of the issues and their relevance to the respective countries

Issue Category	Specific Issue	Country of Reference
Collaborative Management	Difficulty in managing river recreation entrances and controlling the types and numbers of boats when river management and national park management are under different departments.	New Zealand
Environmental Impact Control	-Construction of dams upstream may lead to unstable water levels in river sections flowing through parks, affecting recreational activities (United States). -Waste and noise generated by river recreation may lead to ecological destruction (New Zealand, Africa). -Excessive low-altitude aerial vehicles may disrupt the “natural tranquility” of remote rivers (New Zealand).	United States, New Zealand, Africa
Visitor Experience Management	-Lack of clear visitor capacity limits may lead to overutilization of resources (Africa). -Unplanned issuance of concessions and lack of transparency can result in a decline in visitor experience and excessive negative environmental impact (Africa). -Monopolization in the tourism industry may lead to a lack of diversity, affecting visitor experience (Africa). -Weak infrastructure for river recreation may impact visitor experience (Brazil).	Africa, Brazil
New Recreational Equipment and Activities	The emergence of new river recreational equipment may lead to unforeseen issues such as environmental impact and visitor conflicts.	New Zealand
Monitoring and Assessment	-Insufficient data collection and analysis, lack of effective monitoring of visitor growth trends and behavior patterns. -Lack of research on recreational ecological impacts and environmental carrying capacity. -Inadequate environmental impact assessments.	Africa

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Comparative Research on Relationship between Mining and Biodiversity Conservation in National Parks among Seven Countries and Regions

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Abstract

China is developing a system of protected areas, with national parks being viewed as the country's most valuable natural heritage. Striking a balance between conservation and development is a central challenge in national park management. This paper draws on a literature review and comparative studies to explore the mining rights management models in national parks across seven countries/region: the United States, Canada, Australia, Brazil, Russia, the European Union and China. By analyzing management policies, legal frameworks, and restoration funding, the study aims to summarize approaches to managing mining rights and brownfield reclamation in this countries/region. The study concludes with recommendations for integrating mining activities with biodiversity conservation in national parks, addressing four dimensions: management policy, legal framework, restoration fund, and collaborative networks.

Keywords: National parks; mining; biodiversity conservation; comparative research

1. Introduction

Mining has long been recognized as a significant threat to protected areas and biodiversity both directly through habitat loss and degradation, and indirectly by enabling supporting industries and increasing access to biodiversity-rich areas (Sonter, L. J., et al., 2018). Studies indicate that mining could impact 50 million km^2 of the Earth's terrestrial surface, with 8% coinciding with protected areas, 7% with Key Biodiversity Areas, and 16% affecting remaining wilderness (Sonter, L. J., et al., 2020).

The conflict between biodiversity conservation and mining is a global concern. For example, in 1995, Yellowstone National Park in the United States was listed as a World Heritage Site in Danger due to mining activities (Hazen, H., 2008). Mining also threatens the environment and indigenous communities in the Brazilian Amazon rainforest (Villén-Pérez, S., et al., 2021). In China, the Qilian Mountains National Nature Reserve has suffered significant ecological damage from illegal mining (Zongxing, L., et al., 2021).

Intensive mining development can impact biodiversity far beyond the mining area, with effects extending for several kilometers (Sonter, L. J., et al., 2018). This results in severe environmental harm, including land degradation, vegetation loss, soil and water pollution, noise and visual disturbances, habitat fragmentation, illegal hunting, and invasion of exotic species (Phillips, A., 2001).

2. Material and Method

The research employs a literature review and comparative study to summarize approaches to mining rights management in various countries/region, examining management policies, legal frameworks, and restoration funding on integrating mining activities with biodiversity conservation in national parks (Figure 1). The study analyzes three developed countries (the United States, Canada, and Australia), three developing countries (China, Russia, and Brazil), and one regional union (the European Union).

Figure 1. The distribution map of research countries

2.1 Literature review

According to the WOS core library, academic research on {Mining} AND {Biodiversity conservation} AND {National parks OR Protected areas} has steadily grown, with the publication volume reaching its peak in 2022 (Figure 2). Key areas of focus in this research include environmental science, ecology, and environmental studies.

Prominent research themes cover conservation, management, community engagement, deforestation, connectivity, and related topics (Figure 3).

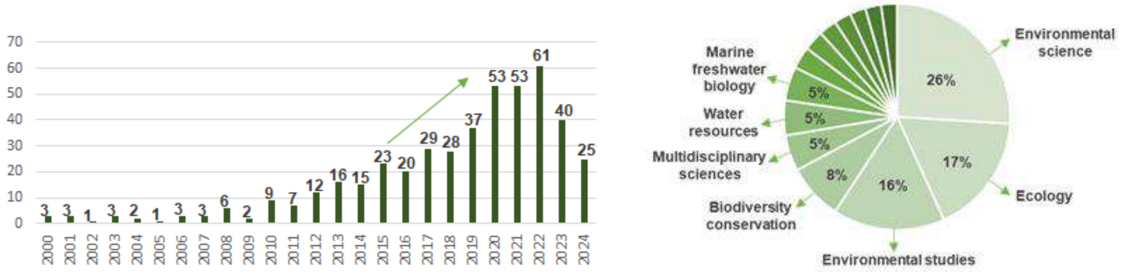

Figure 2. Number of papers and fields of published papers (2000-2024)

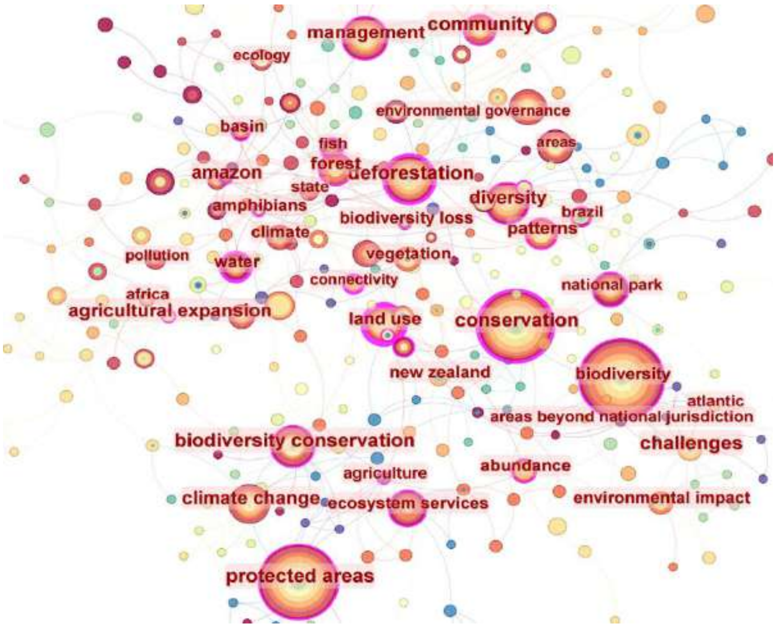

Figure 3. Research keyword frequency analysis based on CiteSpace software (2000-2024)

2.2 Comparative analysis

2.2.1 Management policies

Management policies for mining in protected areas vary by country/region (Table 1). These diverse approaches highlight the global challenge of balancing resource exploitation with biodiversity conservation and environmental protection.:

The United States (U.S.): Although only 2.5% of U.S. land is designated as off-limits to mining, new mining and exploration rights are strictly prohibited in all national parks (NPS., 2024). This reflects a strong commitment to their preservation.

Canada: Mining is permitted only in wilderness areas and migratory bird sanctuaries under federal jurisdiction. National parks are protected from new mining or exploration rights to preserve these ecosystems （Government of Canada，2000）. These two types of protected areas cover 1.2% of the national land area (Government of Canada., 2024).

Australia: Mining rights are managed flexibly, with the possibility of adjusting protected area boundaries or downgrading their conservation status. However, World Heritage Areas and National Parks are legally protected, with mining activities prohibited to preserve their natural and cultural values. These areas cover approximately 7.28% of Australia's total land area (DCCEEW., 2024).

Brazil and Russia: Both countries strictly prohibit all mining and exploration rights within protected areas. In Brazil, 30.30% of the national territory is designated as no-mining zones (Index Mundi, 2021). However, this strict prohibition often leads to significant conflicts between conservation efforts and development demands.

European Union (EU): The EU does not have mandatory mining regulations; instead, each member state develops its own management policies based on national circumstances.

China: About 12.50% of China's territory is designated as no-mining zones, covering roughly 70% of its protected areas (State Council of the RPC., 2010). Within national parks, mining and exploration rights are prohibited. In addition, China is actively working on rehabilitating historic mining sites in these areas.

Through comparative studies, it is evident that the proportion of mining prohibition within protected area systems should be reasonably determined. An excessively high prohibition ratio may lead to significant conflicts and challenges in conservation.

Table 1. Mining management policies in different countries

Country/Region	**Proportion of national territory occupied by protected areas**	**Proportion of mining-prohibited areas in protected areas**	**Protective effect (Li, Y., 2018)**
The United States	13.02% (Index Mundi., 2021)	19.20%	Comparatively good
Canada	11.91% (Index Mundi., 2021)	89.92%	Tendency to liberalize
Australia	19.75% (Index Mundi., 2021)	36.86% (DCCEEW., 2022)	Comparatively good
Brazil	30.30% (Index Mundi., 2021)	100%	Tendency to liberalize
Russia	11.45% (Index Mundi., 2021)	100%	Comparatively good
European Union	26.00% (European Commission., 2022)	No unified regulations	Comparatively good
China	18.00% (Ministry of Natural Resources of the RPC., 2021)	69.44 % (State Council of the RPC., 2010)	Comparatively good

2.2.2 Legal frameworks

Various countries have enacted legislation to regulate mineral rights and the management of national parks (Table 2). The U.S. was an early pioneer, passing national park legislation in 1916 and the Mineral Leasing Act in 1920. In 1976, the U.S. introduced the Mining in the Parks Act, positioning the country as a leader in balancing mining development and ecological protection. Australia, Canada, Russia, and Brazil have all established federal-state and park legal systems. The European Union has developed consistent regional guidelines to integrate abandoned mines with biodiversity conservation, and established national sustainable mining cooperation networks. In China, the Regulations on Nature Reserves were issued in 1994, stipulating that mining activities are prohibited within these areas (Jiang, W., & Jiang, S., 2023). In 2024, China enacted the National Park Law, mandating the clean-up and rectification of activities such as mineral exploration, extraction, and hydro-power development that do not comply with regulatory standards within national parks. Through a classification-based approach for orderly withdrawal, the law strengthens ecological protection and enhances regulatory oversight.

Table 2. Mining-related laws in different countries

Country/Region	Federal-State / Central-Local	Park
The United States	Mineral Leasing Act (1920) Code of Federal Regulations (1938) Federal Land Policy and Management Act (1976)	National Park Service Organic Act (1916) Mining in the Parks Act (1976)
Canada	Canadian Environmental Protection Act (1999) Canadian Environmental Assessment Act (2012)	Canada National Parks Act (1930) National Park General Regulations (1978)
Australia	Environmental Protection and Biodiversity Conservation Act (1999)	National Parks Act (1975)
Brazil	National Environmental Policy Law (1981) Mining Code (1967)	National System of Conservation Units (2002)
Russia	Federal Law No. 71-FZ (State Regulation of Mining and Mineral Resource Activities) (1998) Land Code of the Russian Federation Natural Protected Areas Law (2003)	Federal Law No. 33-FZ (1995)
European Union	Environmental Impact Assessments (2014) Each EU member state has its own legislation to complement EU directives	EU Directive 92/43/EEC—Habitats Directive (1992) EU Directive 2009/147/EC—Birds Directive (2009)
China	Mineral Resources Law (1986) Environmental Protection Law (1989)	Regulations on the Administration of Nature Reserves (1994) National Parks Law (2024)

2.2.3 Restoration fund

Rehabilitation of abandoned mines is primarily funded by federal or central governments in various countries/region (Table 3). The U.S., for example, has established dedicated funds for remediating abandoned mines within national parks (NPS., 2022). Additionally, funds from the Superfund and Brownfields program are available to support the cleanup of abandoned mine lands, ensuring environmental restoration and public health safety. Canada has established the Northern Abandoned Mine Reclamation Program (Government of Canada., 2019), which uses a classification system to prioritize and manage the remediation of abandoned mines, providing a structured approach to funding and cleanup efforts. Australia advocates the establishment of biodiversity banks and trust funds to reinforce mining companies' obligations to compensate for biodiversity loss. The European Union provides regional economic support to its member states for the rehabilitation of abandoned mines. In China, funding for mine rehabilitation primarily comes from central and local governments, with a mine reclamation bond program still under development (Cheng, L., & Skousen, J. G., 2017).

In addition, countries/region are also exploring various financing options for the rehabilitation of abandoned mines, including insurance, industry contributions, and international cooperation, in order to diversify funding sources for this crucial environmental remediation work.

Table 3. Mining-related funding programs in different countries

Country/Region	Federal / Central Financial Funding Sources
The United States	Abandoned Mine Land (AML) Fund (SMCRA) Superfund Program (EPA) Brownfields Fund (EPA) Coal Mine Land Reclamation Fund Funding from the Bipartisan Infrastructure Law, Public Law 117-5 (BIL) for AML projects
Canada	Federal Contaminated Sites Action Plan (FCSAP) Mining and Metals Sector Program (MMSP) Northern Abandoned Mine Reclamation Program (NAMRP)
Australia	Australian Government’s Abandoned Mines Program Abandoned Mines Land Rehabilitation Program
Brazil	Government Programs and Funds (FNMA) National Fund for the Environment State Environmental Funds
Russia	Federal Environmental Fund Regional Environmental Funds
European Union	European Union Funding Programs, such as LIFE Program National and Regional Funding, such as National Environmental Funds
China	Central Budgetary Allocations National Environment Protection Fund Environmental Protection Special Funds

3. Findings and Discussion

The comparative analysis shows that countries/region have made progress in managing mining rights while integrating biodiversity conservation. Among them, determining a reasonable proportion of mining prohibition within the protected area system, establishing a complete legal framework, and exploring diverse financing channels are crucial approaches. The United States and Canada have already established a solid legal foundation, while Australia has advanced practices in diversified financing channels. The European Union, from the perspective of regional cooperation, has established approaches to integrate mining and biodiversity conservation. Although China is still in the early stages, it has made progress in legislation. Russia and Brazil have already established relevant legal frameworks and funding channels, but due to the complete prohibition of mining within protected areas, they face conflicts between conservation and development, especially in Brazil, where such issues are especially significant. Based on comparative research, the paper presents 4 suggestions for mining management and biodiversity conservation in China’s national parks:

(1) Management policy: Determining a reasonable proportion of mining prohibition within protected area systems based on development needs, to avoid conflicts between conservation and development caused by excessively high or low proportions.

(2) Legal framework: Develop a comprehensive legal system to strictly regulate mining rights

within national parks, while maintaining access to services for national strategic energy needs.

(3) Restoration fund: Create national special funds and explore various financing channels to improve the biodiversity compensation system through economic policies, including funds, banks, insurance, and deposit systems.

(4) Collaborative networks: Strengthening international cooperation to improve inter-regional and transboundary mining management and biodiversity conservation in national parks. This includes establishing robust regional protection networks to enable coordinated environmental management.

The paper concludes with four strategies for integrating mining and biodiversity conservation: management policy, legal framework, restoration fund, and collaborative networks. These strategies align with nine Sustainable Development Goals (SDGs), including SDG 1, SDGs 6-9, and 13-16 (Figure 4).

SDG1 Poverty eradication
Mining generates significant revenue streams through taxes, royalties and dividends for governments to invest in socioeconomic development.

SDG 6 Clean water and sanitation & SDG 14 Life below water & SDG 15 Life on land
Mining requires access to land and water, which gives rise to significant and wide-ranging landscape impacts that must be managed responsibly.

SDG 7 Affordable and clean energy & SDG 13 Climate action
Mining activities are also energy- and emissions-intensive in terms of the production and downstream uses of mining products.

SDG 8 Decent work and economic growth
Mining can alter the lives of local communities, offering opportunities for jobs and training, while contributing to economic and social inequities if not appropriately managed.

SDG 9 industry, innovation, and infrastructure
Mining can help drive economic development and diversification through direct and indirect economic benefits, the development of new technologies and by spurring the construction of new infrastructure for transport, communications, water, and energy.

SDG 16 Peace, justice, and strong institutions
Mining can contribute to peaceful societies by avoiding and remedying company-community conflict, respecting human rights (including those of indigenous peoples) and by supporting the representative decision-making of citizens and communities in extractives development.

Figure 4. Integrating mining and biodiversity protection contribute to 9 SDGs (UNEP.,2020)

4. Conclusion

The integration of mining and biodiversity conservation in national parks is long-term challenge. This study, based on a literature review and comparative analysis, provides a comprehensive examination of integration efforts in 7 countries/region around the world. The samples include three developed countries, three developing countries, and one regional union, providing a representative perspective. In the future, this study will thoroughly analyze representative cases and further summarize planning and management strategies for integrating biodiversity conservation with mining activities to guide practices worldwide.

Note

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Landscapes: Memories of Cities

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Abstract

City, landscape, memory, culture and identity are intertwined concepts and each includes the other. Cities and landscapes are important carriers and mirrors of these culture; they both bear the traces of the past and shape the future. Cities form a whole with their geographical locations which constitute their unique landscapes, spatial identities, their pasts, their experiences, and their cultures that have been distilled from all of these, reaching the present day and sustained. Would it be possible to talk about cities today if all these experiences, memories and emotions were not stored in the memory, held somewhere in the mind, if memories were not written? In this research, first of all, a deep conceptual research of landscape will be made. With this research, which is shaped by qualitative methods, it is aimed to investigate the role that past landscapes play and should play in our future. As a result of the study, it was revealed that there is an inseparable bond between people, society, culture and landscape, and most importantly, people's sense of identity and belonging is the greatest need. In this context, the common denominator of all these is the human dependence to the landscape.

Keywords: Landscape, memory, society, culture, identity

1. Introduction

Landscape is a set of layered remains from the past to the present (Mills, 2014). Lewis (1979) defines landscape as “The cultural traces left by human activities in the environment, the autobiography of society that society is not aware of is landscape.” Landscape can also be considered as a heritage of cultural production and transmission. For example, a work such as a poem, prose, painting or film and the landscape that the person who produced it wants to see and shapes; it becomes a part of that society and geography by being passed down from generation to generation (Leader-Elliot, 2004). Landscape is not only a reflection of natural beauty, but also a space where social memory is built and preserved.

Memory is a process that involves a lived or learned past but also includes the present. Events, people or places can take place in the minds of each person in different ways. Therefore, memory data cannot be considered as accurate as historical data. However, a social history can be produced with a memory that can be depicted with a common memory and told with symbols that support reality (Ay Ak, 2023). Landscape memory shows the ability of the landscape to store physical and social changes experienced with the time factor. Landscape can be considered as the most important record-keeping tool, but it does not make this record with written documents (Güler, 2019; Hoskins, 1955).

Landscape memory refers to how a landscape (natural or urban environment) is related to past events, cultural practices, social interactions and individual experiences, and how these elements leave traces on the landscape. This concept considers how physical spaces carry memories and meanings accumulated over time and how this accumulation is embedded in social and individual memory. Landscape memory is not only about the physical characteristics of a place, but also about the historical, cultural and emotional dimensions associated with it (Hayden, 1995).

Each item remembered about past social experiences is necessarily based on a place (Assmann, 2015), and urban landscapes assume the role of the memory of the space formed by encoding social experiences (Güzel & Atabeyoğlu, 2021). Therefore, social memory is engraved on buildings, sidewalks, green spaces, archaeological sites and the entire urban landscape (Gould & Silverman, 2013; Karakaya Aytin & Ertin Tezgör, 2022).

This study aims to focus on the history of Gülhane Park in Fatih district of Istanbul and its role in the city.

2. Material and Method

This study focus on landscape memories of Gülhane Park. Gülhane Park is one of the biggest and important green space in Historical Peninsula, İstanbul. It is located in Sarayburnu, also near the Topkapı Palace that the capital of Ottoman Empire’s between 1460-1856 years. It is approximately 118,000 m² (Milli Saraylar, 2024), (Fig 1). Gülhane Park, together with important historical and touristic places such as Topkapı Palace, Archeology Museum, Sultan Ahmet Mosque, Hagia Sophia, Basilica Cistern, is a very crowded center of interest visited by local and foreign tourists every day of the year.

Figure 1. Location of Gulhane Park (Google Earth, 2024).

A comprehensive literature review was conducted in line with the purpose of the study on the layers of Gülhane under the headings of cultural memory and green memory. Site visits were made, on-site observation, photography, interviews with users and experts were conducted to update the data The study provides important clues about the dynamic structure of landscape memory, its transformation over time and the effects of this transformation on memory, and how identity and sense of belonging are shaped in modern cities.

3. Findings and Discussion

3.1. Cultural memory

In this section, the architectural structures and sculptures, historical events, celebrations, festivals and festivals that constitute the memory of Gülhane Park are described chronologically with the data collected as a result of detailed literature searches under the title Byzantine-Ottoman-Republican Periods. The data is supported by old photographs and current photographs taken during site visits.

3.1.1. Byzantine Period

While Constantinople was still a Byzantine city, the memory values in Gülhane Park were elaborated.

Gots Column: The monument known as the Column of Goths is a Byzantine obelisk. It is rumored to have been erected during the reign of Roman Emperor Marcus Aurelius. It is the oldest column of the city that has survived intact (Dünden Bugüne Istanbul Encyclopedia, 1993). The inscription on the column reads “Fortunae Reducı Ob Devıctos Gothos”, i.e. “Fortune returned with our defeat of the Goths”, indicating that the column was erected after a victory against the Goths. Semavi Eyice also states that the monument may belong to the period of Constantine I (306-337) due to the shapes of the Latin letters in the inscription of the column (Kart Aktaş, 2020), (Fig 2).

Figure 2. Gots Column (Old İstanbul Photos and Ay Ak, 2024).

Gülhane Park Cistern: It was unearthed during the landscaping of Gülhane Park in 1913. German art historian Wulzinger states that the cistern may have been built as the substructure of a monastery or a bathhouse. The Gülhane Park Cistern served as an aquarium for a period. With the closure of the Zoo, this cistern with aquariums became idle again. In 2022, as a result of Istanbul Metropolitan Municipality's detailed restorations, it started to host culture and art events such as exhibitions, talks and concerts (Atatürk Library, 2024), (Fig 3).

Figure 3. Gülhane Cistern (Flickr and Ay Ak, 2024).

The Orphanage of Hagios Paulos: Sources attribute the construction of this orphanage to Augustus II (565-578). It was damaged by earthquakes and rebuilt. The state of the orphanage during the Latin occupation in 1206 is unknown. The last record of the orphanage is that in 1261 an experienced administrator arrived and secured the institution with its students. The exact location of the orphanage is still unknown, whether these ruins belong to the orphanage is still unknown, but according to the description in the sources, it is thought to be “the ruins near the Column of the Goths” (Tezcan, 1989).

3.1.2. Ottoman Period

From the conquest of Constantinople in 1453 and the city becoming the capital of the Ottoman Empire to the proclamation of the Republic in 1923, the memory-valuable events that took place in Gülhane Park are detailed.

Topkapı Palace Garden: Gülhane, the outer courtyard and grove of Topkapı Palace, was used as a grove and rose garden for many years. Gülhane, which was a center of entertainment and recreation for the Ottoman family during the Ottoman Classical period, that is, during the years when the Sultan was still using Topkapı Palace, was less used and neglected as a result of the transfer of the administration from Topkapı Palace to Dolmabahçe and Yıldız Palaces.

Alay Pavillion – Ahmet Hamdi Tanpınar Museum and Library: Alay Pavillion was the building constructed above the outer wall of Topkapı Palace fort he sultans to watch the ceremonies. Before the construction of Alay Pavillion, there was a timber Pavillion in 16th century. The recent building of the pavillion was constructed by Mahmud II in Western Europian style. It was reorganized by the Ministry of Culture and Tourism as the Ahmet Hamdi Tanpınar Literature Museum and opened in 2011 (İBB-Yeşil İstanbul, 2024), (Fig 4).

Figure 4. Alay Pavillion – Ahmet Hamdi Tanpınar Museum and Library (Yedikıta ve Ay Ak, 2024).

Has Stables Building - Museum of Islamic Science and Technology History: In the Ottoman Palace, the stables where the horses of the Sultan and his close servants were kept were called Has Stables. Working to make the World know equipment and machinery invented by Muslims involved in science by finding their models based on shapes and specifications in hand-written books and showcasing them in a museum, Fuat Sezgin, Prof. Dr. about Islamic Sciences, decided that the Has Stables were a good fit fort his and the stables were restored and allocated to him and opened in 2008 (İBB, Yeşil İstanbul, 2024).

Imperial Edict of Reform: Inspired by the French Declaration of Human Rights, the edict provided that the citizens would be granted equality along with the safety of their life, property and honor, some civil rigths and that there would be efforts toward the Western model matters such as tax, military service, justice, finance and education. Also called Gülhane Hatt-ı Hümayunu since it was declared in Gülhane, the Imperial Edict of Reform was read on1839 (İBB-Yeşil İstanbul, 2024) (Fig 5).

Figure 5. Imperial Edict of Reform (Kart Aktaş, 2020).

Cholera Hospital: Between 1907 and 1915, cholera outbreaks occurred in Istanbul at various times. In 1910, as the severity of cholera increased, the pavilions prepared in Demirkapı, Nuhkuyusu, Şişli and Yenibahçe were insufficient and 4 more mobile hospitals were brought and placed in Demirkapı and Gülhane Park (Kart Aktaş, 2020).

Republic Period – Today

From the proclamation of the Republic in 1923 to the present day, the events that took place in Gülhane Park and have a memory value are detailed.

The First Atatürk Sculpture: Located in Sarayburnu, this statue was built where Atatürk boarded the Bandırma Ferry to start the War of Independence. It was also the first place where Atatürk set foot in Istanbul after the establishment of the Republic. This first Atatürk statue of the Republican Era in Istanbul was inaugurated on October 3, 1926 (Sezer and Özyalçıner, 2010), (Fig 6).

Figure 6. The First Atatürk Sculpture (Ay Ak, 2024)

Alphabeth Reform: Atatürk introduced the “Alphabeth Reform” with the new Turkish letters at Gülhane Park on 1928 (Fig 7). On November 24, 1928, Atatürk was bestowed the title of “Head Teacher” who gave the Turks their own language and worked day and night for people learn it (İBB-Yeşil İstanbul).

Figure 7. Atatürk in Gülhane Park (Sözcü Gazetesi, 2023; Ay Ak, 2024).

The Last Ceremony in İstanbul for Atatürk: While Atatürk's body was being taken to Ankara, the last ceremony in Istanbul was held in the Sarayburnu section of Gülhane Park on November 19, 1938. The coffin, which was lowered from the cannon carriage by 12 generals, was placed on the destroyer Zafer, which docked at the pontoon at the pier to be taken to the battleship Yavuz (Sezer and Özyalçıner, 2010) (Fig 8).

Figure 8. Last Ceremony, Atatürk Sculpture (Yeni Ufuk Paper and Ay Ak, 2024)

Nazım Hikmet’s Poem and Cem Karaca’s Song: Ceviz Ağacı: It is widely rumored that the poem was written when Nazım Hikmet escaped from prison and went to Gülhane Park to meet his lover Piraye and climbed a walnut tree to escape the police. However, it is thought that Nazım reflected his homesickness in these lines while living in Bulgaria in 1957 (Kart Aktaş, 2020; Kabacalı, 2002). The 'Walnut Tree in Gülhane Park', which was made popular by Cem Karaca's composition, was planted in the Park by IMM on April 5, 2005, on Karaca's 60th birthday.

İstanbul Spring and Flower Day: Spring and Flower Festival is an event organized for the first time in 1950 with the initiatives of the then Mayor of Istanbul, Dr. Fahrettin Kerim Gökay, to celebrate the arrival of spring and the blooming of flowers. Within the scope of the celebrations, various activities such as exhibitions, concerts, competitions and public markets were organized, enabling the public to socialize inexpensively and benefit from the city's facilities. Although it is not known for how many years it was celebrated, it is thought to have been celebrated between 1950 and 1962, except for the coup of May 27, 1960. This holiday is completely unique to Istanbul and was celebrated for 3 days in the beginning and extended to 90 days in the following years (Mutlu, 2016). In 1954, a circus was established in Gülhane in these celebrations, which were continued by adding a new event every year.

Gülhane Zoo: In 1954, the circus left some of its animals in Istanbul and Gülhane Zoo, which was already planned to be opened, was opened that year. Until its closure in 2001, it continued its life as the only example of this kind in Istanbul, always at the center of controversy, but continued to serve its visitors in Gülhane Park. However, due to numerous complaints about the inadequate care of the animals, it could not withstand the pressure any longer and was closed on September 8, 2001. All the animals in the park were taken to Atatürk Forest Farm in Ankara (Kart Aktaş, 2020).

Gülhane Festivals and Amusement Park: After 1962, the Spring and Flower Festival, which was organized a few more times, was not as popular and therefore the festival did not continue. Similarly, from 1987 onwards, IBB started to organize the “Gülhane Festival” with various activities. The festivities left their mark on history with very crowded concerts.

3.2. Green memory

3.2.1. Byzantine Period

It is difficult to obtain specific and detailed information about the vegetation of Gülhane Park during the Byzantine period before the conquest of Istanbul. However, some inferences can be drawn from the general vegetation. Byzantine gardens were usually planted with aromatic plants and various ornamental plants. Plants such as *Lavandula* L. and *Salvia officinalis* L., as well as seasonal flowers, are likely to have been present in the gardens. It is also known that fragrant plants such as *Rosa* L., *Nerium oleander* L., *Narcissus* L. and *Iris* L. were preferred in ancient gardens (Atasoy, 2011).

3.2.2. Ottoman Period

Before Gülhane was opened to the public, it was an abandoned and desolate woodland and some parts were vegetable gardens (Cumhuriyet Newspaper, 1936). The park surrounding the Topkapı Palace was transformed from a sacred area for the courtiers into an area where the public could go to get fresh air in daily life (Özlü 2018). The pioneer of this transformation was the city mayor of the period, Op. Dr. Cemil Topuzlu Despite the public's reactions to this change, it was opened as a city park in 1912 (Topuzlu, 1982).

The entire Historic Peninsula was drawn by officer engineers between 1875-1882 and then the Ayverdi Map was published by Ekrem Hakkı Ayverdi in 1/2000 scale. On this digitized map, Gülhane Park is defined as the "Palace Garden" (Kart, 2008). When the details of Gülhane Park are examined on the map, it is seen that there are green areas such as vegetable garden, boxwood garden, grassy sofa, aga garden. Today, it is seen that there are grass areas and ornamental pools in the same areas (Fig 9, 10).

Figure 9. Ayverdi Haritası, Gülhane Parkı, 1875-1882 (Fatih Municipality).

Figure 10. Gülhane Parkı (Ay Ak, 2024).

The listed documents indicate that in the 19th and 20th centuries there was a vegetable garden in the vicinity of today's Archaeological Museum. In addition, it is understood from the expense books that *Cestrum nocturnum* L., *Hyacinthus* L., *Azalea japonica* Kuntze, *Rosa* L., *Viola* L. and *Dianthus* L. varieties continued to be grown in the gardens during these periods (Atasoy, 2011).

3.2.3. Republic Period

Gülhane Park is very rich in tree and shrub species; there are over 90 exotic species that have been planted in the park for many years. *Celtis australis* L. trees that have reached large diameters and heights, *Platanus hispanica* Ten., *Acer* L. varieties, *Aesculus hippocastanum* L., *Albizia julibrissin* Durazz., *Aucuba japonica* Thunb., *Berberis thunbergii* DC., *Betula* L. varieties, *Buddleja davidii* Franch., *Buxus sempervirens* L., *Catalpa bignonioides* Walter, *Cedrus libani* G. Don, *Cedrus deodara* (Roxb. ex D.Don) Loudon, *Chamaecyparis lawsoniana* (A.Murray bis) Parl., *Cercis siliquastrum* L., *Cryptomeria japonica* (L.f.) D.Don, *Elaeagnus pungens* Thunb., *Euonymus japonicus* Wall., *Fatsia japonica* (Thunb.) Decne & Planch., *Forsythia viridissima* Lindl, *Ginkgo biloba* L., *Gleditsia triacanthos* L., *Hydrangea macrophylla* (Thunb.) Ser., *Hibiscus syriacus* L., *Ilex aquifolium* L., *Laurus nobilis* L., *Ligustrum lucidum* W.T.Aiton, *Picea abies* (L.) H.Karst., *Picea orientalis* (L.) Carrière, *Pinus brutia* Ten, *Pinus nigra* Aiton, *Pinus pinea* L., *Pyracantha coccinea* M.Roem, *Sambucus nigra* L., *Sequoia sempervirens* Endl., *Spiraea vanhouttei* (Briot) Carrière, *Ulmus minor* Mill., *Taxodium distichum* (L.) Rich., *Tilia tomentosa* Moench, *Robinia acacia* L., *Salix babylonica* L., *Sophora japonica* L. and many other plant species shape the garden (Yaltırık, Efe and Uzun, 1997).

In the last plant inventory studies carried out within the scope of the Gülhane Park New Arrangement 1st Stage Project, 1796 trees, shrubs and shrubs were identified, 449 of which were registered as monument candidate trees by the Cultural and Natural Heritage Protection Board (Yılmaz, 2006). Today, there is a high density of woody species in Gülhane. The shrubs that came to be pruned were used at the entrance of many spaces and played a limiting role at some points.

With the "Culture Street Project", it is aimed to prevent the ruined appearance of the park by renovating the old buildings in the park and to meet the needs of the users with the functions to be given to these buildings. With this project, the forms of rose gardens in Ottoman times were tried to be used. The pergola and seating units were dismantled along with the plants in the park, and the area was divided into large rose garden parcels (Tepe, 2010), and then these parcels were also changed (Fig. 11).

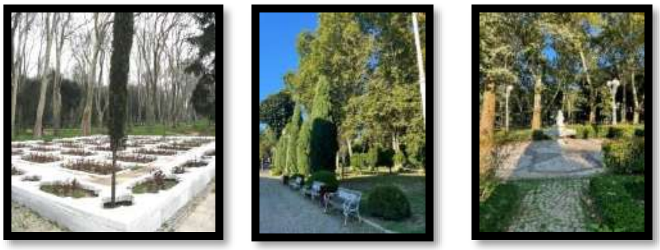

Figure 11. Gülhane Parkı (Tepe, 2010 ve Ay Ak, 2014)

Today, it is observed that there are fewer rose areas in the park and planting is mostly done with seasonal plants and bulbs. As seasonal plants, Begonia L. and Impatiens L. are preferred in the shade of plane trees in summer. In addition, Tulipa L. and Narcissus L. varieties are preferred as bulbous plants.

4. Conclusion

Cities are defined not only by their physical characteristics that exist, can be measured, accepted, seen and experienced, but also by the images that remain in the minds and memories. Events take place in the real world with real people as protagonists and witnesses, and people remember them according to their perceptions, interpretations and knowledge. Analyzing and recognizing Istanbul's memory values, which are added new layers and identities as time passes, is a very important source that will shed light on the future. Gülhane Park has been blended with different cultures from the earliest periods known to exist until today and has taken place on the stage of history in very different roles. This green part of the Historic Peninsula, which has always been in a very valuable and strategic location, has always been very active.

It is as important to preserve a place, especially one that is at the forefront with its historical characteristic, to the future in a sustainable manner as it is to use it within the city. The most feasible way to achieve this goal would be to concretize the values that are already in the memories and all the intangible values that are close to being forgotten, and to add them to Gülhane Park in a perceptible and attractive way for local and foreign visitors of all age groups. In this way, it will help all visitors to spend more quality and conscious time, and in the long term, it will have a deeper place in the memories of visitors. Conservation and sustainability policies can move forward more easily at this point. The historically significant Gülhane Park has been devastated by unqualified and intensive additions, vehicular and human traffic, and various social and cultural activities. The use of historically important buildings in the park for different functions and the deterioration of the plant texture due to lack of maintenance have caused the park to lose its original structure.

The partial renovation works carried out in different periods throughout the park have caused the park to lose its character as "the garden of the palace" and to create spaces without any character. For a long time in its history, Gülhane was the preserve of the palace of a world empire, and this connection is not perceived today. It is perceived as an urban park located near many touristic and historical buildings in the Historic Peninsula. This was supported by the observations made during the site visits; many local and foreign visitors visit this park, Gülhane, just to sit and relax, take a breather and move on to other stops on the Peninsula. However, Gülhane itself is one of these important stops, but this was not fully conveyed to the visitors, and this was supported by the interviews with the visitors. The fact that Gülhane was the place where the Latin alphabet was introduced and Atatürk was given the title of Head Teacher, and the Spring and Flower Festival celebrations are among the lesser known memory values. For visitors, Gülhane is more identified with the Walnut Tree song and the zoo. In other words, most of its values could not be conveyed to visitors.

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CULTIVATING RESILIENCE

Study on Optimization of Blue-Green Infrastructure Elements Allocation in Urban Watersheds: A Case Study of Yangmei River Basin in Guangzhou City

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Abstract

Blue-green infrastructure has emerged as an effective strategy for stormwater management, offering a range of environmental, social, and economic benefits. The response surface method is an optimization technique characterized by relatively straightforward calculations, a limited number of experiments, and a clear presentation of results. In this study, this method was selected to optimize the allocation of four selected green infrastructures components. The total runoff control rate, pollutant removal percentage, and comprehensive economic cost were quantified using the SWMM model and life cycle cost analysis. The results indicated that the optimal proportions for the green roof, permeable pavement, vegetated swale, and bioretention cell were 34.818%, 49.838%, 29.999%, and 20.000%, respectively. Based on this optimal layout scheme for green infrastructure, seven blue infrastructure projects in the Yangmei River Basin were reconstructed to meet the total storage volume requirements of the study area.

Keywords: Blue-green infrastructure, response surface method, rainfall runoff, SWMM, multi-objective optimization

1. Introduction

Under the dual influence of climate change and urban development, water safety issues such as urban stormwater flooding, non-point source pollution, and combined sewer overflows frequently arise(F. Gao et al., 2020; Quan, 2021). These problems significantly impact the stable and healthy development of the social economy in major cities both domestically and internationally. On July 21, 2012, a severe rainstorm struck Beijing, with maximum rainfall reaching 460 mm. The storm resulted in 79 fatalities and direct economic losses amounting to 11.64 billion yuan. In Zhengzhou, the heaviest recorded rainfall was 552.5 mm, with 201.9 mm falling within a single hour between 4 PM and 5 PM.

Blue-green infrastructure is an innovative approach to rainwater management that emulates natural processes through natural or semi-natural landscapes to mitigate surface runoff and improve water quality. Traditional rainwater management, often referred to as grey infrastructure, focuses on the rapid discharge of rainwater runoff, which ultimately disrupts the relationship between humans and nature. With the rapid development of urban areas and the increase in impervious surfaces, natural drainage systems and the hydrological cycle have been severely compromised, revealing the shortcomings of grey infrastructure. In response, the practice of sustainable rainwater management, centered around blue-green infrastructure, has garnered significant attention from various sectors(Fletcher et al., 2015). In this context, green infrastructure refers to a range of low-impact development facilities, such as green roofs and bioretention ponds, while blue infrastructure includes reservoirs, rivers, wetlands, and other water bodies, primarily serving the function of stormwater storage.

Currently, the effectiveness of blue-green infrastructure in reducing rainwater runoff and improving water quality has been validated through pilot tests(Y. Liu et al., 2020), on-site monitoring(Simona et al., 2016), and model simulations(Gwang et al., 2012). To fully leverage blue-green infrastructure for mitigating urban waterlogging and enhancing cities' capacity to manage flood risks, the scientific deployment of blue-green infrastructure is central to this study. Research indicates that the configuration of blue-green infrastructure elements and variations in spatial structure can result in different hydrological responses and benefits. This variability arises because different blue-green infrastructures exhibit distinct water cycle patterns, such as evapotranspiration, infiltration, and absorption, and their spatial arrangements influence runoff transfer between patches differently(J. Liu et al., 2020; Zhang et al., 2023). Moreover, uncertainties related to climate change and socio-economic factors present significant challenges to the effectiveness of blue-green infrastructure in flood mitigation(Ghofrani et al., 2020). Consequently, developing a blue-green infrastructure layout plan that minimizes economic investment while enhancing urban flood resilience is crucial for guiding flood adaptation planning. To establish an effective blue-green infrastructure layout plan, it is essential to systematically evaluate the plan across various scenarios. The primary evaluation criterion should be environmental benefits, while also considering aesthetics, social impacts, and economic advantages(Shen et al., 2017). In recent years, studies on the environmental benefits of blue-green infrastructure have primarily focused on indicators such as peak runoff reduction rates, overall runoff reduction rates, and pollutant load removal rates related to rainwater management(Gwang et al., 2012; Mai, 2021). However, relevant indicators concerning the regulation and storage effects on receiving waters have been overlooked, and the dynamic processes of these indicators have not been adequately addressed.

Tianhe Wisdom City, located in the Yangmei River Basin, serves as a pilot site for sponge city construction in Guangzhou. The optimization of blue-green infrastructure represents a tangible approach to advancing sponge city development. By utilizing the SWMM model and life cycle cost analysis, the response surface method is employed to optimize the proportion of green infrastructure reconstruction within the study area. This research provides both theoretical and technical support for the development of blue-green infrastructure in urbanized regions and holds significant practical importance for urban water security governance.

2. Material and Method

2.1 Study area

Yangmei River Basin (113°22′-113°26′E, 23°8′-23°13′N) is situated to the east of Guangzhou Tianhe Wisdom City, covering an area of approximately 16.5 square kilometers (Figure 1a). Guangzhou experiences abundant rainfall, primarily concentrated from April to September, with over 80% of the annual precipitation occurring during the flood season. The topography of the Yangmei River Basin is characterized by higher elevations in the north and lower elevations in the south. The upper reaches consist of low mountains and hills, while the middle reaches are densely populated with ponds. The lower reaches predominantly feature flat urban villages and residential areas. The river system within the basin includes the Yangmei River, Xintang Reservoir, Ludong Reservoir, Dongdahu Lake, and Mupi Lake. To address issues related to urban waterlogging and surface water quality, the Daguan Wetland has been established as a pilot Sponge City project in Guangzhou, guided by the principle of prioritizing ecological considerations.

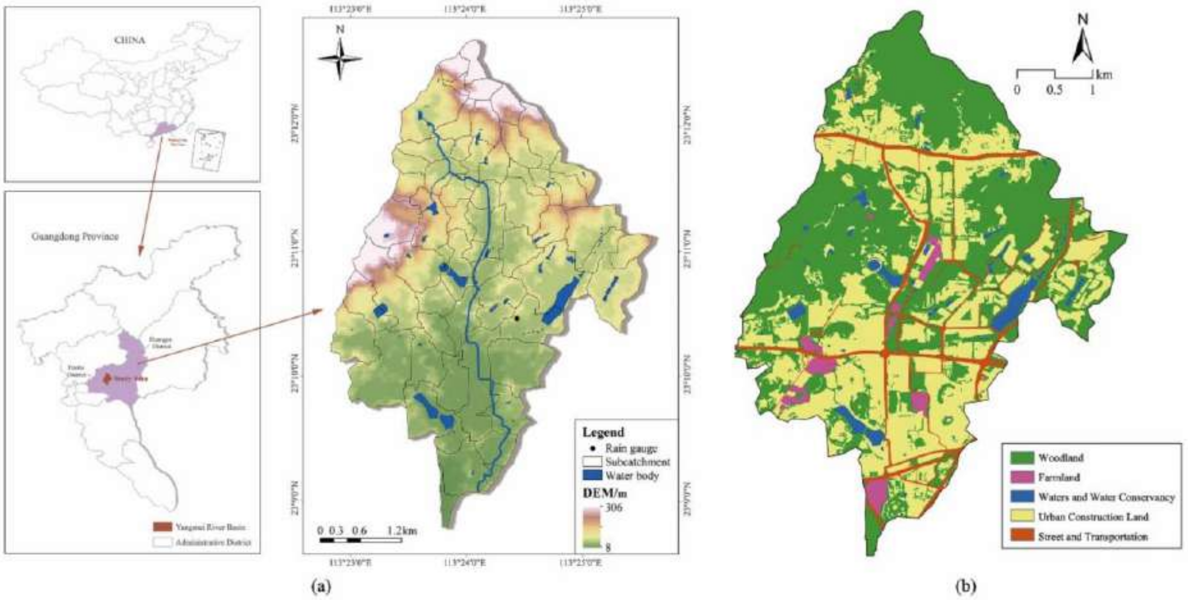

Figure 1. Location and land cover type of Yangmei River Basin

2.2 Data collection

The study will collect essential data on the drainage network, topography, land use types, remote sensing imagery, and rainfall. The Digital Elevation Model, with a resolution of 30 meters, is obtained from the Geospatial Data Cloud. The 2019 Gaofen-2 multispectral remote sensing imagery, with a resolution of 4 meters, is provided by the Satellite Remote Sensing Application Center of the Ministry of Natural Resources and the Natural Resources Satellite Remote Sensing Cloud Service Platform. Additionally, pipe network information will be supplied by the relevant departments in Guangzhou. Rainfall data will be monitored and collected in real-time on-site. To minimize non-systematic geometric errors in the remote sensing data, we first utilized ENVI 5.3 software to conduct radiometric calibration, geometric correction, and image fusion on the remote sensing images. Subsequently, the Yangmei River Basin was classified into five land cover types: woodland, farmland, water and water conservancy, urban construction land, and street and transportation, using the Maximum Likelihood algorithm and visual interpretation method (Figure 1b).

2.3 SWMM model construction

SWMM model can simulate both single events and long-term events. It effectively models surface runoff, pipe and river flow movement, and changes in water quality. The model has demonstrated significant value in rain and flood planning, urban flood simulation, and the design of green infrastructure(Macro et al., 2019; Z. Zeng et al., 2021).

2.3.1 Construction of pipe network system and sub-catchment division

In this study, rainwater was discharged into a nearby river or drainage channel, which consisted of trapezoidal or rectangular open channels. The generalized model indicates that the total length of the pipeline is 31.97 km, while the total length of the river course and drainage channel is 7.12 km. There are 98 cross-sections of the river course and drainage channel, 466 nodes, and 3 outlets. To delineate the catchments, ArcHydro Tools were employed to analyze the flow direction, calculate cumulative flow, extract the surface runoff system, and construct the watershed. Subsequently, based on the current conditions of the study area—including terrain, road boundaries, and buildings—the water catchment area was divided using the Tyson polygon tool and adjusted manually.

2.3.2 Calibration and validation of the model

According to the input requirements of the SWMM model, the attribute information for sub-catchments, drainage networks, and nodes within the study area has been converted into an INP file and loaded into SWMM. The SWMM model for the Zhihuicheng district, located in the Yangmei River Basin, has been calibrated and validated using long-term runoff observations(J. Zeng et al., 2020). This model accurately reflects the local hydrological processes. The initial values of the hydrological and hydraulic parameters in the SWMM model for the Yangmei River Basin are derived from the parameters specific to the Zhihuicheng district. The integrated runoff coefficient method uses the integrated runoff coefficient of the study area as the objective function for model calibration. It compares the integrated runoff coefficient used in the design of the stormwater network with the runoff coefficient simulated by SWMM, and the degree of dispersion is analyzed using the coefficient of variation. In this study, the coefficient of variation for rainfall across different recurrence periods was below 15%, indicating that the model effectively reflects the actual conditions.

2.4 Evaluation of rainwater system effectiveness of blue-green infrastructure

2.4.1 Indicators for evaluating the effectiveness of blue-green infrastructure rainwater systems

The effectiveness of various blue-green infrastructure design schemes in controlling rainwater can be assessed using three key metrics: total runoff reduction rate (R_T), peak runoff reduction rate (R_P), and pollutant load removal rate (R_Q). Economic cost is a significant concern when implementing and promoting blue-green infrastructure. The total cost associated with blue-green infrastructure encompasses initial construction and design costs (*IC*), annual operation and maintenance costs (*OMC*), and residual values (*SV*). Since the area and life cycle of blue-green infrastructure can influence economic costs to some degree, this study compares the economic costs of different design schemes by analyzing the annual life cycle cost (*ULCC*)(Mei et al., 2018).

(1) Total Runoff Reduction Rate

The total amount of runoff control indicates that a specific proportion of rainfall in the study area cannot be managed through enhanced infiltration, retention, collection, and storage. This reflects the capacity of blue-green infrastructure to absorb rainwater and is calculated using Equation (1).

$$R_T = \frac{T_0 - T_i}{T_0} \times 100\% \tag{1}$$

Where R_T is total runoff reduction rate (%); T_0 is total runoff under the current scenario (10^6 L); T_i is total runoff under the *i*th scenario of blue-green infrastructure design (10^6 L).

(2) Peak Runoff Reduction Rate

The peak discharge represents the maximum flow rate of the runoff system and reflects the impact of blue-green infrastructure on the rainfall-runoff process, as calculated by Equation (2).

$$R_P = \frac{P_0 - P_i}{P_0} \times 100\% \tag{2}$$

Where R_P is peak runoff reduction rate (%); P_0 is the runoff peak under the current scenario (m^3/s); T_i is the runoff peak under the *i*th scenario of blue-green infrastructure design (m^3/s).

(3) Pollutant Load Removal Rate

Total suspended solids (TSS) are often correlated with other pollutants, which is generally used as the control index for runoff pollutants, calculated using Equation (3).

$$R_Q = \frac{V_{IL} + V_{BR}}{V_{IB} + V_{SB}} \times 100\% \tag{3}$$

Where R_Q is pollutant load removal rate (%); V_{IL} is pollutant infiltration loss (kg); V_{BR} is the amount removed by best management practices (kg); V_{IB} is the initial growth amount (kg); V_{SB} is the surface growth amount (kg).

(4) Economic Costs

The life cycle cost of the blue-green infrastructure is calculated from Equation (4) to (5). The calculation of *ULCC* is shown in Equation (6).

$$LCC_{j,n} = IC_j + \sum_{i=0}^{n} \frac{1}{(1+i)^t} OMC_j - \frac{1}{(1+i)^n} SV_{j,n}(t \in n) \tag{4}$$

$$SV_n = \left(1 - \frac{1}{n}\right) \cdot OMC \tag{5}$$

Where $LCC_{j,n}$ is all costs of the blue-green infrastructure *j* associated with the project from a systems perspective (RMB); *i* is the discount rate (%), which is set at 5% for this study. *n* is the design life of the blue-green infrastructure (years). In this study, the life expectancy of the green roof and the vegetated swale is estimated to be 20 years, while the permeable pavement has a life expectancy of 8 years; IC_j is the initial construction and design cost of blue-green Infrastructure *j* (RMB); OMC_j is the operation and maintenance cost of blue-green Infrastructure *j* (RMB); $SV_{j,n}$ is the residual value of blue-green infrastructure *j* in the last year of design life (RMB). The operation and maintenance cost for the green roof accounts for 6% to 16% of the initial construction and design cost. The operation and maintenance cost for the permeable pavement is 1% of the initial construction and design cost. The operation and maintenance cost for the vegetated swale ranges from 1% to 2% of the initial construction and design cost. The operation and maintenance cost for the bioretention cell is between 5% and 7% of the initial construction and design cost. The above values are referenced from *Technical Guide for Sponge City* and related literature(Mei et al., 2018; Peng et al., 2015).

$$ULCC = \begin{cases} \dfrac{LCC_j}{n_j} & \text{（}\textit{a single green infrastructure scenario}\text{）} \\ \sum_{j=1}^{m} \varpi_j \cdot \dfrac{LCC_j}{\mathrm{n}_j} & \text{（}\textit{green infrastructure portfolio scenario}\text{）} \end{cases} \tag{6}$$

Where *ULCC* is the annual life cycle cost (RMB/m^2); *j* is a single blue-green infrastructure ($j \in m$); n_j is the design life of blue-green infrastructure *j* (RMB); *m* is the total number of blue-green infrastructure types within the portfolio; ϖ_j is the percentage of the area occupied by each blue-green infrastructure component under the blue-green infrastructure portfolio scenario.

2.4.2 The simulation method for the effectiveness of blue-green infrastructure rainwater systems

The SWMM model is designed to assess the impact of blue-green infrastructure on stormwater runoff and water quality control. The Low Impact Development (LID) module has been incorporated into the model since SWMM version 5.0. The LID unit is represented by a combination of various vertical layers, such as surface, soil, and aquifer, and can be allocated within a specified sub-catchment area based on its regional coverage(Fong et al., 2016). The properties of different LID elements, including thickness, spatial vegetation coverage, porosity, and saturated soil hydraulic conductivity, influence the simulation results of the vertical layers.

This study references the SWMM model user manual and related research(J. Gao, 2021; Mai, 2021; J. Zeng, 2020) to ascertain the vertical layer composition and associated parameters of each green infrastructure component. The vertical structure of the bioretention cell consists of a surface layer, a soil layer, and an aquifer. In the green roof structure, the drainage cushion layer replaces both the aquifer and drainage layers. In the case of permeable pavements, the soil layer is substituted by the pavement layer. Vegetated swales consist solely of a surface layer.

2.5 multi-objective optimization design of blue-green infrastructure based on response surface methodology

2.5.1 Optimization method

Response Surface Methodology (RSM), proposed by Box and Wilson in 1951, is a design optimization approach that combines mathematical statistics with experimental data. It establishes the functional relationship between two or more input parameters and the corresponding output response values, allowing for the prediction of response value variations within non-tested parameter ranges(Myers et al., 2018). RSM is characterized by relatively straightforward calculations, a limited number of experiments, and a clear presentation of results. It is widely utilized in the fields of chemistry, food science, and biology. The general steps involved in RSM include experimental design, mathematical model establishment, model validation, and the search for optimal response values. This study employs the Box-Behnken design method.

2.5.2 Rainfall conditions

The Special Plan for Guangzhou Sponge City (2016-2030) stipulates that the total annual runoff control rate should be 75%. This target is primarily achieved by managing medium and small rainfall events, which occur frequently. According to Table 1, when the total annual runoff control rate reaches 75%, the corresponding design rainfall is 30.3 mm. Based on the design rainstorm equation for Guangzhou City, a rainfall process line of 30.3 mm is established.

Table 1. The corresponding relationship between total annual runoff control rate and design rainfall in Guangzhou

Total Annual Runoff Control Rate / %	**60**	**65**	**70**	**75**	**80**	**85**
Design Rainfall / mm	18.9	22.1	25.8	**30.3**	36.0	43.7

2.5.3 Simulation scheme design

(1) The scope of green infrastructure reconstruction in Yangmei River Basin

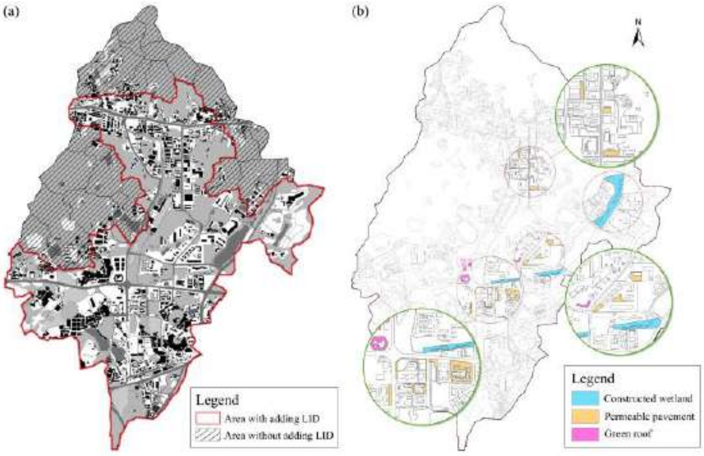

Figure 2. The scope of constructed and reconstructed blue-green infrastructure in Yangmei River Basin

The potential for deploying green infrastructure measures is defined within the context of current land use, as illustrated in Figure 3a. Existing houses can be transformed into green roofs, covering an area of 745,186 m². Additionally, current green spaces can be converted into vegetated swales or bioretention cells, encompassing an area of 389,981,796 m². Furthermore, existing roads and plazas can be upgraded to permeable pavements, with a retrofit area of 4,057,544.79 m². According to the field survey, the constructed wetland spans 169,619 m², the permeable pavement covers 64,453 m², and the green roof occupies 32,110 m². The spatial distribution of these features is depicted in Figure 2b.

(2) Target optimization and transformation area

The goal of optimizing blue-green infrastructure is to identify the most effective design scheme that minimizes costs while maximizing benefits related to water quantity and quality. In this study, we employ RSM using Design-Expert software to optimize the proportion of green infrastructure reconstruction in the Yangmei River Basin. The factors analyzed in the simulation include the proportions of four types of green infrastructure, while the response variables are the runoff control rate, pollutant load removal rate, and economic cost. The response values for each test scheme are calculated using equations (7), (3), and (6), respectively.

$$\alpha=\left(1-\frac{V_{SR}}{V_{TP}}\right)\times 100\% \tag{7}$$

Where α is the runoff control rate; V_{TP} is the total rainfall (10^6L); V_{SR} is the total runoff (10^6L).

According to the requirements outlined in *The Special Plan for Guangzhou Sponge City (2016-2030)* and considering the current conditions of the study area, the constraints for each factor are as follows: the transformation rate of green roofs must be no less than 30%, the transformation rate of permeable pavements must not exceed 60%, and the total transformation rate for vegetated swales and bioretention cells must not exceed 50%. Additionally, the combined area of the four types of green infrastructure should be less than 30% of the total area of the study area. In the test scheme, the values for green roofs (GR) were 35, 67.5, and 100; for permeable pavements (PP), they were 0, 30, and 60; for vegetated swales (VS), they were 20, 35, and 50; and for bioretention cells (BR), they were 20, 35, and 50.

3. Result

3.1 The economic cost of green infrastructure

The life cycle costs of various blue-green infrastructures were presented in Table 2. The life cycle costs per unit area for RF, PP, VS, and BR were ￥95.6, ￥82.7, ￥10.6, and ￥63.4, respectively. The construction and maintenance of VS were relatively straightforward, resulting in the lowest associated economic cost.

Table 2. Annual life cycle cost of green infrastructure (RMB/m^2)

Green Infrastructure	*IC*	*OMC*	*SV*	*LCC*	*ULCC*
RF	783.0	86.1	81.8	1911.7	95.6
PP	619.0	6.2	5.4	661.5	82.7
VS	178.0	2.7	2.5	213.0	10.6
BR	710	42.6	40.5	1268.2	63.4

3.2 Effectiveness of optimal scheme based on RSM

The SWMM model was employed to execute the test schemes, and the corresponding response values were calculated. The experimental results were fitted and analyzed, revealing the functional relationships among the runoff control rate, pollutant load removal rate, average annual cost per unit, and the transformation proportion of various green infrastructures, as illustrated in equations (8)–(10). An analysis of variance and error statistics for these functional relationships (Table 3) indicated that the ρ-values of the three fitted regression equations—runoff control rate, pollutant load removal rate, and annual life cycle cost—were all less than 0.0001. Additionally, both R^2 and adjusted R^2 values exceed 0.9. These results demonstrate that the fitted regression equations possess strong significance and high reliability, making them suitable for predicting the optimal transformation proportion of green infrastructure.

$$\begin{aligned}&\alpha = 65.20184 + 0.075771x_1 + 0.035368x_2 - 0.076424x_3 + 0.126897x_4 \\ &+8.473\times10^{-6}x_1x_2 + 5.084\times10^{-6}x_1x_3 + 3.389\times10^{-6}x_1x_4 + 0.002621x_2x_3 \\ &+0.000011x_2x_4 + 1.84171\times10^{-6}x_3x_4 - 0.000125x_1^2 + 0.000264x_2^2 + \\ &0.001014x_3^2 - 0.000545x_4^2\end{aligned} \tag{8}$$

$$\begin{aligned}&\beta = 7.50537 + 0.073398x_1 + 0.155516x_2 - 0.019840x_3 + 0.082988x_4 \\ &-0.000816x_1x_2 - 0.000262x_1x_3 - 0.000262x_1x_4 - 0.000247x_2x_3 \\ &-0.000857x_2x_4 - 0.000625x_3x_4 - 0.000300x_1^2 - 0.001297x_2^2 + 0.000361x_3^2 \\ &-0.000695x_4^2\end{aligned} \tag{9}$$

$$\begin{aligned}&\gamma = 53.79724 + 0.146386x_1 + 0.559213x_2 - 0.831520x_3 + 0.172977x_4 \\ &-0.001170x_1x_2 + 0.000111x_1x_3 - 0.000708x_1x_4 + 0.001444x_2x_3 \\ &-0.003411x_2x_4 + 0.003155x_3x_4 - 0.000145x_1^2 - 0.002479x_2^2 \\ &+0.003784x_3^2 - 0.000815x_4^2\end{aligned} \tag{10}$$

Where α is the runoff control rate (%); β is the pollutant load removal rate (%); γ is the annual life cycle cost (RMB/m^2); x_1 is the transformation proportion of RF (%); x_2 is the transformation proportion of PP (%); x_3 is the transformation proportion of VS (%); x_4 is the transformation proportion of BR (%).

Table 3. Analysis of variance and error statistics of fitted regression equations for runoff control rate and pollutant load removal rate

Indicators	*F*-value	*P*-value	*C.V.*（%）	R^2	adjusted R^2
Runoff Control Rate	46.57	<0.0001	0.9099	0.9819	0.9608
Pollutant Load Removal Rate	18.28	<0.0001	2.80	0.9552	0.9030
Annual Life Cycle Cost	342.10	<0.0001	0.9514	0.9975	0.9946

In this study, the objective of the optimal scheme is to achieve a total runoff control rate of 75%, the lowest annual life cycle cost, and the highest pollutant load removal rate. The proportions of GR, PP, VS, and BR in the optimal scheme were 34.818%, 49.838%, 29.999%, and 20.000%, respectively, which accounted for 1.58%, 12.28%, 7.11%, and 4.74% of the total study area. According to the aforementioned scheme, the runoff control rate was 75.33%, and the pollutant load removal rate was 11.803%. The annual life cycle cost was calculated to be 60.00 RMB/m² using formula (7). By applying the functional relationships outlined in equations (8) to (10), the runoff control rate was determined to be 75.000%, the pollutant load removal rate was 11.867%, and the annual life cycle cost was 60.27 RMB/m². These results closely align with the simulation outcomes of the model, demonstrating that the fitted regression equation is reasonable.

3.3 Blue infrastructure reconstruction based on the optimal scheme of green infrastructure

SWMM model can demonstrate various metrics, including infiltration loss, evaporation loss, surface outflow thickness, drainage layer outflow thickness, initial impoundment thickness, and final impoundment thickness of different green infrastructures. The optimal scheme indicates a storage volume of 138,313.6 m³ for green infrastructure. The annual runoff control rate is 75%, corresponding to a designed rainfall of 30.3 mm. The rainfall collection area for Xintang Reservoir is 135 hectares, while Ludong Reservoir covers 28 hectares. The total storage volume amounts to 230,687.2 m³. The study area contains numerous lakes and ponds, some of which do not serve the purpose of farmland irrigation. Based on field investigations, seven ponds and lakes have been selected for transformation into reservoirs. Assuming average water depths of 1.5 m and 0.8 m, respectively, the adjusted storage volume for these reservoirs is 9,337.2 m³. In conclusion, the blue-green infrastructure scheme, which combines the optimal green infrastructure design with the blue-green infrastructure reconstruction scheme, can adequately meet the storage volume requirements of the study area.

4. Discussion

Grey infrastructure is designed to facilitate the rapid discharge of rainwater runoff; however, it effectively separates the relationship between humans and nature. The rigid resistance that grey infrastructure provides against heavy rain and flooding is insufficient to meet the demands of more resilient urban development. Therefore, it is essential to leverage the versatility and adaptability of green infrastructure, the reliability and acceptability of grey infrastructure, and the adequacy and inclusiveness of blue infrastructure. Consequently, flood adaptability measures—encompassing source control, mid-way transmission, and end discharge—are established to enhance the overall response to urban stormwater management.

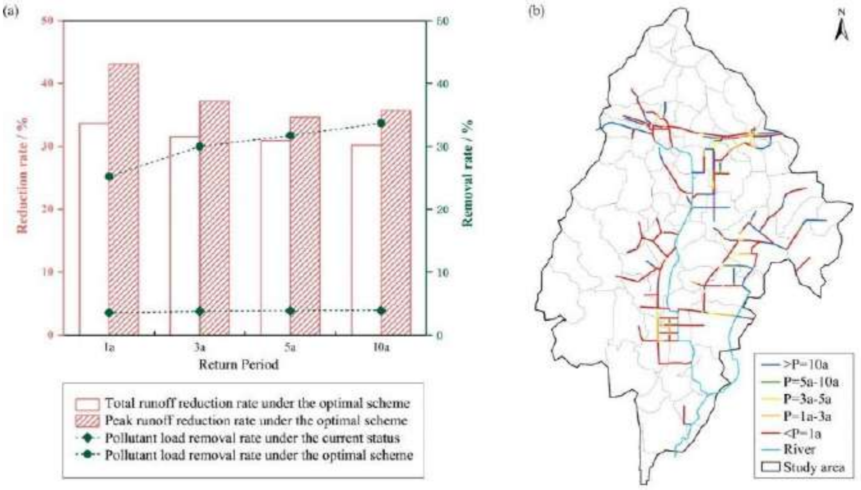

Figure 3. The control effect of the optimal scheme on water quantity and water quality and the evaluation of its pipeline drainage capacity

Figure 3a illustrates that optimal blue-green infrastructure can effectively manage both the total volume and peak flow of runoff under varying rainfall intensities, demonstrating a strong capacity for pollutant removal. However, the effectiveness of green infrastructure diminishes as rainfall intensity increases beyond a certain threshold. Consequently, green infrastructure is more beneficial in medium- and small-scale rainfall scenarios. The Yangmei River Basin is situated in the central urban area of a major metropolitan city, and its stormwater drainage system is designed for a return period of 3 to 5 years, as outlined in Section 4.1.3 of *Standard* *for design of outdoor wastewater engineering*. The SWMM model is employed to assess the drainage capacity of the optimal layout scheme for green infrastructure under different return periods with the results presented in Figure 3b. Statistics indicated that only 28.7% of the pipelines in the Yangmei River Basin comply with the design standards. To effectively address urban waterlogging, the drainage capacity of the stormwater network can be enhanced by increasing pipe diameter and slope, as well as by repairing missing pipes, among other measures.

5. Conclusion

As an urban stormwater management strategy rooted in the concept of ecological civilization, the construction of blue-green infrastructure aims to alleviate the pressures of urbanization and address ecological challenges faced by stormwater systems. Additionally, it enhances the resilience of urban rainwater systems in the face of climate change. Currently, research on the life cycle cost evaluation of green infrastructure is extensive; however, it often assumes a uniform service life across various types of green infrastructure, overlooking the differences in the actual service life of different systems. This study comprehensively measured the service life of various green infrastructure types and introduces the annual life cycle cost as an economic cost evaluation index for the green infrastructure design. An optimal allocation model for green infrastructure in the study area was established, and the optimal solution was derived using the response surface method, which considers multiple objectives, including runoff control rate, pollutant load removal rate, and economic cost. This approach achieved the dual benefits of efficient stormwater management and low-cost investment. Furthermore, the blue infrastructure improvement scheme was determined based on the results of the optimal allocation of green infrastructure, effectively leveraging the functions of blue-green infrastructure for rainwater storage.

Funding

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Alternative Reading of the Urbanised Water Towns in the Yangtze River Delta: Positioning the Indigenous Polder-Based Landscape

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Abstract

Inspired by landscape urbanism, regenerative landscape heritage refers to the process where the landscape is always evolving, generating something new but fundamentally based on prior context. Challenged by urbanization, whether the landscape is regenerative by its tradition or being displaced is debatable. The paper briefly presents examples from my PhD research, studying the polder (wei-tian)-based water urbanism in China's Yangtze River Delta. Mapping is the main method used to narrate the landscape as a regenerative process, where major changes can be linked to broader project contexts that are not necessarily in situ or temporarily continuous. The paper argues that an adaptive inheritance of polder-based landscape traditions can still be systematically interpreted, except for the phenomenal modern planning that is most visible. Examining and enhancing the regenerative landscape process is crucial to countering the abuse of generic modern planning terminologies and their led practices.

Keywords: Polders, water urbanism, landscape-based traditions, mapping, Jiangnan water towns

1. Adaptive Landscape-based Traditions

Landscape-based practices are often read as processes rather than stagnant states by the moment of the finishing of construction (Corner, 2006). In this sense, sustainable landscapes are always regenerative, resulting from natural succession, constant human interventions, socioecological resilience, etc. Considering this, regenerative landscape practices refer to the planning and design processes that produce something new but fundamentally based on its prior context. The prior context changes can be situated in an extensive history of the site——the area of control, influence, and effect (Burns & Kahn, 2005). This is not only out of respect for history and culture but also for interacting with the intrinsic regenerative process, often without unified spatiotemporal boundaries.

Landscape Urbanism is the main theoretical discourse this short paper wants to highlight. This theoretical discourse initially emerged in the context of the post-industrial crises in North America and positioned landscape as a strategical regenerative medium tackling the issues that modern architecture and urban planning cannot resolve (Waldheim, 2016). In the recent decade, practice-based theoretical discussions have extended from pioneering contemporary projects to learning from indigenous landscape-based practices. Especially by learning from landscape traditions in the Global South, scholars developed theoretical notions, such as the art of survival (Yu, 2006), water urbanism (Shannon et al., 2008), Lo-TEK (Watson & Davis, 2019), etc. A locally-rooted narrative is not merely romanticized rhetoric because pluriversal ontological new stories might inspire strategies to solve many "modern problems without modern solutions" (Escobar, 2016).

Linking theoretical criticisms to practical inspirations, the regenerative system is expected to integrate indigenous landscapes as basic layers in planning. Well-studied landscape-based traditions by urbanists are usually the ones that are still functioning adaptively under inevitable modernization and urbanization. For those not “frozen” as heritage due to their large areas and crucial practicality, it is debatable whether the many dramatic changes are a positive result of regenerative uses or a negative outcome of deconstruction and replacement (Smith, 2006). The broader concept of being regenerative counters many mainstream landscape conservation practices, simplifying landscape-based practices into some heritage projects. They are confined to limited heritage zones driven by consumerist tourism. Research-enhanced territorial planning has not yet corrected their blindness to regenerative traditions deeply rooted in everyday sociocultural ties and enduring practicality, such as water management, biodiversity, etc. This can be partially attributed to the lack of strong narratives to “decolonize” many well-taken traveling planning methodologies and notions before they have been robustly institutionalized (Vicenzotti & Qviström, 2018). The insufficient potential manifestation of the regenerative landscapes makes it hard to shift the worldview (Gibbons et al., 2018).

2. The Longue Durée of Polders-based Deltaic Settling

An example is the wei-tian (polder) landscape in the Yangtze River Delta (YRD), one of the most developed metropolises in China. Water urbanism in the deltaic regions presents the longue durée of the polder-based landscape traditions. Unignorably stereotyped functional zoning, modernist architecture, road systems, etc., gradually evolved into a biased but prevalent culture of in-situ modernity while sarcastically without contextualized attachment. While academia has proposed the polder as a water heritage, Chinese governmental regulations have not yet implemented the proposal (Wang et al., 2023).

Affiliated with my PhD research, the polder-based settling is positioned to represent Chinese landscape urbanism (Figure 1). One of the hypotheses is that the traditional knowledge of polder-based water management and landscape systems demonstrates resilience and can interpret present scenarios without being largely replaced by prototypical traveling planning and design concepts. Such a hypothesis is based on the readable regenerative characters of landscape-based practices by literature and fieldwork. Since landscape urbanism is based on reading the palimpsests and theorizing the phenomenon, mapping is a common methodology for documenting and narrating the synthesized findings (De Meulder & Shannon, 2010). My research explores mixed methods to create multi-scalar and spatiotemporal mappings to position the evolving polder-based landscape.

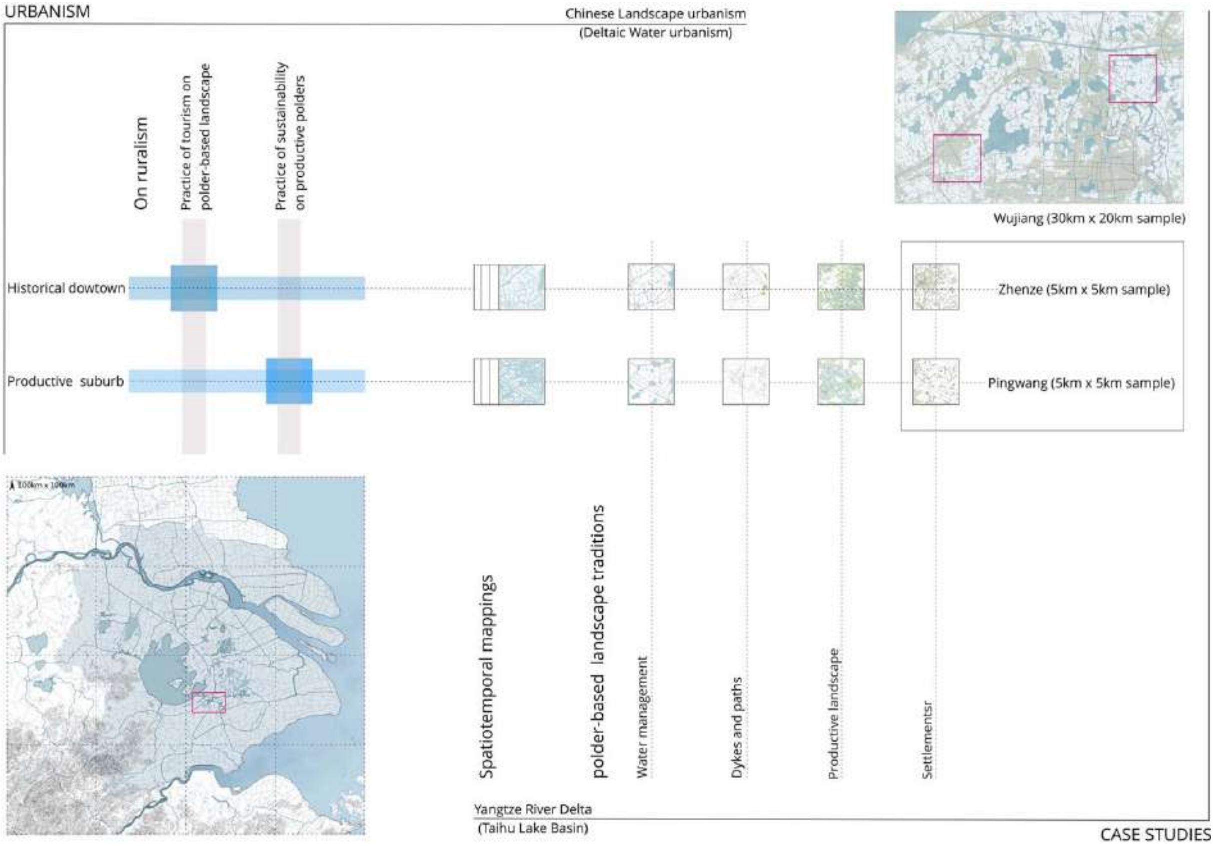

Figure 1. Diagram of the research framework depicting the relationship between the reflection on Chinese landscape urbanism and the grounded case studies in the YRD region (Lei, 2024)

The study dived into millennium history by first situating the polder-based landscape as some categorised prototypes concerning the known dramatic environmental changes in the delta (Miu, 1985; Xie, 2017). The purpose is to examine whether the contemporary polder-based water management models can be linked to certain historical ones. The diagram classified the types of polders and presented systematic processes of polders' evolution (Figure 2). Regeneration of the polders presents an iterative progression—between the bottom-up small-size and top-down big-size polders throughout history. Polder reclamation and management are closely linked to deltaic typographical and sociopolitical changes. Initially achieved through garrison reclamation and management, the gridded da-wei (big polder) system was gradually disintegrated in the delta from the 10th century onwards and replaced by the bottom-up developed fishscale-patterned polders (yulin-wei) due to the weaker central government in the following dynasties (Zheng, 1987). Contemporary China has reemerged a strong central government. Wei-qu (polder zones), the modern water management zones formed through the communist social campaign in the latter part of the 20th century, can be deemed a revival of the historical da-wei (big polder) system.

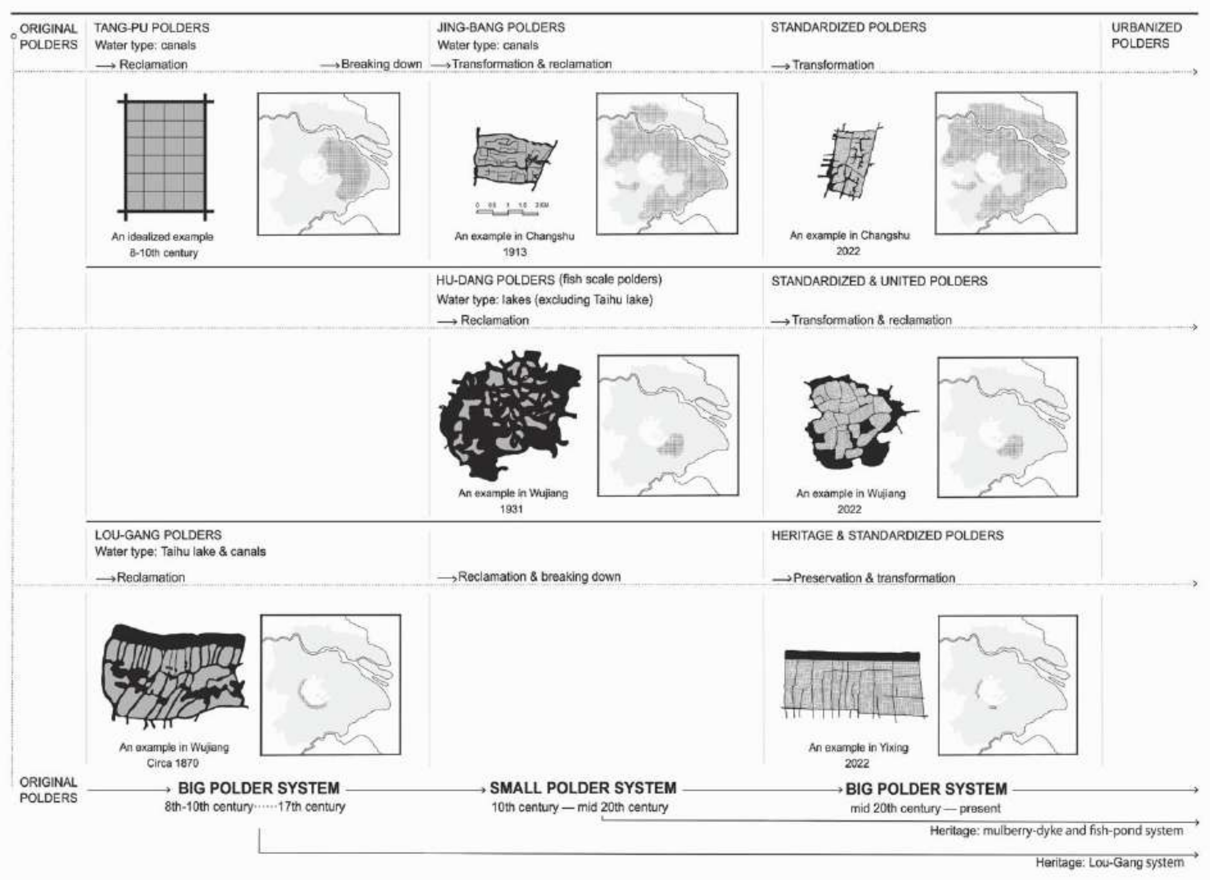

Figure 2. Polder models in evolution throughout millennia in the YRD region (Lei, 2024) with reference to (Xie, 2017)

3. Regenerative Polder-based Landscapes

While prototypical polder models present an iteration on the mega deltaic scale, smaller-scale mapping-based analyses further depict the polder-based landscape system. Two adjacent historical water towns along the ancient Ditang Canal—Pingwang and Zhenze- were selected as study cases. Located on the present Eastern lakeside of Taihu Lake, their polders have been intensively reclaimed from the 10th century in the lowland, which used to be a free water outlet of Taihu Lake. Each town contributes a 5km x 5km study sample of wei-qu (polder zones, Figure 3). While polders stand for an integral system itself, the polder-based landscapes are decomposed into several intertwined sub-systems, such as water management (path-topped) dikes, productive landscapes, settlements, etc. While meeting the common sense of being "modernized" in the past decades, each polder-based system can be linked to its historical prototypes, similar to the analyses of the polder models on the deltaic scale. As exemplified by the following highlights, this can be part of the evidence that the polder landscape is regenerative rather than being erased and replaced.

Figure 3. Drone views of the studied 5km x 5km sample of wei-qu (polder zones). The chosen sample in Zhenze is with its historical town included, where urban sprawl can be observed. The one in Pingwang is segregated from its downtown by a wide canal and remains rural and productive (Lei, 2023)

Despite the increased size and mechanization, the fundamental idea of a polder-based water management system has not changed. Flood control and irrigation are achieved through different typographical elevations, dikes, and water sluices (Figure 4). Currently, polders can be defined as one of three types of water management systems that operate on radically different scales: 1] a few yulin-wei (fishscale-patterned polders) used for traditional farming that is still remaining. Frequently located near farmers' homes, those polders are often well-cultivated by many retired elders as their handy food source and living habitat.; 2] bing-wei (merged polders), most visible on satellite maps as grids of irrigated fields surrounded by water. The large grided fields are formed by the numerous former fish scale-pattered polders for the convenience of mechanized cultivation. And 3] lian-wei (joined polders), often separated by major canals and lakes, dammed by channels and lakes, and regulated through sluices. Nevertheless, the water management systems of the latter two types are often difficult to perceive due to their large scale. In some tourism projects, fishscale-patterned polders are showcased to tourists to experience participatory farming, an over-simplified public education in the locally promoted countryside tourism projects. To have a "frozen" visually aesthetic-driven perception of landscape in certain scenic spots counters the idea of "landscape" in landscape urbanism (Vicenzotti, 2017).

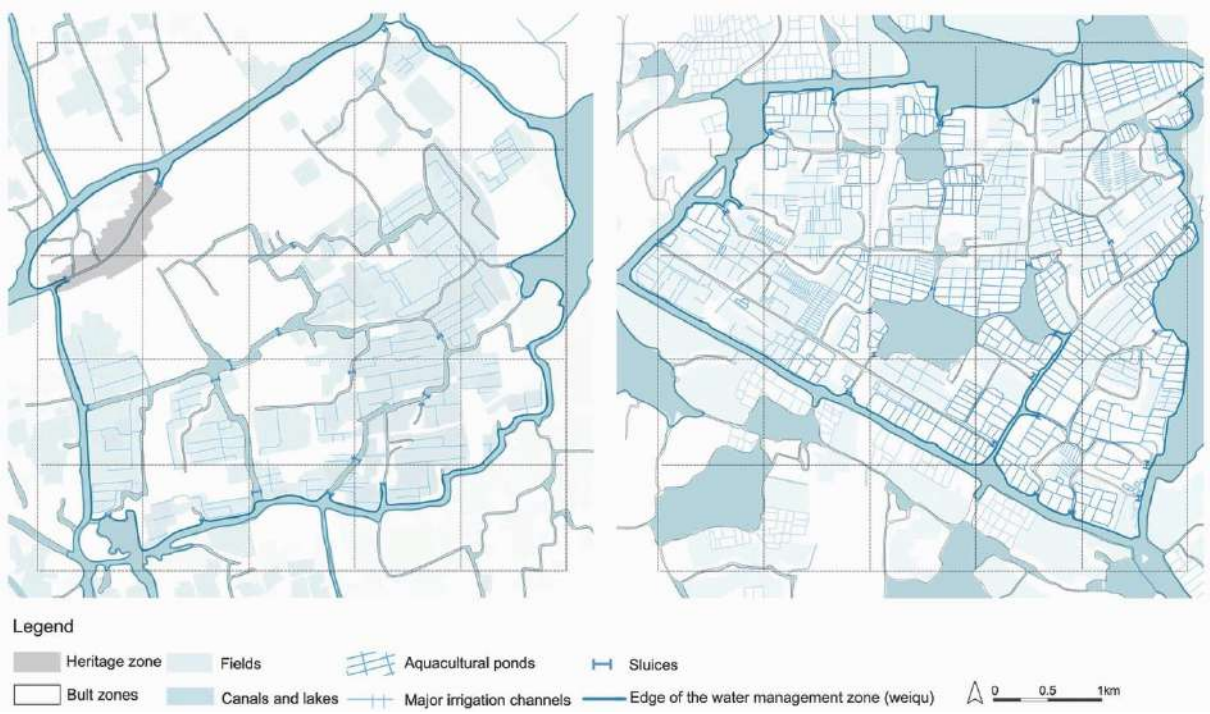

Figure 4. Polder-based water management system in the 5kmx5km samples of wei-qu affiliated to Zhenze and Pingwang (Lei, 2024)

The traditional path-topped dykes and the plant-enhanced dykes are still prevalently observable after the polder engineering and the road networks. Initially, the added functions to the dikes were crucially adaptive to the deltaic settling for practical uses, such as connecting land by bridges, preventing flow erosion, etc (Zheng, 1987). Gradually, public spaces emerged on and along the path-topped dike. The water infrastructure began to be perceived as scenic pots, appearing in landscape poems and paintings from the Song dynasty onwards (Wang, 2016). This can be read as an indigenous resonance to today's well-used concept of "landscape as infrastructure" (Bélanger, 2013).These landscape traditions share multiple identities nowadays when modern planning and design terminology prevalently name them as boulevards, greenways, linear waterfront parks, eco-friendly dykes, etc., in practice (Figure 5). While new landscapes are created mainly under projects stated by those modern terms, the traditional multifunctions of dykes are not fundamentally repurposed.

Figure 5. An exemplary new dyke scene in an urbanized area of Zhenze. New green belts and modern roads are added on both sides of the canal (Lei, 2023)

The land productivity limit and alternative cultivation development have regenerated the dominant agricultural and forestry landscape. Growing settlements and vegetation were initially significantly linked to constant sedimentation and reclamation. The increased land areas and elevation allowed the sprawl of many introduced species and several major migrations into the area that used to be lakeside wetlands. However, polder reclamation slowed down and was no longer the major boost to productivity from the 14th century onwards (Fan, 1990). The initial key economy of rice cropping reached the land capacity to feed the local population. More profitable industries started to emerge, generating new landscapes, such as vast mulberry tree forests for silkworm raising, partially replacing the rice-cropping fields. Several dominant plant species linked to further settling can reflect the gradual changes throughout the centuries (Figure 6).

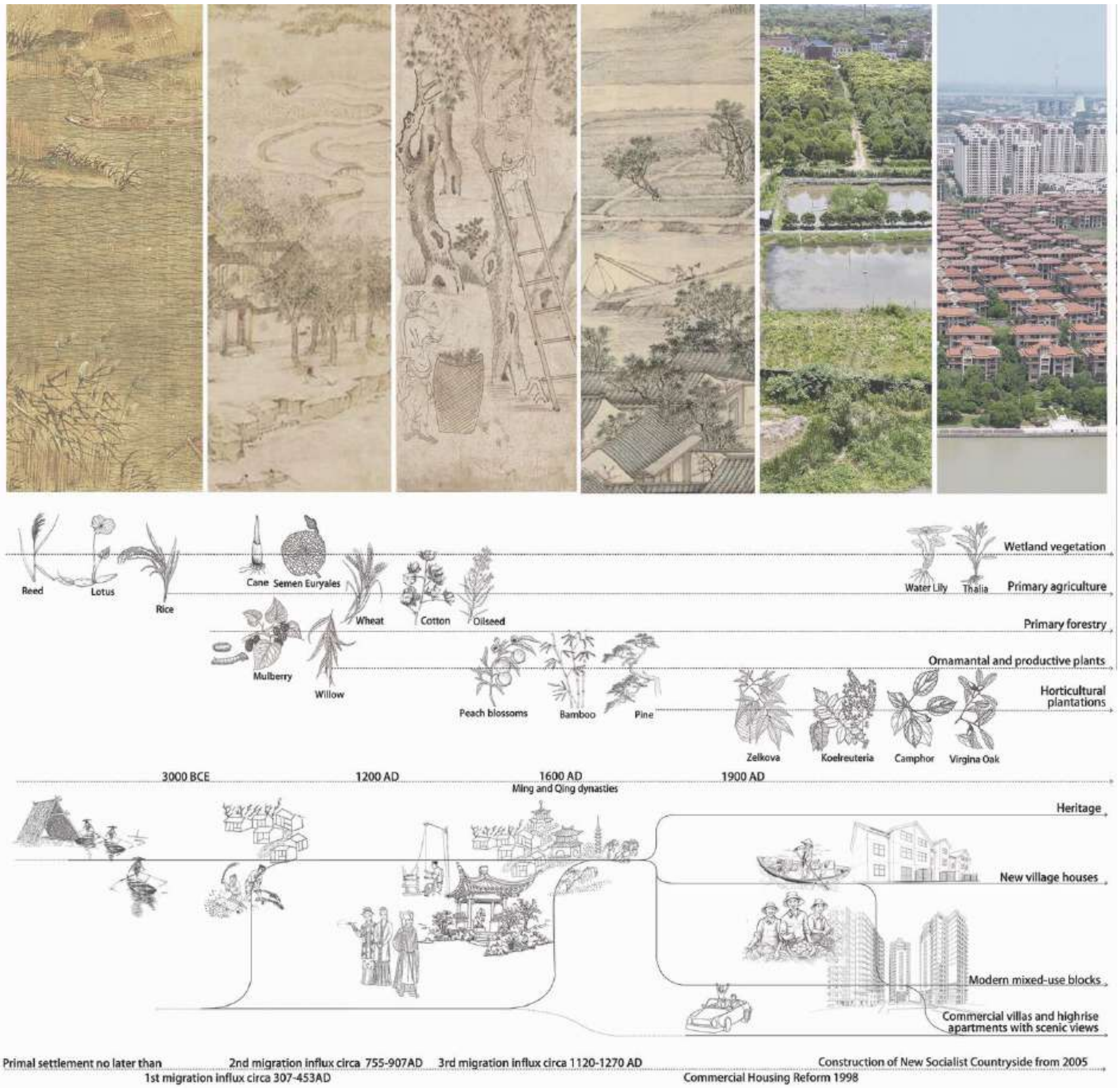

Figure 6. To produce more profit from the land, the productive landscape is constantly regenerative, readable from the evolving dominant vegetation species and ways of settling (Lei, 2024)

Even after the decline in raw silk and cropping profit in recent decades, forestation continues growing by replacing mulberry trees with more profitable ornamental plantations to support the long history of exporting-oriented local industry. The initial growth of the ornamental plantation in water towns can be linked to China's millennia-old gentry culture of living in seclusion. As can be speculated, it was not the migrated farmers but the early gentries who initially introduced ornamental plant species with strong cultural meanings to their gardens (Wang, 2013). The initial gentry consumption of ornamental plants shaped the many cultural landscapes and eventually developed into one of the key local agricultural industries.

4. Conclusion and Discusion

While exhibiting dynamic polder changes throughout time, the polder-based landscapes exemplified can be deemed regenerative rather than abandoned and displaced. The landscapes are repurposed for many reasons, while the infrastructural functionalities, ways of cultivation, and waterfront everydayness stay fundamentally similar. Admittedly, this cannot be elaborated in case-specific detail limited to the paper format. As landscape heritage is neither frozen nor self-evident, the inevitable repurposing in traditional ways needs efforts to build strong narration. The mapping-based method applied in my research is a qualitative evaluation based on critical synthesis that links historical evidence to current observations during fieldwork.

Theoretically regarding landscape urbanism, the research values the examined potential approaches of describing the present site through the landscape as a medium rooted in an extended local history and culture. Their historical versus present uses and further socio-environmental interventions that deeply define the site identities are highlighted and interlinked. Sites are thus not dichotomized from being modernized or not, categorized as heritage zones and the rest non-conservative zones. Landscape-based traditions present resilience to those traveling notions and their methods of mass urbanization in that their historical identities can well nuance many contemporary conceptual notions and spatial prototypes. On the other hand, localizing these traveling notions into situated knowledge is also a regenerative process from the theoretical level, which needs further critical reflection and, in return, needs proofs grounded in specific case studies.

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The Resilient Landscape of a Community

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Abstract

In Italy recently we have witnessed an acceleration on natural disasters. This panorama is creating emotional insecurity and social unease.

How can we re-inhabit land by turning obstacles into opportunities for the future? Can landscape become the foundation for a resilient community, or rather become itself a resilient landscape?

Landscape is the SPACE of LIFE.

According to holistic thinking, man is a landscape and landscape is a body acting as MAN'S HABITATION. In traditional cultures there has always been a relationship between man and nature, as a place that generates both illness and care.

In this continuous mutation it is the physical city that forms the place for RELATIONSHIPS in URBAN SPACE. Revolutions and movements start within a network, but occupy the streets where citizens give the territory and cities its physical geography.

The first acts to accomplish for a resilient landscape, are to: OBSERVE, LISTEN and open a DIALOGUE; as a doctor does with a patient; in order to read the traces and memories of a place, welcoming its moral and social wounds.

Keywords: Resilience, community, healing, relationship, urban space

1. Introduction: Facing Landscape’s Loss of Identity

Recently, there have been many consultations, statements (Dichiarazione per l’adattamento climatico delle Green City, Conferenza Nazionale delle Green City, Carta di Peccioli 2019), and concerns about the impact on our landscape of extreme weather phenomena, that have already struck the Mediterranean region with strong heatwaves, prolonged droughts, heavy rainfall in short periods of time, floods and landslides, storms and whirlwinds.

As pointed out in Report From The Commission To The European Parliament And The Council (On the implementation of the EU Strategy on adaptation to climate change, 2018), these phenomena, like major floodings in Pianura Padana and Emilia Romagna region, caused to Italy economic loss amounting to 63 billion euros, calculated over the 1980-2016 period, which makes Italy the second ranking in Europe for economic loss.

In this context, the study of adequate solutions and the ever-growing need and research for new landscape identities is contrasted by the homogenization of architecture and by the international omnipresence of skyscrapers. They are similar in aspect even while thousands of kilometers apart, built in completely different environments, in which the globalization of certain functions is connected to the loss of local identity.

With this comes also the arrogance of using nature in a miniaturized form, forcing it to live in the confinement of prearranged space, depriving it of capability to grow and become one with architecture itself. This technique is far from the seven rules of Zen (Kapleau,1981) that describe the concept of Bonsai, put into practice by Japanese people with attention and humility.

In our urban landscape this miniaturization feeds from cold endless marketing where nature is not a living being, but it's downgraded to ornament of structures.

The expression "urban landscape" seems to contain some kind of epistemological conflict, since the attribution of landscape to a city is rather new, as opposed to the dichotomy nature-artifice that characterized human history until recent years.

Therefore, through this desire to redeem landscape, in this context of use and abuse, simplified emotional consumerism with little sentimental attachment, in which emotions are a matter of seconds, we end up limiting landscape to a digitally captured moment, as a souvenir. This happens because we lack historic site culture.

2. Values and Steps for Reaching a Resilient Landscape

The use of green infrastructures, also called Nature-based solutions (road trees, parks, garden, green roofs and urban gardens) has numerous benefits, especially if they are included in both urban and sectorial planning, and in the management and financing of green spaces.

Nevertheless, the effectiveness and efficiency of these solutions depends on how and where they are put into practices and they need to be incorporated in a cultural vision.

If today the separation between building and symbol is clearly visible, it is mostly because it is up to engineers to define the structure and the architect sees to the shell (Olmo, 2016) and nothing more, so that an office tower in Dubai is similar, if not identical, to one in New York. The care for urban landscapes needs to have its own IDENTITY and CHARACTER.

Let's not forget that between the wilderness devotees and the believers in the perfect lawn there is a third solution, as Evelyne Bloch-Dano and Alexander Pope reminds us and as Norberg Schulz so well describes: *always listen to the genius loci*.

"*That tells the waters to rise, or fall;*

Or helps th' ambitious hill the heav'ns to scale,

Or scoops in circling theatres the vale"

But how can this third solution be translated into action?

The emotional consumption of an urban landscape doesn't create a narrative structure or conscience and memory of the context, but is instead conformed with urban spaces distant from us.

If climate change influences people's life and enhances emotional insecurity and social uneasiness, we should not forget that the Italian landscape, in comparison with the whole planet, it's an area with precise borders, limited spaces, not like the great geographical masses. It also possesses a rich cultural universe, diverse in macro and micro landscapes, which are the result of intense anthropic presence and of an endless succession of people and cultures.

It is a rather narrow space, yet rich in cultural and micro landscapes, which are the result of intense and uninterrupted human occupation.

In this ever-changing space, URBAN SPACE is the place where relationships take space. It's the space of LIFE.

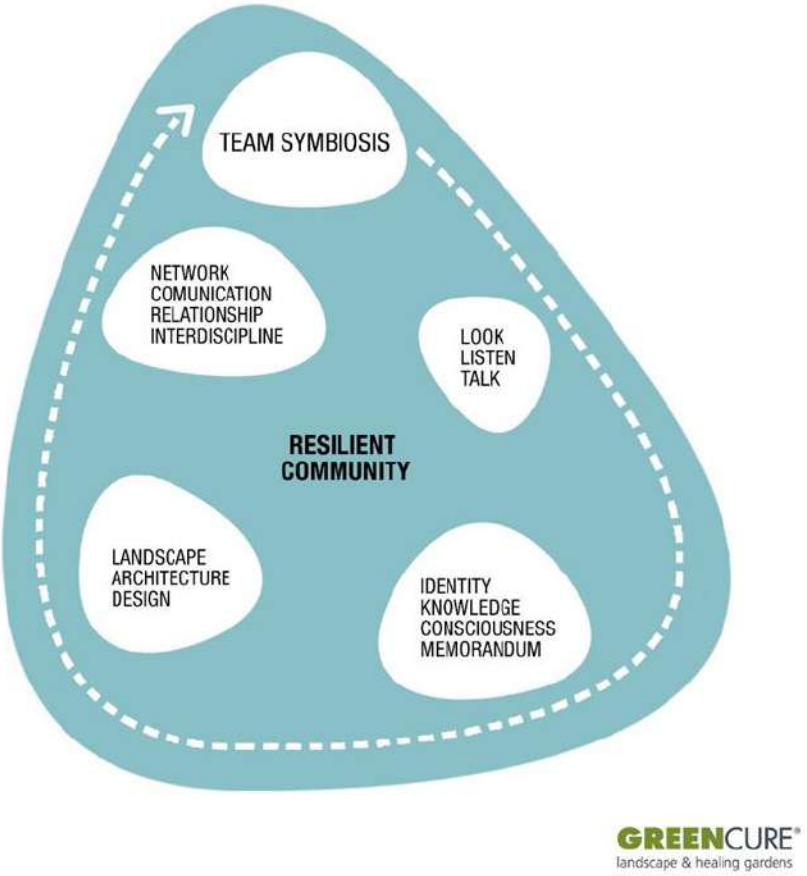

Figure 1. Resilient commuinities (GREENCURE, 2021)

Revolutions and movements start within a network, but occupy the streets where citizens give the territory and cities its physical geography.

The first acts to accomplish for a resilient landscape, are to: OBSERVE, LISTEN and open a DIALOGUE; as a doctor does with a patient; in order to read the traces and memories of a place, welcoming its moral and social wounds.

Emotional safety exists if man perceives and acts according to a good image of the environment. The image varies according to the location, where the followings are recognizable: a centre to refer to, a path to take, in a place defined by spatial boundaries.

A community becomes resilient if it lives dinamically, creating places with a WELLBEING culture.

We need to rethink urban planning starting from landscape as a structural aspect of the city.

It is an interdisciplinary project that requires a MISSION, a DIRECTION and the use of survival tools.

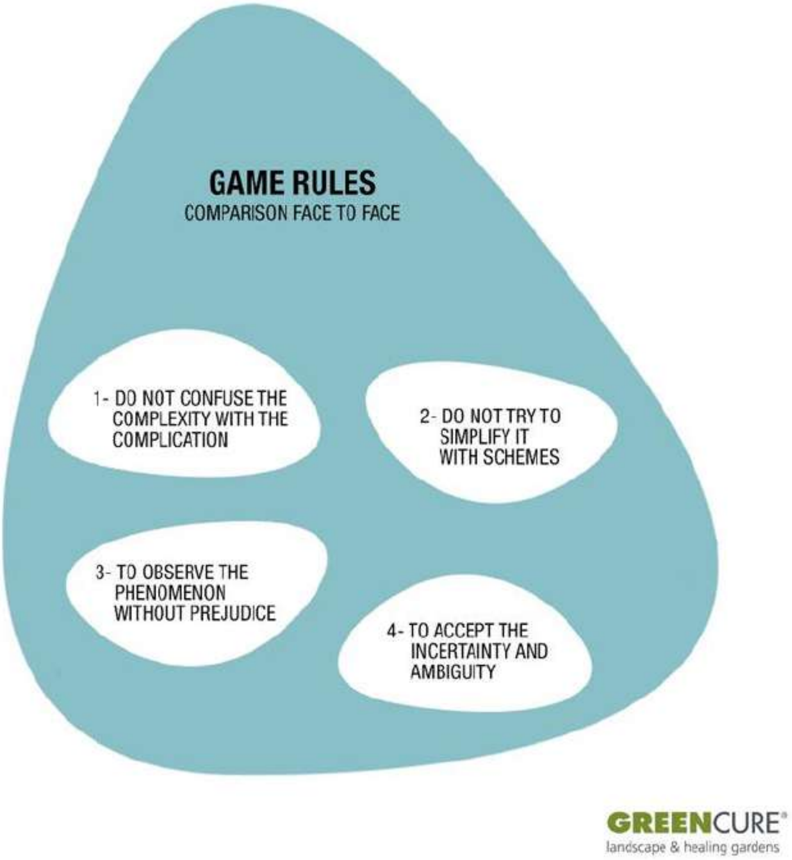

Figure 2. Game rules (GREENCURE, 2021)

Promoting good practices for landscape goes through affirming the importance of intervening on a landscape as an "organism" in continuous evolution.

Italo Calvino in his “Invisible Cities” said how that novel was the last love poem addressed to the city… *Nowadays people talk with equal insistence of the destruction of the natural environment and of the fragility of the large-scale technological systems… The crisis of the overgrown city is the other side of the crisis of the natural world.*

The image of "megalopolis" — *the unending, undifferentiated city which is steadily covering the surface of the earth — dominates my book, too. […] A city is a combination of many things: memory, desires, signs of a language; it is a place of exchange, as any textbook of economic history will tell you — only, these exchanges are not just trade in goods, they also involve words, desires, and memories*. (Calvino. 1972)

It is with this premises that the job needing to be done can begin. It is not only a matter of techniques against climate change, but also against humanistic change, in order to give a SOUL back to urban landscapes. Because urban space it’s a constantly evolving living organism and *we need to seek and learn to recognize who and what, in the midst of the inferno, are not inferno, then make them endure, give them space."*

But the job of a landscape architect it’s humble, not seeking dominion over the space. It needs to accompany and participate, so that the citizens can become interpreters and not consumers of the urban landscape.

The aim is to raise awareness that landscapes have ECOLOGICAL VALUE in interrelation with other values:

- CULTURAL – demonstration of culture,
- SOCIAL – perceived and enjoyed by the citizen,
- ENVIRONMENTAL – cooccurrence of physical, chemical and biological factors,
- ECONOMICAL – goods with price for society.

These values need to be recognised by citizens first, but also by public administration.

The eight steps that constitute these guidelines for the urban landscape of a resilient community were defined envisioning both the work of professionals and communal engineers.

Their concise form serves as starting point for an interdisciplinary work, that will avail itself of behavioural sciences like proxemics and ethnobotany(Bracco,1998), since the factors involved are the well-being of people making use of the green areas, and also the natural growth for the environmental future of our landscapes.

In order to make this green system the framework of regeneration of our urban landscape, this needs to:

1.Be analysed according to:

- Its macro- and microclimatic environmental structure
- Its botanic-naturalistic, cultural and landscape value
- The user’s needs

2.Develop the following points:

- Make the area consistent and recognizable
- Assimilate the context
- Biodiversity
- Functionality and safety
- Path clarity
- Easy management and low maintenance
- Innovation in the technology of material

3.Answer these simple questions:

- Which users is it address to?
- Which message does it want to convey?
- Should it be a place of leisure, meditation or contemplation?
- What kind of management or maintenance will it need?
- Will people harvest it, cultivate it or walk on it?

4.Start a virtuous circle as a site for eco-friendly experimenting, supporting ecosystemic services for the renewal of natural resources (water, waste, light) and supporting biodiversity in species.

5.Safeguard the health of plants, choosing species and cultivar able to resist parasites, which lead to the most common pathologies. Using species resistant to various types of stress: hydric, treading, soil density and intense heat.

6.Studying new solutions to provide adequate diversified water requirements, soil conditioners, soil types, able to better the field capacity and guarantee diversity in urban micro-landscapes.

7.Promote a rational approach in management to intervention planning, adopting the Piano del Verde Urbano (Urban Green Plan). Without this plan there is a relevant waste of public money, and green areas end up being less accessible.

8.Become a mean of VISUAL COMMUNICATION:

- Symbol of accessibility and interaction in practicability,
- Help to practice orienteering skills and increase in the sensation of emotional safety,
- Sustainability,
- Wildlife corridor,
- Reduction of the Urban heat island effect during Summer.

3. Resilience of the Land Rebuilding New Urban Spaces

Those that will follow are a few projects designed by GREENCURE Landscape & Healing gardens, showing how an holistic approach can develop urban spaces welcoming for communities.

Campo Laudato Si’, Caserta, Italy

Located in the city center of Caserta, just a 15-minute walk from the Royal Palace of Caserta. Covering an area of more than 324,000 square meters, it was born from the desire to activate sustainable urban development. The project consists of green infrastructure for biodiversity, social and economic infrastructure, and activities for care, reception, culture and education. The intervention consists of five parks, 252,000 sq m of green space, 511 trees, 786 m of water paths and 10 squares.

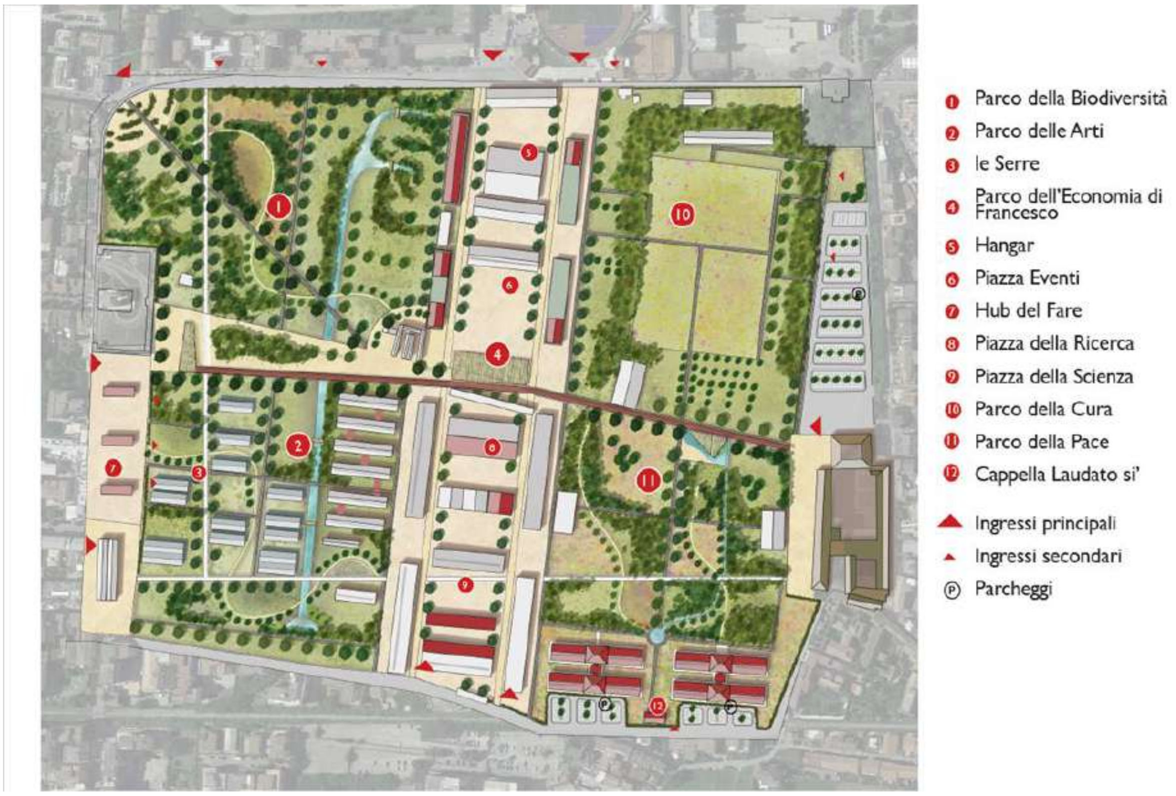

Figure 3. Campo Laudato Si', masterplan (GREENCURE, 2023)

MoLeCoLa, Milan, Italy

MoLeCoLa is the winning project of the C40 Reiventing Cities call for proposals on the Bovisa Node, which affects an abandoned space near the Trenord train station by intercepting the Bovisa University Pole and the neighborhood.

The project was developed with the goal of achieving zero CO2 emissions by 2050. The use of permeable pavements, respect for free-form plant development and building orientation will ensure thermal comfort and meet the principle of climate resilience.

Figure 4. MoLeCoLa, masterplan (GREENCURE, 2021)

Figure 5. MoLeCoLa, vısual (GREENCURE, 2021)

New Headquarter Regione Sicilia, Palermo,Italy

Located in the heart of Palermo, and covering an area of 35,000 square meters, the park is structured in bicycle and pedestrian paths that follow the elevations on different heights and a gradient of 5 percent while also favoring walking for people with motor difficulties.

Green rooms, belvederes bearing the names of the dominant plants present, stand on the paths. Water takes different forms and uses: water pools, gushing on the pavement of, bioretention facilities with rain gardens.

Figure 6. New Headquarter Regione Sicilia, masterplan (GREENCURE, 2020)

Figure 7. New Headquarter Regione Sicilia, visual (GREENCURE, 2020)

TRAMVIA, Palermo Italy

The developing of the Tramvia in Palermo is a clear example on infrastructure becoming landscape. The project aims to create a linear link connecting spaces and people through public transportation.

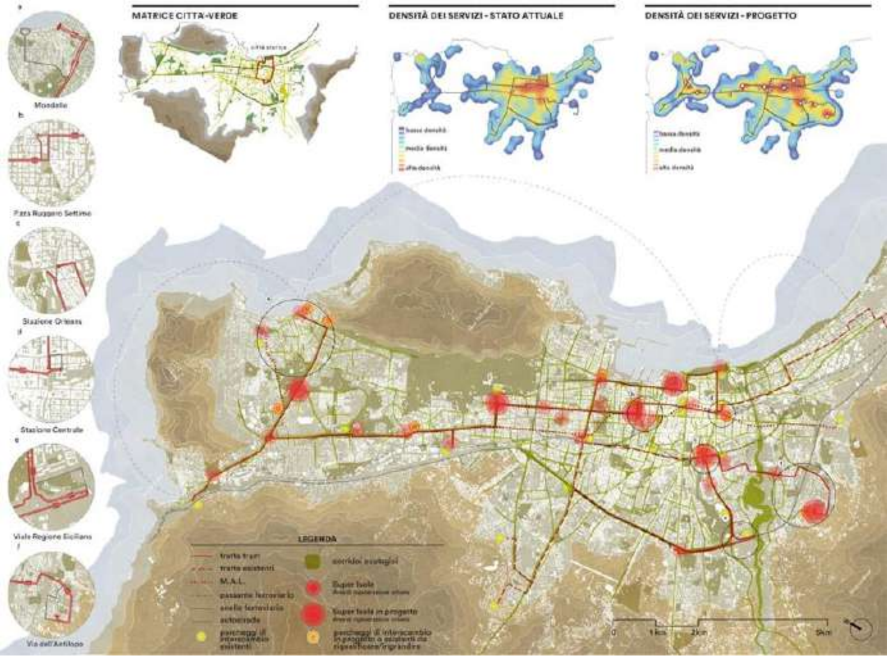

Figure 8. Tramvia Palermo, masterplan (GREENCURE, 2018)

Fıgure 9 and 10. Tramvia Palermo, visual (GREENCURE, 2018)

Sportshall, Cagliari, Italy

The new arena will be able to accommodate at least six thousand spectators and will be a venue for major national and international events. Proximity to the sea proved both a challenge and an opportunity, leading to the selection of plants resistant to salt spray, strong winds, sunlight, and marshy soils.

The plants are typical of the Sardinian landscape: Tamarix gallica, Jacaranda mimosifolia and Lippia nodiflora for the green roof, which is a distinctive and identifying mark of the city's new landscape.

Figure 11. Sportshall Cagliari visual (GREENCURE, 2024)

4. Conclusions: How Will We Live Together?

Altough those projects show that through an holistic approach it is possible to integrate urban spaces with the existing identity of a specific landscape, This gives rise to open questions about how man can live in spaces that generate wellbeing, which defines them in their completeness, because talking about landscape means addressing architectural, social, environmental, spiritual and health issues.

In this idea of a resilient landscape, is there room for a New Humanism?

It is possible that a new landscape vision of a resilient community will help to answer the question: "How will we live together?"

Resilience Wisdom Reflections under the National Planning System

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Abstract

With the frequent occurrence of various types of public emergencies around the world, the construction of "resilient" territorial space is imperative. In the face of the new requirements of dual-carbon and the new changes of digital intelligence, the integration of resilient cities and smart cities is in line with the new trend of socio-economic development and the new requirements of the modernisation of spatial governance capacity. Urban resilience construction and planning has become an important task in the preparation of territory development planning and spatial governance. Under the national planning system, urban resilience construction should be integrated into all aspects of the territory development planning work system, so as to enhance the level of comprehensive resilience in the new period. Based on the connotation of urban resilience wisdom, the study constructs a framework of land space wisdom governance for the construction of resilient cities by sorting out the current status of related research on land space in China and the possible problems and deficiencies, and proposes strategies and revelations for the construction of resilience wisdom in land space planning under the national planning system, so as to provide decision-making references for the improvement of the overall ideas and specific work practices of the construction of resilient land space.

Keywords: Resilience, National planning systems, territorial spatial planning, smart cities

1. Introduction

Currently, various risks are surging globally, and cities, as complex social ecosystems, have been challenged to varying degrees by both external and internal factors(Zhai & Lee, 2024). In this context, humanity has begun to pursue a safer, healthier, and more sustainable urban and rural living environment, and the construction of resilient national land and space is imperative (Wardekker et al., 2010). Since ecologist Holling proposed the concept of ecosystem resilience in the 1970s, emphasizing the stable maintenance of ecosystem structure, function, and organization (Holling, 1973), the field of social sciences has gradually paid attention to the concept of resilience. By the early 21st century, concepts such as "resilient cities" and "urban resilience" frequently appeared in urban planning and geography, emphasizing the adaptation and restoration process of complex urban social ecosystems in the face of external risks and disturbances (Pickett et al., 2004). A relatively complete content system has been formed. For the first time in the 14th Five Year Plan, China has identified the construction of resilient cities as an important task in the formulation of national spatial planning and spatial governance. As an important basis for various development, protection, and construction activities, the new era of national spatial planning should integrate the improvement of urban comprehensive resilience throughout the work system, and achieve safe and effective control of the national spatial pattern (Li & Yi, 2020).

Faced with the new requirements of dual carbon and the new changes of digital intelligence, the National Land and Space Planning Bureau of the Ministry of Natural Resources has repeatedly pointed out in its speeches at conferences that "the future national land and space planning should be a perceptible, learnable, well governed, and adaptive intelligent planning. "The integration of resilient cities and smart cities is in line with the new trend of social and economic development and the new requirements of modernizing spatial governance capabilities. We need to consider the formulation and implementation of national land and space planning from the perspective of resilient intelligence. Based on the connotation of urban resilience intelligence, this study conducts an in-depth analysis of the current research status and possible problems related to China's national land space, and constructs a national land space smart governance framework for resilient city construction. This provides strong support for improving the overall ideas and specific work of resilient national land space construction.

2. Definition of Resilience Wisdom

Resilient city refers to the ability of a city to actively resist disasters and achieve rapid post disaster recovery through rational resource allocation (Ribeiro & Gonalves, 2019); Smart city refers to the use of emerging technologies to upgrade and achieve intelligent management of urban spatial environment, social economy, infrastructure, and other aspects (Zanella et al., 2014). Resilience intelligence is the deep and organic combination of smart cities and resilient cities, covering the intelligence of smart cities and the robustness of resilient cities. It is reflected in the improvement of resilience capabilities such as rapid response, governance, and recovery of cities based on "smart" information, technology, hardware, etc.

Resilience wisdom emphasizes not only the systematic improvement of urban risk resistance capabilities, but also the comprehensiveness and flexibility of cities in various development stages such as perception and warning, emergency decision-making, and learning adaptation (Feng et al., 2024). This requires resilience coordination and strategic guidance in the overall urban planning, the integration of resilience elements and smart technologies at the detailed planning level, and refined management of resilience transportation, communities, healthcare, environmental protection, and other aspects in special planning (Walker et al., 2004); National, provincial, municipal, county, township and other levels of organizations need to support regional planning and special planning based on spatial planning, in order to achieve the unity of smart governance and resilient service levels in the time dimension of "integrating epidemic prevention and control" and the spatial dimension of "soft hard interaction"; Emphasizing the comprehensive application of smart technology in the planning and operation support of optimizing resilient and intelligent governance through the preparation and approval, implementation supervision, regulatory policies, and technical standard system, comprehensively perceiving, analyzing (Li et al.), and enhancing the resilience status of cities, providing reasonable suggestions for building a modern and sustainable national spatial planning system with transmission function and guiding specific implementation and construction, and ultimately achieving resilient intelligence in national spatial planning decision-making.

3. Methodology

This study uses a systematic literature review to determine the current status of resilience planning and smart city planning construction in China, and explores the current issues of resilience smart planning in Chinese cities from the perspective of national spatial planning. On this basis, combined with the workflow of the national spatial planning system, summarize the overall idea of building a resilient and smart national spatial system.

3.1 Literature search and screening

The search queries were developed using the combination of key terms in Table 1. Retrieved books, works, and related literature on China's research in the fields of resilient cities, smart cities, and national spatial planning. The PRISMA method was followed for selecting literature from scientific databases.

Articles related to Chinese cities, which published in journals between 2010 and 2023 in both " Web of Science" and "China National Knowledge Infrastructure" databases, were considered for inclusion. The screening stage involved three steps: title and keywords screening, abstract screening, and full-text screening.

By manually filtering based on titles and keywords, 302 articles were retained for further summary analysis, leaving 189 articles for full-text screening. The inclusion criteria were focused on resilient and smart city research in spatial planning and construction practices, which is consistent with the research objectives. Out of 189 full-text articles, 68 articles met this criterion. 68 articles were selected and analyzed in this study

Table 1. Key terms used for developing the search query

Key terms	**Category**
National Planning System, Land Use Planning, Regional Planning, Comprehensive Planning	The articles related to the National Planning System
Resilience, Adaptability, Suitability, Ecological City Disaster Management, Climate Change	The articles related to the Resilient City
Smart City, Digital City Intelligent City, Urban Informatization, Big Data	The articles related to the Smart City
Spatial Planning, Spatial Governance, Planning Implementation	The articles related to the Spatial Planning Practice

3.2. Content analysis and organization

After identifying relevant literature sources, the selected studies were subjected to thorough content analysis. Table 2 demonstrates a spreadsheet to organize data research subjects, methods, and key content.

An inductive approach guided the content analysis, used to identify relevant resilience, intelligence attributes, and national spatial planning systems from selected literature sources, and refine the extracted content. Initial codes were developed based on the commonly used social science research methodology system, and new codes were added to the data extraction sheet as needed after reviewing each subsequent paper. This process continued until all papers in the database were reviewed.

Table 2. Summary table of Research on Resilience Wisdom (Using Partial References as Examples)

Category	Objects	Methods	Key Content
National Planning System	Planning System	Case analysis	International experience reference
	Huangmei County	Theoretic Framework	Construction of Indicator System for County level Land Spatial Overall Planning
Resilient City	16 cities in the Yangtze River Delta	Quantitative evaluation	Construction of resilience index system and evaluation of urban resilience
	Xiong'an New Area	Qualitative description	Path to Building Resilient Communities
	Coping with Climate Change in Cities	Theoretic Framework	Resilient urban planning methods for coping with extreme climate disasters
Smart City	Special planning	Theoretic Framework	Research on the Framework of Comprehensive Disaster Prevention Planning System Based on Smart Technology

	Wuxi City	Qualitative description	Smart city planning based on spatial scale
	Shanghai Central City	Empirical analysis	Research on Urban Spatial Structure Based on Baidu Maps Heat Map
Spatial Planning Practice	Changchun City	Case analysis	Implementation Path of Urban Planning and Construction
	Block 9, "Five Avenues", Tianjin	Empirical analysis	Protection and Green Design of Historical and Cultural Blocks

4. Findings and Discussion

4.1 The current situation and problems of resilience and smart construction in China from the perspective of national spatial planning

Although the resilience and intelligence of national land space have been greatly improved with the development of industrial technology, and many scholars have proposed resilient city systems based on multidimensional monitoring and intelligent networking in their research (Xia & Zhai, 2022), the awareness of resilience, intelligent infrastructure construction, maintenance, and application still needs to be implemented in the implementation of national land space planning. This includes not only the integration of key resources using smart tools at all levels under the national planning system to achieve collaborative and efficient emergency management, but also the construction practice of dispersed responsibilities and benign collaboration among various parties in national land spatial planning to build a resilient national land space with multiple functions. The author believes that in the context of the current reform of the national land and space governance system and the new era of technological reform, the implementation of the concept of resilience and the integration of intelligent technology in the systematic improvement of national land and space planning is a higher requirement for the modernization of the national land and space system, and is also an important manifestation of the strategic and guiding nature of national land and space planning at the national level.

4.2 Overall idea for building a resilient smart national spatial system

The resilient and intelligent implementation of national spatial planning is a complex system engineering that needs to be continuously promoted. It requires a macro national planning system led by the government and coordinated with multiple social entities to clarify the overall idea of national spatial planning, integrate smart city construction technology, and take "resilience" as the basic guidance. Specific tasks of national spatial planning should be implemented at different planning levels and stages to ensure that the concept of resilience and digital technology run through the entire process, improve the level of refined urban governance and risk prevention, and effectively practice the specific work of resilient and intelligent national spatial construction. Based on the hierarchy of resilience construction and the logic of digital technology, the author believes that the construction of a resilient smart land space system should form a resilience smart support system throughout its lifecycle from the perspectives of perception monitoring, evaluation decision-making, action implementation, and management learning (Figure 1).

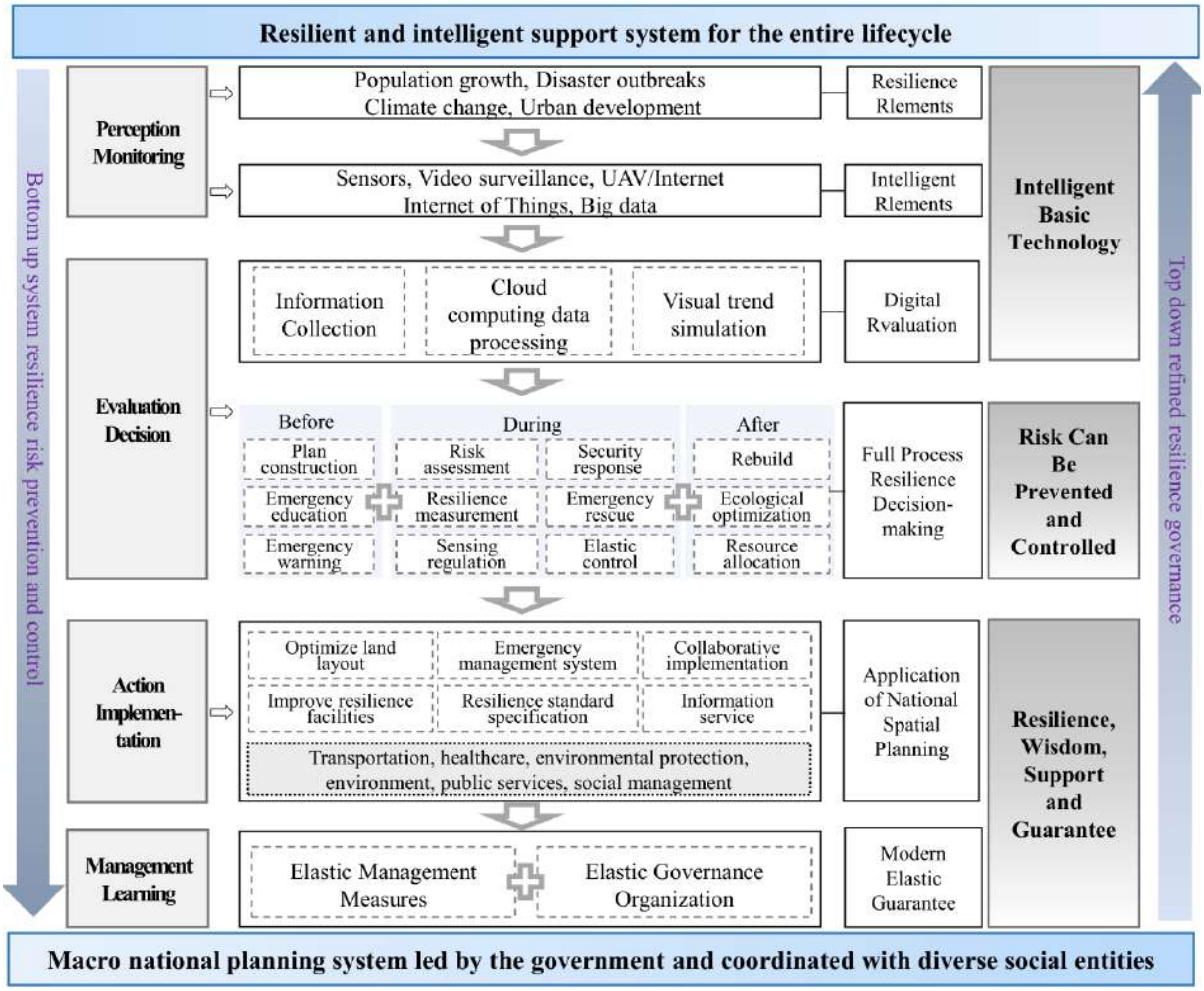

Figure 1. Overall idea for building a resilient smart national spatial system

5. Conclusion

Establishing the concept of building resilience and integrating it into the overall national spatial planning is a prerequisite and foundation for enhancing spatial resilience. In the new era of reform environment, relevant departments under the national planning system need to coordinate and plan resilience work such as comprehensive improvement and ecological restoration on the premise of clarifying the connotation of resilience wisdom and the overall idea of the relevant national spatial system. Under the current national planning system, the construction of a resilient smart system for national spatial planning should highlight integrity and systematicity. Firstly, new technologies should be used to clarify the resilience resource base and accurately assess the resilience level; Secondly, in the process of perception monitoring, evaluation decision-making, action implementation, and management learning of national spatial planning, resilience elements and smart technologies are comprehensively considered to construct a national spatial resilience smart system; Furthermore, a hierarchical and systematic national spatial resilience smart planning is implemented, with a focus on strategic planning at the national level, coordination at the provincial level, and implementation at the city and county level. This aims to build a resilient smart national spatial system that covers the entire process and has multi-level transmission, providing the most solid guarantee for the healthy and livable environment and the safe development of cities.

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Understanding Urban Surfaces: Nature-Based Solutions (NbS) for Stormwater Management

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Abstract

This study explores the challenges posed by urbanization in Puerto Rico, with a focus on stormwater management and sustainable land use. It combines spatial analysis, thematic classification, and on-site soil testing to establish a comprehensive taxonomy of Urban Land Use and Land Cover (LULC). Each LULC category is analyzed to determine its water/surface relationship, highlighting the interplay between urban surfaces and hydrological dynamics. These results help us find nature-based solutions (NbS) that work in cities, with a focus on methods that improve water infiltration, lower runoff, and lessen the impact of the urban heat island effect.he study highlights the potential of urban areas to integrate NbS through interventions such as depaving, green roofs, permeable pavements, and the conversion of abandoned properties into green spaces. By assigning water management roles to LULCs, the research provides a framework for optimizing urban soils, improving water retention, and reducing carbon emissions. This approach not only addresses stormwater challenges but also enhances biodiversity, air quality, and urban aesthetics, contributing to climate resilience and sustainable urban development. A key outcome of this research is the creation of a user-friendly tool that empowers stakeholders—municipalities, water management agencies, policymakers, and local communities—to make data-driven decisions. By aligning NbS with Puerto Rico's unique urban and ecological conditions, this tool supports participatory water management practices and fosters collaborative approaches to urban planning. The study underscores the importance of integrating ecological principles into urban development, offering actionable solutions to balance growth with environmental sustainability in the context of a changing climate.

1. Introduction

Urban areas are defined as regions with specific population densities, economic activities, and spatial characteristics, all interwoven to sustain human operations within the Anthropocene. These areas epitomize the convergence of human necessities and livelihoods, driving a need to modify natural systems to fulfill fundamental requirements. Scholars argue that urbanization represents the most definitive manifestation of changes in global human settlement patterns, reflecting a transition toward landscapes dominated by anthropogenic influence (Zhang et al., 2016). Urban settlements, in contrast to rural or underdeveloped areas, play a pivotal role in fostering economic growth, promoting social and cultural diversity, and ensuring access to essential services and infrastructure (Gebre & Gebremedhin, 2019). These contributions underscore the dual role of urban areas as engines of development and key drivers of environmental transformation. Globally, urbanization has been marked by a relentless upward trajectory in population. From 1950 to 2020, the global urban population rose dramatically from 0.8 billion (29.6%) to 4.4 billion (56.2%) and is projected to reach 6.7 billion (68.4%) by 2050 (He et al., 2021). This growth places immense strain on natural resources and ecosystem services, increasing the urgency to address the environmental and social challenges posed by urban expansion. The expanding urban footprint transforms natural landscapes through land-use changes, deforestation, and the proliferation of impervious surfaces, significantly disrupting ecological processes.

Urbanization's environmental footprint manifests in multiple forms, from increased greenhouse gas emissions and biodiversity loss to the intensification of urban heat islands and the disruption of hydrological cycles. As urban populations grow, the demand for food, water, energy, and shelter escalates, compounding pressures on finite natural resources. The demand for urban infrastructure drives significant land-use transformations, converting forests, wetlands, and agricultural land into built environments. Water resources, being renewable due to their cyclical nature, face variability influenced by climate and land surfaces, leading to a highly heterogeneous hydrological cycle and water resources in both space and time (Yang et al., 2021).

This transition not only reduces the availability of ecosystem services but also heightens risks associated with climate change, such as flooding, heat waves, and water scarcity. Effective urban planning and governance are critical to addressing these challenges, yet they remain inadequate in many contexts.

As Su et al. (2024) say, ecosystem services (ESs) are the essential things that natural ecosystems do to keep people alive. They include providing, regulating, supporting, and cultural services. Although these services are renewable, the rate at which we consume them, especially in urban areas, often outpaces the time required for natural systems to replenish. The interactions between different ecosystem services can result in synergies or trade-offs. A trade-off occurs when a reduction in one service enhances another, whereas a synergistic relationship exists when both services increase together (Liu et al., 2022). Climate regulating ecosystem services (CRES) are highlighted as a crucial measure to fight climate change, but the provision of these services is strongly influenced by changes in land use and land cover (Campos et al., 2022).

Integrating nature-based solutions (NbS) into urban planning offers a transformative approach to harmonizing development with ecological stewardship. Leveraging ecosystem services, NbS can address challenges such as stormwater management, air quality, and energy efficiency, making cities more sustainable and livable. As urbanization continues to shape the global landscape, a paradigm shift is essential in how cities are planned and managed. Sustainable urban practices, including the integration of NbS and equitable resource distribution, can transition cities from drivers of ecological degradation to leaders in environmental restoration and resilience. Moving toward a predominantly urban future requires strategies that align development with natural systems, ensuring cities thrive without compromising the planet’s ecological integrity.

Urbanization presents both challenges and opportunities for sustainable development. The density and resource concentration of urban areas provide unique platforms for innovative solutions to global challenges. Compact cities can lower per capita resource consumption and emissions, while mixed-use development and efficient public transit reduce reliance on private vehicles. Green infrastructure, such as urban parks, green roofs, and permeable pavements, helps mitigate urban heat islands, enhance biodiversity, and improve water management, increasing cities’ resilience to climate change.

2. Materials and Methods

This study examines urban land use and land cover (LULC) in Puerto Rico to understand the interaction between urban surfaces and water, focusing on integrating nature-based solutions (NbS) into communities. In order to create a customized taxonomy of urban LULCs, this research integrates spatial analysis, thematic analysis, and on-site soil testing, leading to the development of a user-friendly tool that facilitates participatory water management and sustainable urban planning. The tool enables stakeholders—such as governments, municipalities, water management agencies, and local communities—to make informed, sustainable decisions for addressing stormwater challenges. This study aims to address the lack of accessible tools, resources, and frameworks at the community level, which exacerbates the vulnerability of urban areas to changing climatic conditions (Jurgilevich et al., 2023). The study fills in the gaps in our knowledge about urban LULCs and how they affect water systems. It supports collaborative approaches to managing stormwater in cities, and it gives stakeholders the chance to take the lead and make things happen.

The method uses spatial analysis, thematic analysis, and on-site data collection to make sure that LULC classifications in cities are in line with NbS. A specific study area was selected based on community-reported flooding issues identified using Volunteered Geographic Information (VGI) from online platforms and social media. Volunteered geographic information (VGI), defined as the “act of having simple citizens produce geographic information, either intentionally or unintentionally”, it emerged from Web 2.0 technologies (Arapostathis, 2021). Reports of “inundación” (flooding) between December 1, 2022, and December 1, 2023, were geolocated using QGIS, identifying clusters to help define a 2.5 km radius for analysis. Spatial data was further enriched using the USDA-NRCS Farm Planning Tool, which provided layers such as the Land Use Plan (PUT) and the Puerto Rico Gap (PR GAP) Analysis. Based on the data in these two planning tools, urban LULCs were put into groups, which made it easier to create a taxonomy that fits Puerto Rico's urban environment.

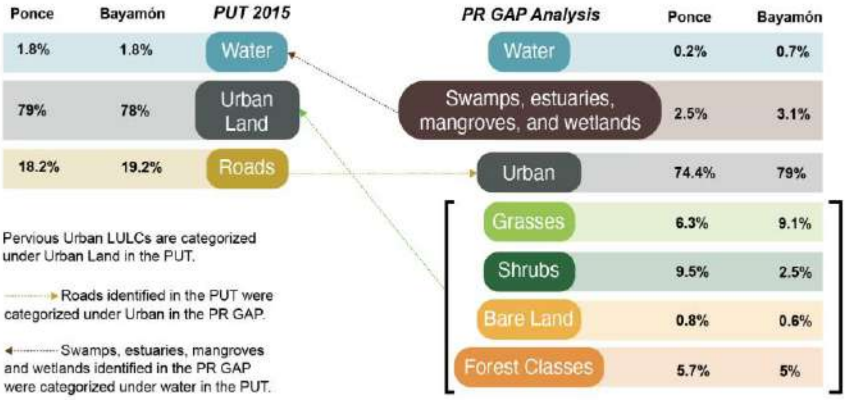
To validate the Urban LULC taxonomy, a visual characterization was conducted using October 2023 Landsat 8 images at a 1:1000 scale, obtained from the USGS EarthExplorer platform.

Urban stormwater management aims to lessen the bad effects of flooding and improve water resource use at the block or community level (Xu et al., 2023) so it's important to understand urban soils and surfaces at a meso level. On-site texture tests were conducted on randomly selected impervious urban LULCs. Soil samples were collected from April 30 to May 2, 2024, using a soil sampler probe across seven sites in both municipalities. A total of 7 urban soil samples were examined for texture, with observations documented through photographs and text. On-site soil texture was Thien’s (1979) tactile method, which classifies soils based on moisture, ball formation, and ribbon length. This analysis provided insights into soil profiles and texture, hydrologic behavior, and water-holding capacities. The information gathered made it easier to find Hydrologic Soil Groups (HSG) (NRCS, 2017) so that we could learn more about how water behaves in cities. Leveraging the HSG tool, traditionally used for soil conservation in agriculture, provided valuable insights into water/surface relationships to enhance urban soil management.

3. Findings and Discussion

The study identified 11 municipalities experiencing flooding incidents through Volunteered Geographic Information (VGI) from December 30, 2022, to December 30, 2023, resulting in the selection of Bayamón and Ponce for detailed analysis based on greater quantity of reportings. VGI data were clustered into areas with the highest concentrations of flooding reports within a 2.5 km radius. Using the Puerto Rico Land Use Plan (PUT) and the PR GAP Analysis for spatial analysis, land use and land cover (LULC) were identified into seven main groups, as shown in Table 1.

Table 1. Comparison between the Urban LULC as per established in current planning tools at a local level: Plan de Uso de Terrenos and the PR GAP Analysis (Burgos-López, 2024).



Ponce	Bayamón	*PUT 2015*
1.8%	1.8%	Water
79%	78%	Urban Land
18.2%	19.2%	Roads

PR GAP Analysis	Ponce	Bayamón
Water	0.2%	0.7%
Swamps, estuaries, mangroves, and wetlands	2.5%	3.1%
Urban	74.4%	79%
Grasses	6.3%	9.1%
Shrubs	9.5%	2.5%
Bare Land	0.8%	0.6%
Forest Classes	5.7%	5%

Pervious Urban LULCs are categorized under Urban Land in the PUT.

Roads identified in the PUT were categorized under Urban in the PR GAP.

Swamps, estuaries, mangroves and wetlands identified in the PR GAP were categorized under water in the PUT.

Through further visual characterization of the Landsat 8 images, 15 urban LULC types were identified in Bayamón and Ponce, grouped into pervious and impervious surfaces. These include backyards and gardens, abandoned structures, cemeteries, vacant lots, flowing rivers, urban agriculture, parking areas, single roofs, planting strips, open/natural areas, plazas/public spaces, drainage channels, building roofs, streets and sidewalks, and channelized water bodies (Table 2). Eight LULCs were classified as pervious surfaces, retaining their capacity to provide critical ecosystem services, while seven were identified as impervious, dominated by features such as parking lots and rooftops. This distinction underscores the potential of diverse urban soils that remain uncovered to continue delivering ecosystem benefits. These findings highlight opportunities for targeted management and preservation of urban pervious surfaces to enhance sustainability. Although there were 7 impervious surface types compared to 8 pervious surface types, the impervious surfaces were larger and more contiguous. In contrast, the pervious surfaces were more diverse but fragmented, forming smaller, disconnected urban soil systems. This fragmentation of pervious surfaces limits their ecological functionality, reducing their capacity to support biodiversity, manage stormwater, and regulate urban microclimates. However, as long as these surfaces remain unsealed, they still provide valuable ecosystem services (Minixhofer, 2021).

Table 2. Taxonomy of the 15 Urban LULCs identified in the study areas of Bayamón and Ponce divided by its infiltration capacity

Urban LULCs	
Impervious	Pervious
Parking areas	Open/Natural Areas
Streets and sidewalks	Planting strips
Single unit roofs	Gardens and backyards
Abandoned structures	Flowing rivers
Building roofs	Drainage channels
Channelized water bodies	Cemeteries
Plazas/Public Spaces	Urban Agriculture
	Vacant lots

Among the identified LULCs, notable impervious surfaces included large-scale commercial roofs and parking areas, such as Plaza del Caribe in Ponce, which contributes approximately 39 hectares of impervious surface, and Plaza del Sol in Bayamón, with 15 hectares. Water bodies, including flowing rivers, channelized watercourses, and drainage channels, were observed as significant but highly altered urban features. Examples include Río Bayamón and Río Portugués, where large-scale flood control infrastructure was implemented, often reducing natural connectivity and ecological health. Green corridors along these water bodies, while present, varied significantly in density and biodiversity between municipalities, with Bayamón exhibiting more robust ecological features compared to Ponce.

The soil sampling and W/S (water/surface) relationship analysis provided insights into urban stormwater dynamics. Categories like backyards and vacant lots demonstrated shallow infiltration potential, while others, such as planting strips, indicated soil compaction conditions with limited water retention capabilities. Urban agriculture and open/natural areas demonstrated the lowest runoff potential, making them highly effective for managing water in urban environments. These soil types are particularly suited for enhancing infiltration and reducing stormwater challenges in urban settings. Impervious LULCs, including single-unit roofs, building roofs, and paved parking areas, primarily contributed to runoff. The study also pinpointed crucial problems in green spaces, including the conversion of open/natural areas into impermeable developments, which intensifies runoff and diminishes infiltration opportunities.Despite these challenges, eight pervious LULCs indicate that NbS still has significant potential in urban Puerto Rican contexts. Once the taxonomy of urban LULCs was finished and water/surface relationships were assigned to each category, the next step was to find nature-based solutions (NbS) that would work for each water/surface relationship (Figure 1). A general overview of each NbS is provided below, categorized according to their associated water/surface relationships as detailed in the table. This overview includes a definition of each solution, the relevant legal and regulatory framework, cost considerations, and management requirements. These elements form the basis for identifying optimal NbS tailored to specific site conditions, emphasizing the critical role of understanding water/surface dynamics in urban planning and sustainable water management.

deep infiltration	runoff	shallow infiltration	storage
Bioretention	MS4 & curb maintenance	Planter boxes	Green roofs
Constructed wetlands	Curb and gutter retrofit	Soil Amendments	Rain-water harvesting
Ecosystem restoration	Split-flow management	Bioswales	Water potabilization
Conservation areas	Permeable Pavements	Infiltration trenches	Detention tanks
green corridors		Rain Gardens	
Stream restoration		Infiltration basins	
		Community gardens	

Figure 1. Nature- Based Solutions organized as per Water/Surface Relationships

The study identified four primary W/S relationships—runoff, shallow infiltration, storage, and deep infiltration—using this classification to organize NbS. These relationships underscore how urban surfaces interact with water and offer actionable insights for stormwater management. Runoff-heavy areas require solutions such as permeable pavements, asphalt/structure removal, and curb retrofits. Shallow infiltration can be enhanced through street trees, planter boxes, and urban agriculture, while storage-focused areas benefit from green roofs and rainwater harvesting systems. Deep infiltration is supported by bioretention systems, constructed wetlands, and ecosystem restoration initiatives. For instance, runoff management solutions like bioswales and infiltration trenches were highlighted for their ability to reduce surface water accumulation, mitigate flooding risks, and improve water quality. These solutions are particularly applicable to impervious LULCs like parking lots and streets. Storage-focused solutions, including green roofs and rainwater harvesting, were emphasized for their potential to reduce peak runoff volumes and offer additional water resources. In deep infiltration contexts, bioretention cells and constructed wetlands demonstrated long-term efficacy in improving water quality and recharging groundwater. Implementation costs for NbS varied widely. Green roofs were noted for their higher upfront costs but long-term durability and energy-saving potential. Rainwater harvesting systems, including community-based initiatives, offered cost-effective management solutions with scalability. Soil amendments, bioswales, and tree planting programs were recommended for shallow infiltration areas, particularly in degraded soils, to restore hydrological function and increase biodiversity.

The analysis revealed significant challenges in urban water management, including limited implementation of NbS due to policy gaps and inadequate maintenance of existing green infrastructure. While planning instruments like the PUT highlight urban land and water categories, they lack enforceable mandates for NbS implementation, leaving such measures discretionary for property owners. Additionally, the lack of integration between large-scale flood control projects and localized NbS has hindered the holistic management of water resources.

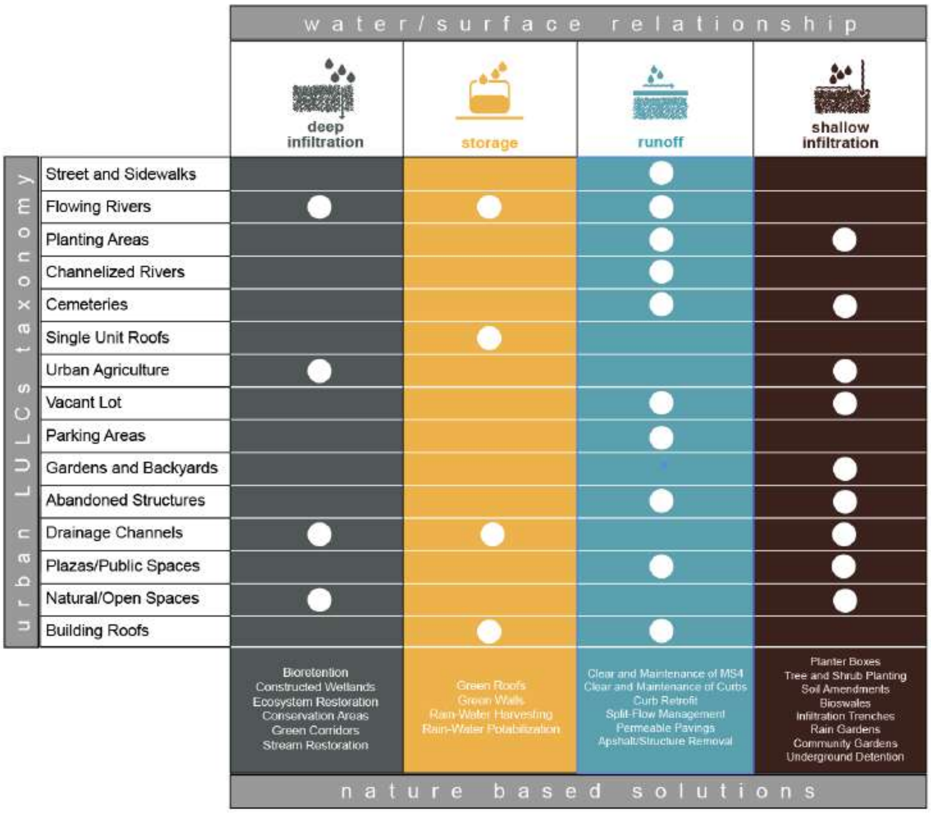
The conversion of open/natural areas into impervious surfaces underscores the pressing need for sustainable urban planning. Just two projects around the 2.5 km radius in the study area of Bayamon transformed approximately 60 hectares of pervious green spaces into paved areas over five years, highlighting the urgency of preserving urban soils and implementing NbS. Furthermore, the lack of robust green infrastructure maintenance, particularly in channelized water bodies and planting strips, reduces ties heir capacity to manage stormwater effectively.

The Nature-Based solutions (NbS) selection tool

Puerto Rico’s water management systems have developed through historical influences, including colonial policies, agricultural demands, urbanization, and modern regulations such as the Clean Water Act. The current framework is fragmented among ten federal and local agencies, resulting in inefficiencies, jurisdictional overlaps, and gaps in implementation. Recent updates, such as incorporating Low-Impact Development (LID) practices, demonstrate progress but lack mandatory enforcement, reducing their operational impact. Addressing these challenges requires an integrated, data-driven, and stakeholder-engaged approach to improve system resilience, optimize resource allocation, and adapt to the hydrological complexities of a changing climate.

Nature-based solutions (NbS) for water management are important to governments, agencies, and institutions, and they have been working hard to collect information to organize and describe the different strategies (see guides from the EPA, The Nature Conservancy, USACE, UN, and IPCC). However, decision-making regarding which specific NbS should be studied in a given context remains challenging. To move toward an operational framework that can guide applications of the NbS concept (Cohen et al., 2016), we need to learn more about NbS and confirm the principles on which it is based. The development of the NbS Selection Tool represents a significant advancement in addressing these challenges. This tool integrates spatial data, stakeholder input, and hydrological insights to recommend tailored NbS for specific urban contexts. By analyzing urban LULCs and their W/S relationships, the tool guides the implementation of solutions such as rain gardens, permeable pavements, and bioretention systems. It emphasizes a participatory approach, encouraging collaboration between communities, municipalities, and technical experts to co-create effective water management strategies.

The tool also democratizes access to resilient infrastructure knowledge by supporting communities in taking the lead in their water management needs. For example, it facilitates decision-making at household and municipal levels by providing clear guidance on the costs, maintenance requirements, and ecological benefits of NbS. Additionally, the tool bridges gaps in existing policy frameworks by offering actionable recommendations that align with local hydrological and urban conditions.



	water/surface relationship			
urban LULCs taxonomy	deep infiltration	storage	runoff	shallow infiltration
Street and Sidewalks			●	
Flowing Rivers	●	●	●	
Planting Areas			●	●
Channelized Rivers			●	
Cemeteries			●	●
Single Unit Roofs		●		
Urban Agriculture	●			●
Vacant Lot			●	●
Parking Areas			●	
Gardens and Backyards				●
Abandoned Structures			●	●
Drainage Channels	●	●		●
Plazas/Public Spaces			●	●
Natural/Open Spaces	●			●
Building Roofs		●	●	
nature based solutions	Bioretention Constructed Wetlands Ecosystem Restoration Conservation Areas Green Corridors Stream Restoration	Green Roofs Green Walls Rain-Water Harvesting Rain-Water Potabilization	Clear and Maintenance of MS4 Clear and Maintenance of Curbs Curb Retrofit Split-Flow Management Permeable Pavings Apshalt/Structure Removal	Planter Boxes Tree and Shrub Planting Soil Amendments Bioswales Infiltration Trenches Rain Gardens Community Gardens Underground Detention

Figure 2. Nature-Based Solution Selection Tool
(Burgos-López, 2024)

4. Conclusion

The primary consequence of urbanization is the transformation of natural landscapes into impervious surfaces, which disrupts natural hydrological cycles, exacerbates flooding, intensifies urban heat islands, and diminishes ecosystem services. Through spatial analysis and on-site assessments in the study areas of Bayamón and Ponce, this study confirmed these effects. It showed that urban land use and land cover (LULC) and water management are complicated and affect each other in many ways. While the study provided valuable insights, the limited diversity of urban land use types in the two municipalities underscores the need to expand the analysis to include additional areas to develop a more comprehensive tool for managing urban surfaces. Also, it's important to keep getting soil samples from the different types of soil in the seven previous urban LULCs so that we can learn more about how they behave with water, how much water they can hold, and how they can provide ecosystem services. This ongoing analysis provides critical data to refine and optimize Nature-Based Solutions (NbS) for stormwater management, ensuring that interventions are tailored to the unique characteristics and needs of each urban context.

Urban hydrology in Puerto Rico has shifted significantly due to high-value urban land being converted into single-use, car-dependent developments. Impervious surfaces have replaced previously found infiltration zones in open natural spaces and vacant lots, leading to an increase in stormwater runoff. Responsibility for managing this runoff is transferred entirely to public entities like Municipal Separate Storm Sewer Systems (MS4s) and the Department of Natural Resources, despite originating from privately developed properties. This disparity highlights the need for policies that enforce accountability and sustainable urban development practices. Additionally, current planning tools, such as the *Plan de Uso de Terrenos (PUT)*, fail to recognize the hydrological and ecosystem contributions of pervious surfaces, categorizing them uniformly as “urban land.” This oversimplification disregards their role in stormwater infiltration, urban cooling, and climate resilience, exacerbating the environmental challenges associated with urbanization.

Transportation infrastructure also plays a significant role in shaping urban dynamics. Roads and highways, which constitute approximately 20% of the study areas, contribute substantially to surface runoff and ecosystem fragmentation. There haven't been any high-density, mixed-use projects with green infrastructure built into suburban developments near transit hubs in Bayamón and Ponce. This has hurt the potential of transit-oriented development (TOD) to reduce impervious surfaces and encourage sustainable urban growth. TOD offers a crucial opportunity to minimize impermeable surfaces, reduce reliance on private vehicles, and integrate green infrastructure to enhance urban livability and environmental sustainability (Smart Growth America, 2018). However, these opportunities remain underutilized as developments continue to prioritize car-centric designs.

Urban agriculture, vacant lots, and abandoned spaces present untapped opportunities for enhancing urban ecosystem services. The study highlights the potential of urban soils, such as those in the Huerto Urbano Callejón Trujillo in Ponce, to support deep infiltration and food production, addressing both stormwater management and food security in a region where 85% of food is imported. Abandoned properties and vacant lots present significant opportunities for implementing Nature-Based Solutions (NbS), converting underutilized urban spaces into functional assets that enhance resilience and sustainability. Incorporating high-quality agricultural soils and green infrastructure into these areas can improve water infiltration, restore soil health, reduce urban runoff, and mitigate flooding risks. Additionally, these transformations contribute to lowering carbon emissions by enhancing carbon sequestration, reducing the urban heat island effect through increased vegetation, and promoting sustainable land use practices that foster healthier urban ecosystems.

The study also underscores the importance of addressing climate justice in urban planning. Many vulnerable communities in flood-prone areas, such as those near rivers in Ponce, are exposed to environmental hazards, further exacerbating social and environmental inequities. These settlements, often located in areas with poor environmental quality, face heightened risks from flooding and climate-related disasters. Comprehensive strategies that integrate NbS into urban planning are critical for enhancing climate resilience and addressing these disparities. Innovative approaches like sponge cities and Room for the River initiatives, which emphasize restoring natural hydrological functions, offer promising models for sustainable urban development.

To address these challenges effectively, it is essential to implement policy reforms that mandate the preservation and restoration of pervious surfaces and promote NbS. Taxation on large impervious surfaces could provide financial incentives for sustainable urban practices and generate revenue for urban greening and stormwater management initiatives. Promoting NbS, such as rain gardens, green roofs, and urban tree planting, can mitigate urban heat islands, enhance biodiversity, and improve water management. Expanding community-driven projects, such as urban agriculture and depaving initiatives, further leverages underutilized spaces for sustainable development.

Mainstreaming nature-based solutions (NbS) requires interdisciplinary collaboration, integrating applied science, systems ecology, and community participation to develop context-specific solutions for effective water management. Tools such as the NbS Selection Tool developed in this study provide a framework for communities and stakeholders to evaluate, prioritize, and implement strategies that optimize stormwater management while reducing dependence on traditional gray infrastructure. By delivering critical data on hydrological performance, cost-efficiency, and long-term maintenance requirements, applied science ensures that these solutions are both technically viable and sustainable. This integrated approach not only enhances urban resilience and adaptive capacity but also promotes co-benefits such as biodiversity conservation, carbon sequestration, and urban cooling, strengthening the multifunctional role of urban green infrastructure. The world’s urban landscapes, including Puerto Rico, face significant challenges due to the impacts of urbanization and climate change. However, by integrating NbS into urban planning, fostering community engagement, and adopting innovative practices, stakeholders can create resilient urban environments that address current challenges and prepare for future impacts.

Note

The protocol, approved on April 2, 2024, under number B03-138-24, outlines a systematic approach for achieving the project’s goal while ensuring compliance with the Institutional Review Board (IRB) and other mandatory procedures established by the Ana G. Méndez University. This adherence to ethical standards and regulatory guidelines guarantees that the research is conducted responsibly, with respect for participant rights and data integrity throughout the data collection and analysis process.

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Doing Urban Home Gardening: Ways of Operating

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Abstract

This article traces the routines, connections and interactions of urban home gardening practices, arguing that the urban home garden is a naturecultural network – that is, a hybrid entity arising through the participation, relationship, interaction and actions of all those we would conventionally call natural and cultural entities – while the practice of urban home gardening per se is a practice of everyday life. The purpose here is to delineate performances and highlight their anthropological and cultural dimensions based – on a theoretical level – on Bruno Latour's Natureculture and Actor Network Theory, Michel de Certeau's Theory of Everyday Life and Joan Tronto's Ethics of Care.

This research adopts a mixed method approach which in terms of research tools includes the mapping of urban home food gardens in the city of Volos with the use of digital media, semi-structured in-depth interviews of a non-probability sample of gardeners/ gardens and observations made by the researcher during her visits to garden spaces of the sample. The sample, chosen through a process of stratified purposive sampling, consists of 16 gardens presenting a spatial distribution within the reseach area. This allowed for the study of characteristics and typologies of the urban home gardening in different areas of the city of Volos.

Through gardeners' speech, the active network of a series of active agents – human, non-human, material, immaterial – who affect the ways of operating in urban home gardening is highlighted and who, depending on the case, are shaping the role and importance of urban home gardening in the city, everyday life and the food culture of urban dwellers. As such, they connect the urban to the rural, forming individual and social identities, keeping alive memories and habits of other eras, but also territorialising co-existences of care and co-vulnerability within the city.

Keywords: Urban home gardening, natureculture, everyday practices, care, food culture

1. Introduction

While few years back urban home gardens have been the most neglected form of research of urban gardening (Kortright and Wakefield, 2011, Taylor and Lovell, 2014, Burgin, 2018), they have recently attracted the research interest of different academics from various disciplines, as their contribution to many issues concerning everyday life in the urban fabric has been recognised (Taylor and Lovell, 2021). According to references in the relevant literature, the motives of city dwellers cultivating home gardens include quality of life while pursuing personal pleasure resulting from the physical activity in the garden, contact with nature and production of healthy fruits and vegetables (Ruggeri et al., 2016), (Church et al., 2015). Partalidou και Anthopoulou (2016) mention that financial hardship has been a significant motivation for city inhabitants who turned toward home food gardening, especially during the period of the economic crisis in Greece, while seeking liberation from the stresses of everyday life.

Respectively, other studies draw the conclusion that urban home gardening is directly related to cultural deposits (Taylor and Lovell, 2015, Marou and Kotionis, 2018). On the importance of urban home gardening in the urban food system, Burgin (2018) suggests that urban home gardening has the potential to play a significant role in urban food sufficiency.

This article concentrates on tracing the human and non-human active actors, the connections and interactions of practices in the naturecultural web of urban home food garden. The area of research is the city of Volos. Volos is a medium-sized city, inhabited by populations of strong rural origins and with an important refugee element (Dimoglou, 2007, Hastaoglou, 2007). The highest percentage of inhabitants comes either from the Pelion villages and the Thessalian plain or are descendants of Asia Minor and Cappadocia refugees that settled in the city at the beginning of the 20th century. To delineate the research area, so that its urban character is ensured, the ring road of Volos has been set as the spatial limit. Research was conducted in the urban fabric lying inside the curve of the upper limit (see figure 1), presenting urban characteristics and qualities that can offer an interpretation of the research questions.

Figure 1. Map of urban home food gardens in Volos (Marou, 2023)

2. Material and Method

Research methodology

As it is referred above, the research was carried out in the Greek city of Volos during the years 2018-21. To provide an adequate account of the naturecultural network of urban home gardens a mixed approach was chosen.

The research tools included mapping with the use of digital tools. Semi-structured in-depth interviews as well as observations made by the researcher during her visits to garden spaces included in the research sample. The 16 urban home gardens of the non propability research sample were chosen due to their close relation to research questions through a process of Stratified Purposive Sampling. Therefore, cases were included that integrate different subgroups of interest. Layers of sampling consist of gardeners. Pseudonyms were used to protect the anonymity of interlocutors. The oral material of the interviews was processed using the method of discourse analysis and coding. The coding analysis with the help of Actor Network Theory (Latour, 2000 [1991]), is leading to map the “social” relationships between humans, non-human entities, materials and immaterial ideas, emotions, habits etc, treating them all as agenting entities (Cerulo, 2009) that coexist and interact.

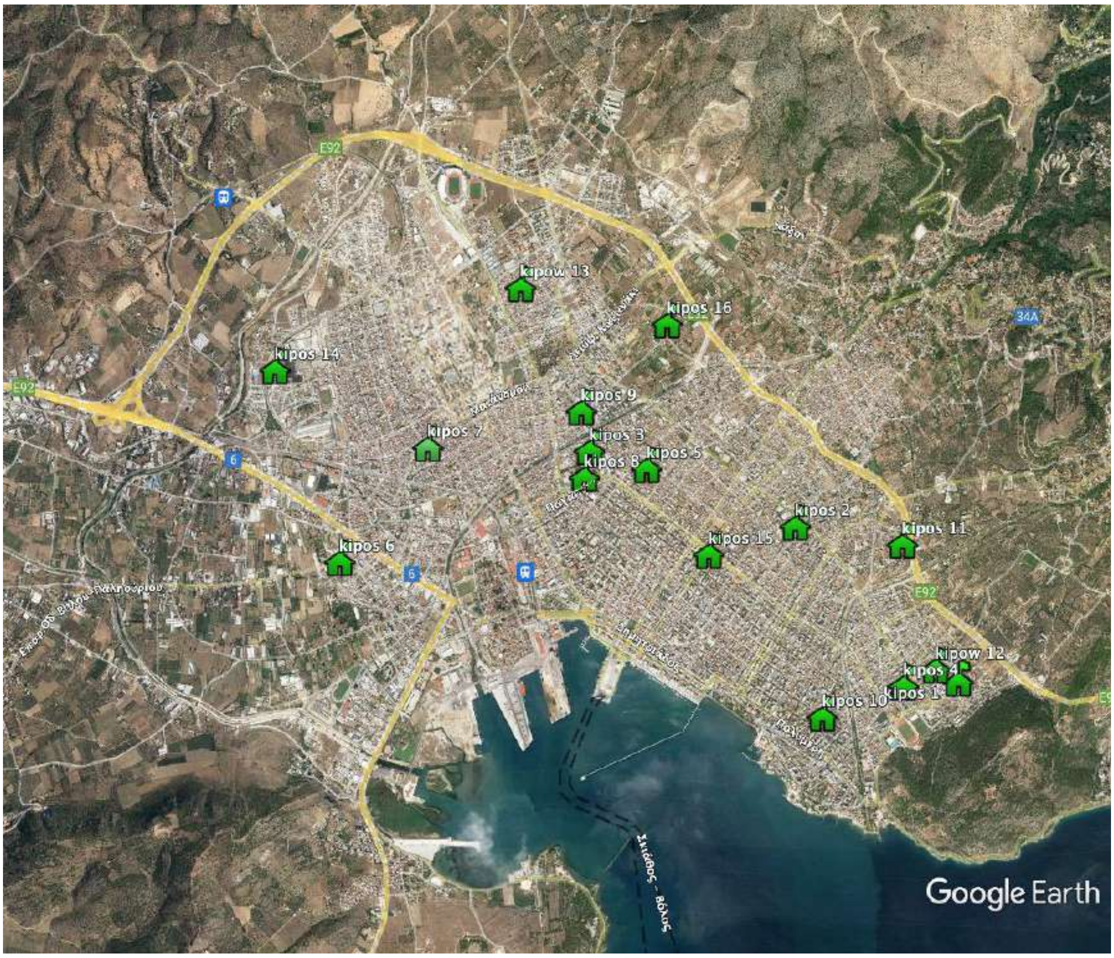


Figure 2. Map of the research sample (Marou, 2023)

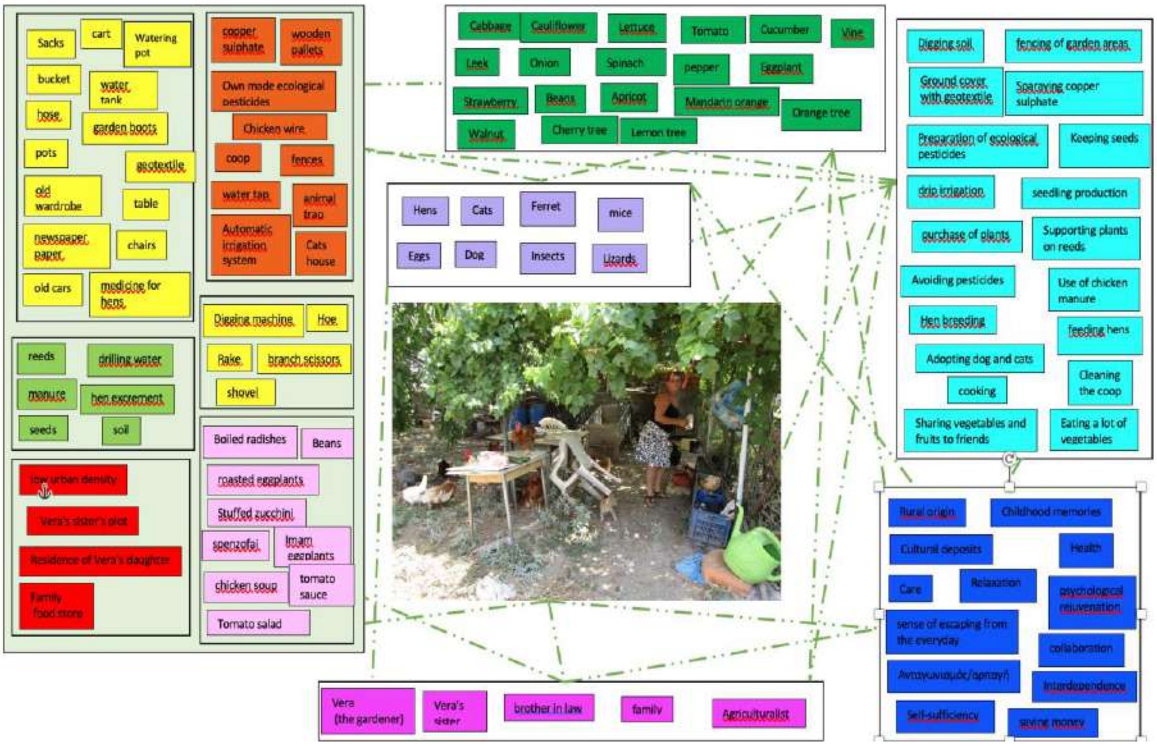
Theory matters

This venture derives its documentation and is supported by the more-than-human thinking. By rejecting the dualism, it is based on the concept of the “collective” as a connection between human and non-human entities and the “social” as a series of associations among heterogenous, according to Latour (2005).

The notion of “Natureculture” as rendered by Haraway (1991, 2003, 2008) and Latour (2000, [1991]) enters the discussion. Tronto’s Theory of Care, (1993, 1998, 2013) acts as a background for reflection on urban home food gardening, as a practice of everyday life (De Certeau et al. 1998), interacting with other practices taking place within the private space as the dwelling space and neighborhood spaces.

3. Findings and Discussion

From the findings of this research process, 16 diagrams were composed, that the researcher call Naturecultural Maps of the urban home food garden. These 16 Naturecultural Maps reveal to us the different actors who have "social" relations in each garden separately, organized in a network of interactions.



🟦 Practices
🟩 **Plants**
🟪 **Human/s**
🟪 Animals
🟨 **Things/objects/materials/foods**
🟥 **Space/place of the urban home garden**
🟧 Urban Systems
🟩 **Natural resources**
🟦 **Immaterial actors (emotions, ideas, opinions, culture, everyday life habits)**

Figure 3. Naturecultural Map of Vera's urban home food garden (included in the research sample) (Marou, 2023)

With the help of Active Network Theory and subsequently through Naturecultural Maps, the ways of operating of urban home food gardening are revealed.

The practices performed in the urban home food gardens exhibit repeatability and a steady rhythm in relation to seasons, weather and the alternation of day and night. They are inserted between other everyday practices and participate in the social and material production of city space and landscape. They are repeated performances taking place in the familiar space of the house, or near it, in the neighborhood, and are collectively composed by humans, non-humans, materials, objects and immaterialities. Space availability and the garden's location, the urban microclimatic conditions, accessibility to resources, cultural deposits, gardener's inventiveness, his emotions and the body, tools and materials, domestic use objects are all acting collectively in the formation of the naturecultural network of the urban home garden. At the same time, interactions between non-human beings and life-sustaining processes support the collectivity of the garden and affect the forming of garden practices.

Care constitutes a connective tissue networking all the above. Thus, by following the "socially" connected actors of the urban home garden natureculture, ways of doing are being traced. These define the imprint of the urban home gardening and its importance for urban resilience. Practices and tactics as working the soil without mechanical tools, keeping or not traditional varieties of seeds, using compost fertilization, weeding out by hand, recycling and re-using materials and objects, and finally harvesting and sharing with friends and neighbors the vegetables, express an Ethics of Care for people, plants and the urban ecosystem, life and the planet generally. Life in the urban home food garden sheds light at the co-vulnerability of human and hon human.

As it turns out through the research, urban home gardening tactics of traditional farming cultures may be revived, strengthening the rural-urban connections.

Difficulties regarding availability of natural resources within the urban fabric – such as water – are dealt by gardeners with inventiveness. They utilize agricultural knowledge and experience, applying traditional practices that incorporate schemes and materials toward a low-resource economy. Circular procedures are being adopted, such as the harvesting rainwater from the roof, and for this purpose gardeners engage in self-made constructions. Usually, the urban home food garden and the chicken coop service each other, through circular flows, connecting plant development with the feeding of poultry and the collection of organic waste with the garden fertilisation. Gardening becomes understood as a practice of ecological economy, where something will rarely be registered as useless. On the other hand, if the urban home gardeners who don't have any cultivation experience and knowledge, they make up for it by information coming from new communication technologies, the television, and the social media. These advice recources influence on the practices of urban home gardeners.

In the urban home food garden, ecologies and relationships developed in the context of an uncontrollable nature are not welcome. For this reason, gardeners implement control practices in the context of the garden's becoming. The practice of cultivation, although characterised by an ethics of Care, includes practices of removal and elimination of native plants, the latter being characteristic of the human paternalism toward the other-than-human beings. Nevertheless, according to this research findings, in the urban home food garden, the practice of weed extermination includes acts performed with respect and an understanding of co-vulnerability within the web of life, since no use of chemical herbicides and pesticides in general is taking place.

In order to deal with extreme microclimatic conditions prevailing in the densely built urban fabric, especially during summer periods, urban home gardeners depend on simple traditional practices, like the garden's shading. Shading or access to sunlight registers in the naturecultural network of the urban home garden tools, constructions and gardener's inventions and tricks.

Urban home gardening and cooking are communicating vessels. They share the same acting bodies, experiences, sensations, products, materials. I this private sphere of home, they are connected with objects and common spaces while both of them mediate the practice of eating. Their interconnected operations influence the natureculture of the urban home garden, shape everyday food behaviours, and finally, cooking with the harvest of the home garden affect positively the urban food system resilience.

4. Conclusion

Urban home food gardening activates possibilities of enjoyment, care, perception of co-vulnerability of humans with other forms of life. Shaping individual and social identities, keeping memories and habits of other eras alive, it produces socioecological memory and experience, sustains rural-urban connection, but also grounds symbioses of care and interdependence within the city.

Ways of operating in urban home garden are depending on the active actors being activated in the naturecultural network of the garden. These active actors determine the role and the importance of the practice urban home gardening, in the shaping of city's everyday life, food culture, urban biodiversity and generally environmental footprint.

The spaces of urban home food gardens are 'commons' for the neighbourhood. Although their contribution to the urban food system is not quantitative, but cultural they can have positive influence on urban food, ecological, social and cultural resilience. They create a naturecultural network of Care. Although it networks the individual doings and operations of the gardeners, nevertheless connects and it is connected with various active actors of the city, its past, community, ecosystem, landscape, culture and everyday life.

As a conclusion, according to the findings of the research, doing urban home food gardening, can be a tool for the transition towards urban socio-ecological resilience and the sustainability of the city.

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Green Schoolyards Design: Exploring School Landscape's Impact on Child Health

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Abstract

As urbanization intensifies, the availability and accessibility of green spaces are rapidly declining, posing significant challenges to urban health. Children, as a particularly vulnerable demographic, face heightened risks from environmental stressors, potentially impacting their physical development, psychological well-being, and social-emotional growth. Green spaces, especially in schoolyards, hold the potential to mitigate these risks by providing essential environments that foster both physical and mental health benefits. The creation of child-friendly urban environments has emerged as a critical global priority, with existing studies highlighting the moderately positive effects of green spaces on children's health. Despite this, there remains a significant knowledge gap regarding how specific characteristics of school green spaces influence children's physical activity (PA) levels and overall well-being. This study seeks to bridge this gap by examining the spatial qualities of school landscapes and evaluating their association with children's PA participation and perceived well-being.

Keywords: Green schoolyards, physical activity, health promotion, children's well-being

1. Introduction

Green space in school can be defined as outdoor natural environments or planted areas within the schoolyards, including lawns, gardens, trees, green belts, plant walls, roof gardens, and other vegetated zones. These areas serve multiple purposes, including providing ecological benefits, fostering environmental education, offering spaces for student relaxation, and promoting overall health and well-being. Green spaces are not merely part of the natural landscape but are often integrated into the educational framework, serving as outdoor classrooms or areas for extracurricular activities (Lanza, 2021). By interacting with these environments, students have the opportunity to engage with nature, develop ecological literacy, and cultivate a deeper awareness of environmental sustainability.

Beyond their educational and aesthetic value, green spaces play a crucial role in promoting physical activity (PA), which is vital for children's physical and mental health. According to the World Health Organization, children should accumulate a minimum of 60 minutes of moderate-to-vigorous-intensity physical activity (MVPA) daily. Green spaces within school environments offer an ideal setting for such activities, providing ample room for outdoor play, sports, and unstructured physical movement. These spaces also support social development, as they encourage interaction, teamwork, and the cultivation of social skills through outdoor games and collaborative activities. Wells and Evans highlight how exposure to green spaces can buffer the impact of life stress on children, contributing to better psychological well-being

(Wells & Evans, 2003). Similarly, other studies, such as those by Vanaken and Danckaerts, underline the positive associations between green spaces and children's mental health, particularly in reducing symptoms of hyperactivity and improving attention spans (Vanaken & Danckaerts, 2018). These findings emphasize the ecological and psychological benefits of integrating natural environments within urban settings, including schools

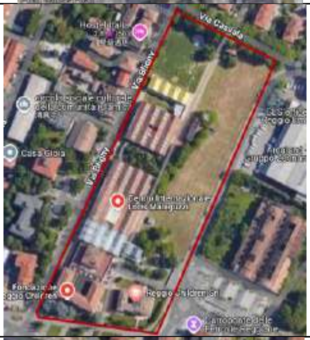
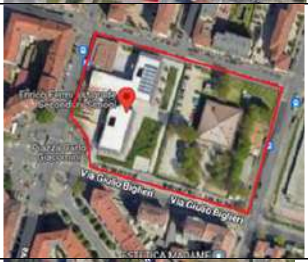
In Italy, green spaces in schools reflect the country’s historical and cultural connection to landscape design. Italian schools often emphasize the integration of green spaces with historical architecture, creating environments that are both functional and aesthetically pleasing. These spaces serve as outdoor classrooms for environmental and cultural education, allowing students to learn about the local flora and history in an interactive way (Dessì, 2023). The design of green spaces in Italian schools often prioritizes sustainability, blending tradition with modern ecological practices. Additionally, these spaces provide ample opportunity for physical activity, relaxation, and social interaction, supporting the holistic development of students.

This paper explores the design principles and functional roles of school green spaces through field research conducted in five Italian primary and secondary schools. By observing and documenting the landscape features and students' interactions with these green spaces, the study aims to identify patterns in usage and their impact on student well-being.

2. Material and Method

From March to August 2024, surveys were conducted at six primary and secondary schools in Italy. The selection criteria focused on schools with distinctive features, including those that offer green spaces open to the public after school hours or are integrated with the local community. Additionally, the study included schools where green spaces extend beyond the school boundaries, as well as schools that follow the pedagogical approaches of Italy’s most renowned educators—Reggio Emilia, Giacomo Pizzigoni, and Maria Montessori. The teaching philosophy of Italian primary and secondary schools is closely related to the campus environment, and different educational philosophies have their own characteristics and requirements for the design of the campus environment. Montessori advocates the concept of ‘child-centred’ environment design, stressing the order and autonomy of the environment, and designing suitable teaching aids and spaces for children at different stages of development. Pizzigoni paid special attention to the integration of natural elements, emphasising the promotion of holistic development through hands-on practice and natural observation. Reggio Emilia considers the environment as part of learning, stimulating diverse expression through rich, flexible spatial design. They overcome the limitations of traditional education by designing new teaching strategies that emphasise children's independent learning and personalised development.

Table 1. Research information on green spaces in Italian primary and secondary schools

School	**Characterizations**	**Green space area(m^2)**	**Green space ratio**	**Master plan**
Trotter La scuola Cas del Sole ,Milano	Open-air school: Schools in the park, open after 4:30PM from Monday to Friday	99379.36	74.96%	
Istituto Forlanini ,Sesto San Giovanni	Playground outside the school, Share with the community	20006.75	76.38%	
Reggio Children，Reggio Emilia	Reggio Emilia Approach	19264.03	61.58%	
Enrico Fermi 1st grade Secondary School, Torino	Community school: add ground-floor facilities, effectively creating a civic center open to all, with a gym, a library, an auditorium and a canteen	7696.95	58.01%	
Pizzigoni Rinnovata Scuola, Milano	Pizzigoni Renewed School, experiential and pedagogical activities in outdoor spaces	55877.16	72.26%	

First, Bedimo-Rung Assessment Tools（BRAT）was employed to collect landscape features concerning primary and secondary schoolyards. This included site conditions, facilities, green space exposure rates, safety, vegetation, and aesthetics (Liu, 2023).

Subsequently, children's interactions with landscape were observed using an adapted version of the System for Observation of Play and Recreation in the Community (SOPARC) to assess their physical activity levels and engagements with landscape features (Marquet, 2019). Spatial overlay analysis of landscape features and physical activity behaviors was used to demonstrate the multidimensional relationship between green spaces and children's physiological health. Finally, planning strategies for green spaces in child-friendly contexts were discussed.

1. Interview: Students: how much they like the school outdoor space, why they like it or dislike it, when they use the green space, what kind of activities they do in the green space, what they think of the school green space.

2. Observation: 1) A direct observation method that focuses on environmental features including site conditions, facilities, safety and aesthetics. 2）The method records visitors' physical activity levels, including gender, age, time, type and level of activity. It classifies PA into high, medium and low levels.

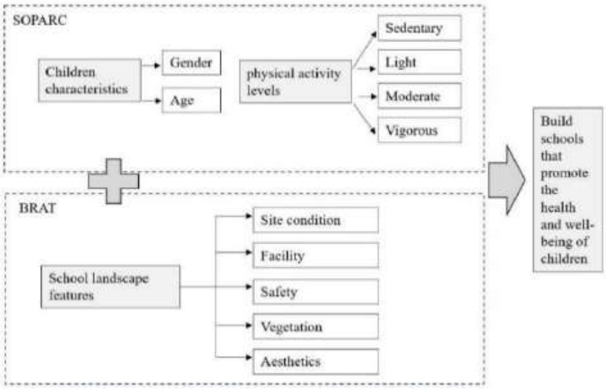


Figure 1. Technology route

3. Findings and Discussion

3.1 Innovative educational models of green space

Green spaces in Italian primary and secondary schools are essential not only for student activities and exercise but also for enriching educational experiences. A significant portion (over 50%) of green space in selected schools demonstrates the emphasis on utilizing natural environments to stimulate learning and practical skills among students. The Trotter School serves as a model of outdoor education, featuring extensive green areas and an open layout that encourages the integration of natural environments into traditional educational settings (Thyssen, 2009). The school's design, inspired by outdoor schooling models from the UK and Germany, reinforces the educational value of direct engagement with nature. Natural grass areas at Trotter School provide students with diverse opportunities for activities, contrasting with the standardized hard-surface sports facilities typically found in other schools. The flexible characteristics of natural spaces lower potential risks during physical activities and foster varied educational and recreational possibilities. The renovation of the Pizzigoni School highlights the integration of indoor and outdoor spaces, promoting interaction and enhancing educational experiences. Facilities designed for educational purposes, such as greenhouses and gardens, allow students to directly observe and engage with natural changes, facilitating experiential learning.

3.2 Community ınteraction and space sharing

Italian school designs emphasize deep integration with the surrounding community, exemplified by the Trotter School's transition from a closed educational space to a community park after school hours. The Reggio Emilia school promotes community engagement through its architectural layout, which includes public areas while maintaining privacy for educational activities, balancing community use with the needs of students and staff. By integrating these green spaces into school designs, Italian schools are not only enhancing the educational experience but also contributing to the overall well-being and social cohesion of their communities.

3.3 Enhancement of psychological and physical well-being

The presence of green spaces within school environments is increasingly recognized as a vital factor in enhancing both psychological and physical well-being among children. Research indicates that access to natural environments encourages higher levels of physical activity, which is crucial for combating childhood obesity and promoting overall health. The varied landscapes in schoolyards, such as gardens, playgrounds, and open green areas, not only motivate children to engage in physical play but also provide opportunities for exploration and discovery, which are essential for holistic development.

Furthermore, engaging with nature has profound implications for children's psychological and social-emotional development. Studies have shown that time spent in green spaces can reduce symptoms of anxiety and depression, improve mood, and enhance cognitive function. The sensory experiences afforded by natural environments—such as the feel of grass underfoot, the sound of rustling leaves, and the sight of diverse flora and fauna—stimulate curiosity and creativity, fostering a deeper connection to the world around them. Additionally, collaborative outdoor activities promote social skills, teamwork, and communication among peers, further strengthening emotional resilience and interpersonal relationships.

Table 2. Functions and landscape characteristics of green spaces

Function	Field research		Landscape features
Educational			Vegetable gardens, planted green spaces, aesthetics, educational signage
Community sharing			Large areas of vegetation, openness, park-like nature, security, central urban location
Health promotion			Diversified amusement facilities; large area of vegetation

4. Conclusion

This study provides field research evidence supporting the positive impact of green schoolyards on child health, specifically in terms of physical activity and overall well-being. The elements of schoolyards, particularly the distance and accessibility between the schoolyards and school buildings, influences both the intensity and duration of PA among students during recess. Raney et al. identified playground density, green space percentage, unique play zone quantity, game types, area segregation, and shaded areas as factors influencing recess PA (Raney, 2023). Their study revealed that playgrounds with more unique play zones, segregated areas, and shaded spaces encourage MVPA engagement, while those with higher student density tend to promote sedentary behavior.

Furthermore, the study recommends promoting the design of green spaces to encourage physical activity. The findings of this research provide specific evidence for understanding the factors contributing to children's physical activity and investigating the impact of the green schoolyards on physical activity levels. Moreover, the results offer theoretical support for future research on models of children's physical activity. Policy and planning processes should consider these determinants to enhance children's health and well-being. The study calls for continued investment in and commitment to green schoolyards as a means of fostering a healthier future for children.

In conclusion, the design of school landscapes holds significant potential as a public health intervention. By prioritizing the development of green schoolyards, policymakers and educators can contribute to the creation of healthier, more supportive learning environments that foster both the physical and mental well-being of children. These findings underscore the importance of incorporating natural elements into school design, not only as an aesthetic choice but as a strategic investment in the health of future generations.

Acknowledgements

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Cultivating Creative Climate Resilience: 3 Projects from Northern England

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Abstract

All projects fit the theme of "Code red earth" as they embrace 3 climate resilient projects in the north of England, around 3 vulnerable communities with some very familiar threats that many countries face, covering coastal estuarine and riverine, defence projects. All came about principally to protect lives and property from devastating floods and erosion but they also delivered huge social and environmental benefits, creating special places for people and nature, through designs which all celebrated their unique Landscape context.

Keywords: Landscape engineering, enhanced identity, flood protection, historic context, places for people and nature

1. Introduction

The first of these projects collected a UK Landscape Institute award in 2023. Based in the village of Mytholmroyd in West Yorkshire with a population of around 4,000 its located between Leeds and Manchester in northern England. This place is perilously tucked into the Pennine hills at the confluence of two rivers and was earmarked for emergency flood defence works after a series of catastrophic flood events, affecting 300 properties and 70 businesses. The works started in 2018 and completed in 2021. This was a Landscape and engineering led project which initiated a series of interventions around the village at a cost of around £41m, covering approximately 10 hectares. The project embraced new flood walls, managed flood plain and wetland park creation, the opening up of riverside walks and new views and spaces enhancing the identity of the village as well as protecting it, with new access including footbridges and green bridges which were all sensitively woven into an historic natural stone village all constructed during the pandemic.

Figure 1. Mytholmroyd Village masterplan showing key interventions: Atkinsrealis 2018

Figure 2. Sketch showing opened up views enhancing the sense of place: Atkinsrealis 2018

"The flood management interventions have decluttered and skilfully enhanced the village centre. Strengthening the sense of place and local identity."

"The civic aspect of the design enables people to have a positive association with the river once again."

A number of elegant and efficient design solutions have been delivered which also create multi-functional design outcomes.

Figure 3. Mytholmroyd`s completed flood defence works creating new public realm

"Understanding of local context is evident in the quality of the place created through these works."

"Impressive and sensitive interventions that positively contribute to the sense of place."

Figure 4. Mytholmroyd flood defence interventions : Atkinsrealis photography 2023

"New footpath and cycle links help promote active travel.. with visual appeal and landscape consideration."

"The community engagement and co-design is exemplary."

Figure 5. Mytholmroyd, creation of managed wetlands: Atkinsrealis photography 2023

Morecambe Promenade and sea defence wall.

Key words: artistry and engineering, coastal defences, Promenade, accessible.

The second project collected numerous awards and recognition and was a £11.5m coastal defence project located in Morecambe on the north-west coast of England a deprived town of around 35,000 inhabitants. Many of the UKs coastal towns are on the front line of the battle against climate change and here the threat is sea borne with wave and storm damage along a 3.6 km stretch of coastal promenade covering 27 hectares, principally to replace a failing sea wall built in the 1980s.

The project started in 2014 and was completed in 2018 protecting 13,500 properties. The works embraced the promenade and sea wall area over a varying width of a few metres to 10m and a key part of the resort`s sea front experience. The designs were a blend of artistry and engineering designed to complement not compete with the spectacular coastal views towards the lake district. We created a visually appealing wall embossed with appropriate imagery and motifs from the surrounding context, including the towns notable personalities, architecture and landscape, improving access through a series of "up and over" landings, whilst comprehensively re surfacing the promenade. The proposals also included new gardens extensive new seating and marine planting.

The new wall not only protects the town but delivered the wholly more enjoyable, engaging and accessible experience for the many visitors, residents, walkers and cyclists who use the Promenade, lifting the appeal of the town and promoting more use and visitor numbers.

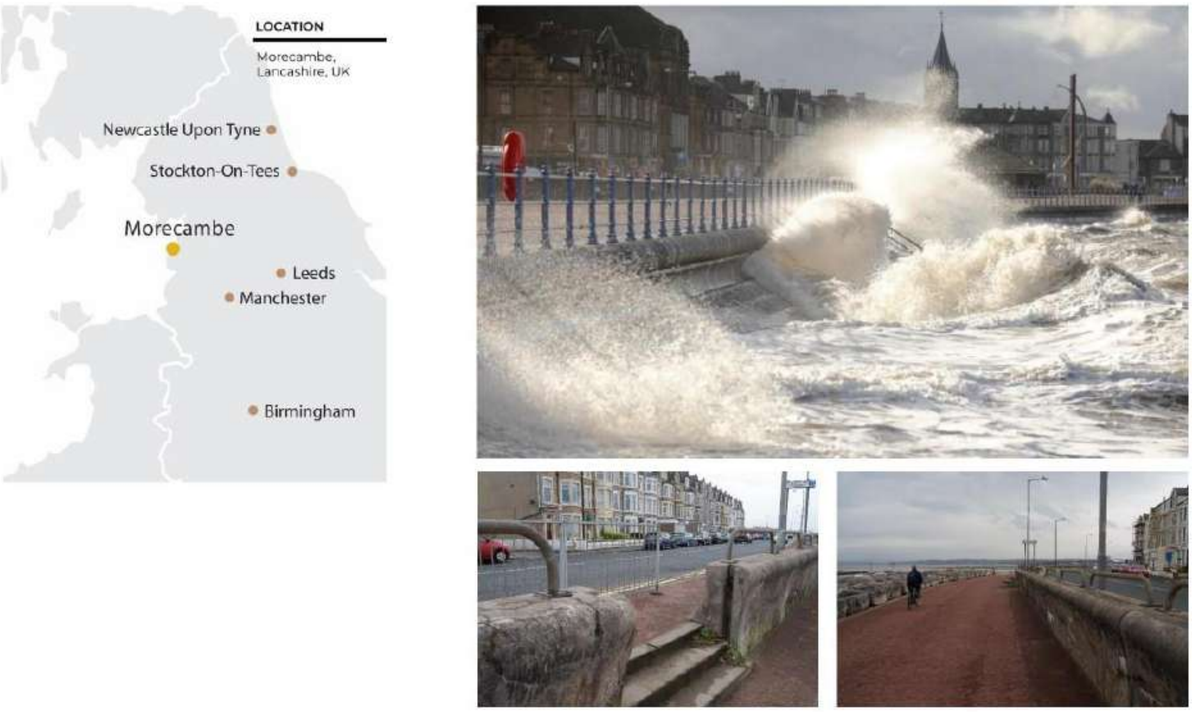


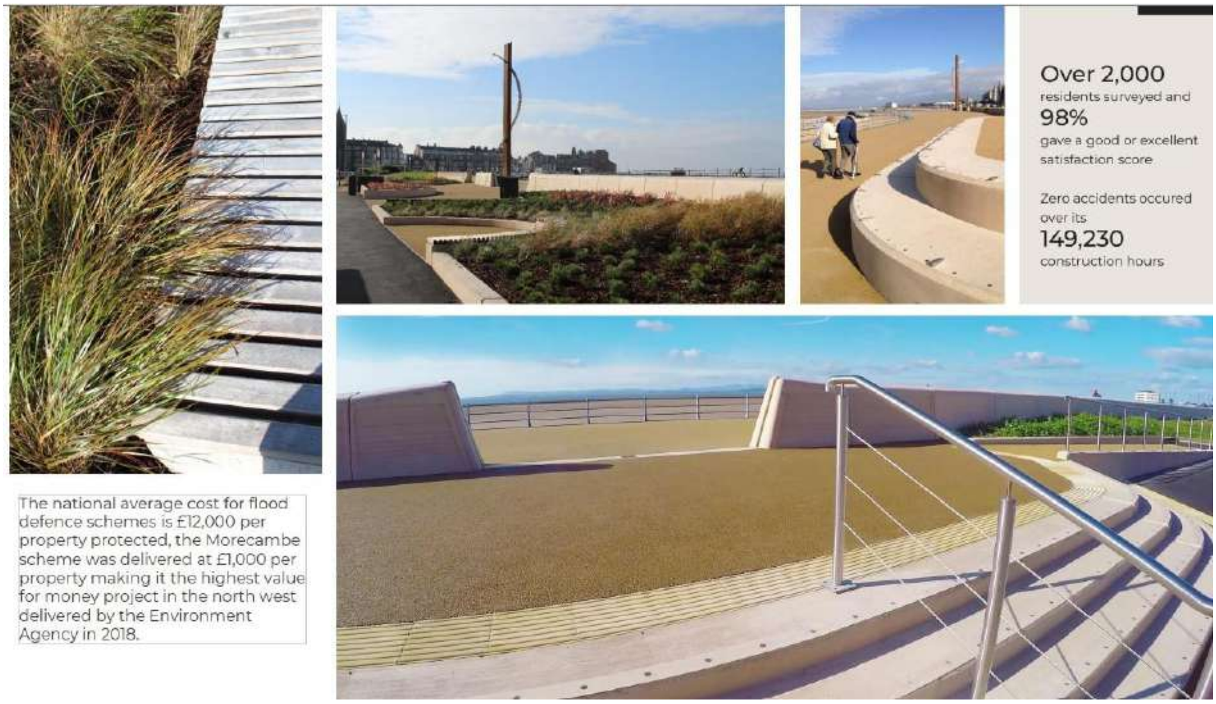
Figure 6. Morecambe location and nature of the problem. Atkinsrealis 2014

Figure 7. Morecambe masterplan of key interventions – Atkinsrealis 2018

"The design is second to none and as well as the protection it provides, the wall has really helped to enhance the promenade and reflect the beauty of its setting in Morecambe Bay."

Janice Hanson, Lancaster City Council Cabinet Member for Regeneration and Planning

Figure 8. Morecambe aerial overview: Volker stevin Boksalais Westminster and Atkins 2018

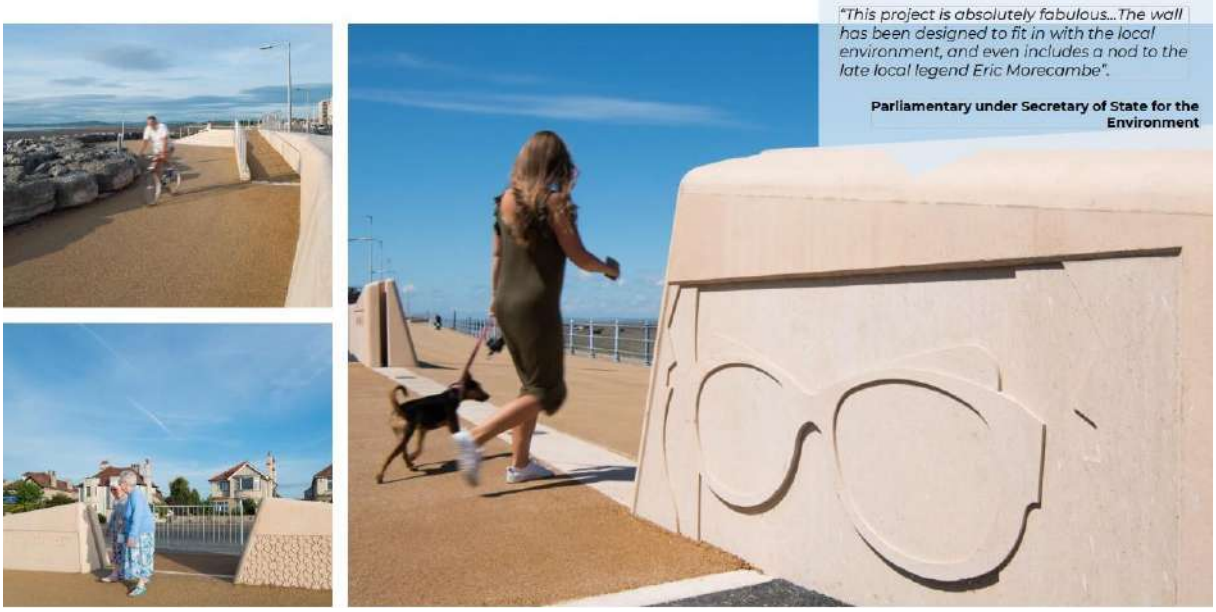


Over 2,000 residents surveyed and 98% gave a good or excellent satisfaction score

Zero accidents occured over its 149,230 construction hours

The national average cost for flood defence schemes is £12,000 per property protected, the Morecambe scheme was delivered at £1,000 per property making it the highest value for money project in the north west delivered by the Environment Agency in 2018.

Figure 9. Morecambe Promenade medley of images : David Millington photography 2018



"This project is absolutely fabulous...The wall has been designed to fit in with the local environment, and even includes a nod to the late local legend Eric Morecambe".

Parliamentary under Secretary of State for the Environment

Figure 10. Morecambe Promenade medley of images: David Millington photography 2018

Figure 11. Morecambe Promenade medley of images: David Millington photography 2018

Figure 12. Morecambe View of up and over: David Millington photography 2018

Fairhaven Promenade Key words: Estuarine erosion, Promenade revetment

The last of the three projects is located on an estuary, not far from Morecambe on the Fylde Coast in the north-west of England. Delivered between 2017 and 2020 at a cost of £22m. This 2.5km long site is sandwiched between two beautiful spaces, the wide-open River Ribble and Alt estuaries and an historic lakeside park dating from the 1920s and replaces a crumbling revetment constructed in the1890s. This was a simple and elegant response, protecting a vulnerable community of 2,500 properties in Fairhaven, Lancashire from storm borne events and coastal erosion. The design forms a sinuous but robust defence structure, following the natural curves of the estuary, creating a stunning new piece of public realm, which can host cycling, walking and many other healthy pursuits. The new revetment bridges two engaging landscapes, managing to link both in an unobtrusive way, creating a stepped edge from which to enjoy the stunning vistas and huge skies.

Figure 13. Fairhaven promenade arial view 2020 Volker stevin Boksalais Westminster and Atkins

Figure 14. Fairhaven Promenade 2021 Atkinsrealis photography

Figure 15. Fairhaven Promenade 2021 Atkinsrealis photography

Figure 16. Fairhaven Promenade 2021 Atkinsrealis photography

Figure 17. Fairhaven Promenade 2021 Atkinsrealis photography

Figure 18. Fairhaven Promenade 2021 Atkinsrealis photography

2. Conclusion

All projects fit the theme of “Code red earth” covering three climate resilient projects in the north of England, protecting three vulnerable communities from threats that many societies face across the globe, covering coastal, estuarine and riverine locations. These projects came about principally to protect lives and property from the devastating impacts of flooding and erosion but they also delivered huge social and environmental benefits, creating special places for people and nature, through designs which all celebrated their unique Landscape context.

Spatial and Social Resilience in Crises: Migration Response to Disasters

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Abstract

It is widely recognized that millions of individuals worldwide relocate either by choice or necessity each year. The reasons for forced migration can vary greatly, stemming from conflicts, oppression, political pressures, wars, poverty, and even natural disasters like floods and earthquakes. In the wake of such calamities, people seek to rebuild their lives by migrating to safe havens, either temporarily or permanently. Over the past two decades, we've seen an unprecedented number of natural disasters occur in various countries around the globe. The February 6, 2023 earthquakes centered in Kahramanmaraş, Türkiye had a significant impact on social life, resulting in forced migration and affecting 11 provinces including Kahramanmaraş, Hatay, Gaziantep, Adana, Kilis, Osmaniye, Malatya, Elazığ, Şanlıurfa, Diyarbakır, and Adıyaman. Many individuals were forced to relocate to safe provinces not impacted by the earthquake, with approximately 2.7 million people being displaced. The migration movements and human trends after the earthquake were analyzed and compared to examples from world literature in a recent study. The study identified spatial problems in the places of migration and has suggested solutions to provide spatial and social resilience for cities to minimize the consequences of these migration movements on urban systems.

Keywords: Disasters, resilience, migration, environmental crises, Türkiye

1. Introduction

Migration is the movement of individuals or groups from one region to another, motivated by a variety of economic, social, political, or environmental factors. This journey is often undertaken in search of better living conditions, security, employment, or educational opportunities (De Haas et al., 2019). Research indicates that such movements can lead to both domestic and international migration. Notably, this phenomenon is not a modern development; it has been an integral part of human civilization throughout history.

However, the migration of people following a catastrophic natural disaster can present significant challenges for both their regions of origin and their new destinations. Areas left behind may suffer a loss of valuable human resources, hindering economic recovery and contributing to population decline. At the same time, destination regions may face urban challenges such as housing shortages, slums, and pollution, along with strains on critical services like education, healthcare, security, and infrastructure.

The concept of migration is examined from multiple disciplinary perspectives in the literature. From a sociological standpoint, the effects of migration on the social structures of individuals and families are critically important. Economically, migration is analyzed in terms of labor mobility and its implications for economic development (Massey et al., 1993). Studies on the causes and consequences of migration often emphasize the demographic, economic, and social changes instigated by migrants in both their regions of origin and their new homes. In situations of forced migration, particular focus is given to the challenges faced by migrants and their processes of adaptation in new settlement areas (Bakewell, 2013).

Over the past two decades, an unprecedented number of natural disasters have occurred in various countries around the world. Research shows that these events can trigger both domestic and international migration. The movement of people following a catastrophic natural disaster presents challenges for both the areas they leave and those they relocate to. Throughout history, migration has brought about significant demographic, economic, and cultural changes within societies. Forced migration, in particular, arises when individuals are compelled to vacate their homes due to conflicts, political pressures, poverty, social injustice, natural disasters, and climate change (UNHCR, 2020). Conflicts and wars often lead to mass displacements as people flee violence and insecurity in search of safety (UNHCR, 2020). Political pressures—such as persecution and human rights violations—drive many to leave their countries to escape oppressive regimes (Power, 2013). Furthermore, poverty and social injustice are critical factors, as economic hardships and the unequal distribution of resources push individuals to migrate in search of better opportunities (World Bank, 2018). Additionally, natural disasters like earthquakes, floods, and hurricanes can devastate communities, making immediate relocation necessary to ensure safety (Cross, 2014).

Climate change exacerbates these issues by increasing both the frequency and severity of disasters, further intensifying trends in forced migration (Abel et al., 2019). Rising sea levels, extreme weather events, and prolonged droughts are compelling communities—especially in vulnerable regions—to abandon their homes and seek refuge elsewhere. The impact of climate change on migration is particularly pronounced in areas like the Pacific Islands, where entire communities are facing displacement due to rising sea levels (Intergovernmental Panel on Climate Change, 2014). These varied drivers of forced migration highlight the complex interplay of factors that push individuals to leave their homes in search of safety and stability in new environments.

This study aims to explore the effects of forced migration resulting from natural disasters and the essential spatial and social resilience required to address these impacts. The objective is to analyze instances of natural disasters that have prompted forced migration globally, with a particular emphasis on the February 6 Kahramanmaraş earthquake. By examining these events, the study seeks to understand how large-scale disasters influence migration dynamics and the spatial and social challenges these migrations create for both the regions of origin and the destinations. The focus is on identifying ways to mitigate the negative impacts of forced migration on cities and populations through social and spatial resilience strategies. The scope of the study includes three case studies from Italy, Japan, and Türkiye, each marked by significant material and emotional losses that resulted in forced migrations. These cases will be compared to develop strategies aimed at enhancing the resilience of cities worldwide, particularly in Türkiye, to better withstand disasters.

2. Material and Method

2.1 Study area

Kahramanmaraş is a province located in the Southern part of Türkiye. The city boasts a history dating back to 2000 BCE, having been home to several civilizations, including the Hittites, Assyrians, Persians, Romans, and Byzantines. The history of the city is reflected in the cultural diversity and architectural landscape of Kahramanmaraş (Günay et al., 2021). Kahramanmaraş is also a significant industrial and commercial hub in Türkiye, particularly known for its textile, food, and metal industries. The city's economy is further bolstered by agriculture and livestock farming. Kahramanmaraş is globally famous for its traditional ice cream, and it also stands out for its traditional crafts and weaving (TUIK, 2020).

The earthquakes centered in Kahramanmaraş in 2023 caused significant destruction across the province. Due to its geographical location, Kahramanmaraş is situated in a high-risk earthquake zone. The city gained significant attention following the major earthquake on February 6, 2023, which caused severe damage and loss of life both in the city and surrounding provinces (AFAD, 2023). On 6 February 2023, two major earthquakes struck the Kahramanmaraş province in Türkiye, causing widespread destruction and loss of life in the southeastern part of the country. The first earthquake, with a magnitude of 7.8, occurred at 04:17 local time, followed by a second earthquake of 7.5 magnitude approximately nine hours later at 13:24 (AFAD, 2023). The earthquakes most severely impacted the provinces of Kahramanmaraş, Gaziantep, Adıyaman, Malatya, and Hatay. Hatay, particularly the district of Antakya, witnessed substantial destruction and loss of life (AFAD, 2023). The earthquakes resulted in the deaths of over 50,000 people and left more than 100,000 injured (UN OCHA, 2023). Rescue operations continued for an extended period, with many individuals being pulled alive from the rubble. The earthquakes caused the complete collapse or severe damage to more than 2 million buildings (Turkish Strategy and Budget Presidency, 2023).

Post-earthquake studies revealed that a substantial portion of the buildings in Kahramanmaraş and its vicinity were not earthquake-resistant, highlighting the urgent need for interventions and renovations (Avcil et al., 2024). This situation underscores the importance of developing resilient structures and communities capable of withstanding natural disasters. For Kahramanmaraş to effectively cope with such adverse impacts, it is essential to develop social and spatial resilience strategies.

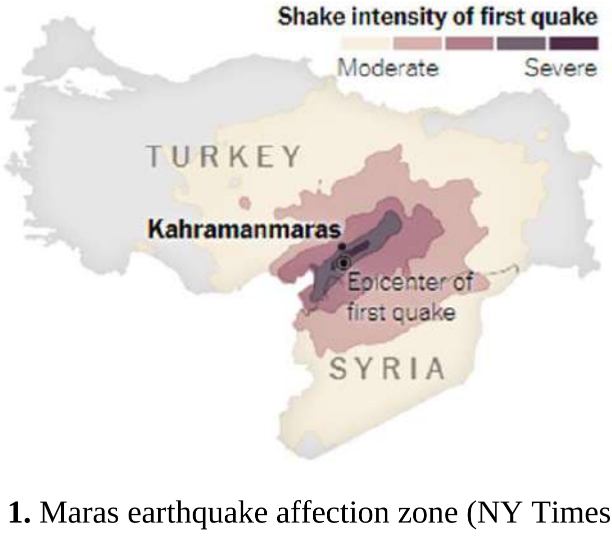


Figure 1. Maras earthquake affection zone (NY Times, 2023)

2.2 Methods

Within the scope of this study, case study research was determined as the research method. Case study research is a qualitative approach that involves an in-depth, contextual analysis of a limited number of events or conditions and their relationships. This method is particularly useful for exploring complex phenomena within their real-life context. According to Yin (2018), a case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident. In the current literature, there are several case study research examples to examine the relationship between natural disasters and migration (Gray & Mueller, 2012; Fussell et al., 2010; Karanci et al., 2005; Lu et al., 2012).

In the first stage of the study, a literature review was conducted and the relationship between migration and resilience was explained. In the second stage of the study, the concept of social and spatial resilience was examined through three different cases selected from the literature. The case areas are cities where natural disasters caused large-scale destruction and loss of life and property. In addition to the Kahramanmaraş earthquake, which formed the basis of the study, the L'Aquila earthquake, which caused similar destruction, and the Miyagi earthquake, where an earthquake and tsunami occurred together, were discussed.

The destruction caused by natural disasters in cities and their social and spatial resilience dimensions were compared through different case examples of locations that caused large-scale destruction. While making the comparison, comparison tables were prepared by taking into account parameters such as the area affected by the disaster, the number of people affected by the disaster, collapsed buildings, and the number of people migrating. By comparing the tables developed in the third stage of the study, design and planning strategies for social and spatial resilience that can be proposed against the destruction and migration caused by natural disasters in cities were discussed (Figure 2).

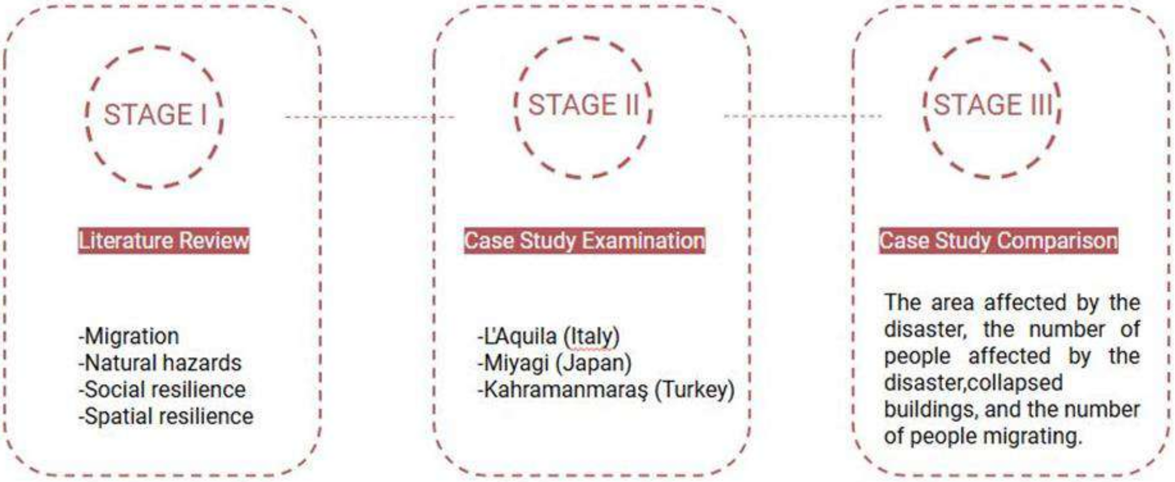


Figure 2. Stages of the study (Dilman Gökkaya et al., 2024)

3. Findings and Discussion

L'Aquila province (central Italy) was struck by an earthquake (6.3 magnitude) on the 6th of April 2009. The physical event was relatively moderate, but it revealed the very high vulnerability of lives, livelihoods, building stock and institutions. More than 300 people were killed and 1500 injured (Alexander, 2014) (Table 1). After the earthquake, people chose to relocate to nearby cities in the Abruzzo region because they wanted to eventually return. They stayed in temporary shelters in these cities. However, foreign residents chose to leave the city permanently (Figure 3). During the recovery process, more robust buildings and wider roads were constructed. However, the public was not involved in the process. A disconnection emerged between the authorities and the local population, and after reconstruction, housing prices increased, this prevented many displaced residents from returning to their homes. At the same time, new residents arrived in the city for work purposes.

Table 1. Destruction impact of L’Aquila Earthquake (Adapted from Italian Civil Protection Department, 2009)

Category	Impact
Residential Units	25,000 severely damaged or destroyed
Public Buildings	1,500 schools, hospitals, and government buildings
Infrastructure	Major roads, bridges, and utilities disrupted
Displaced People	65,000 people

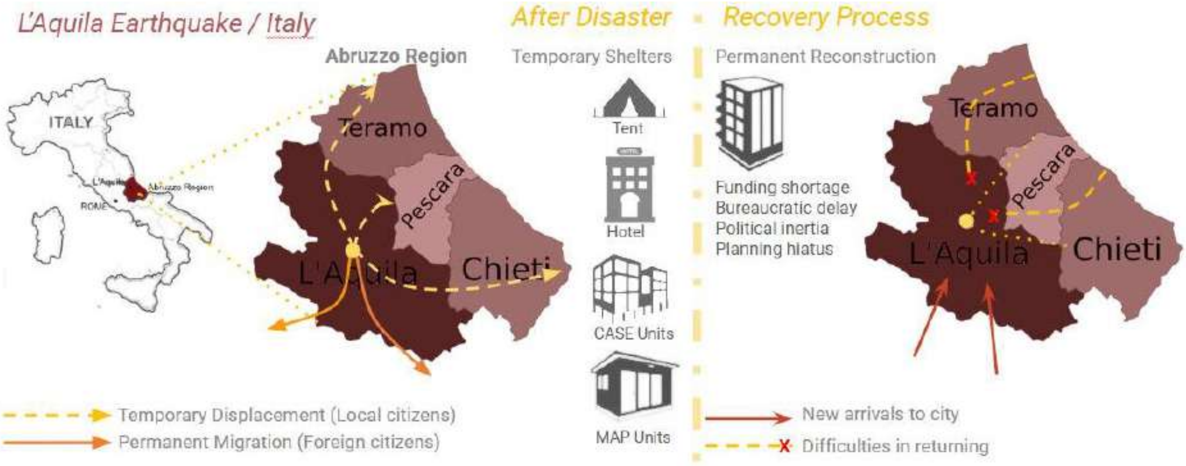
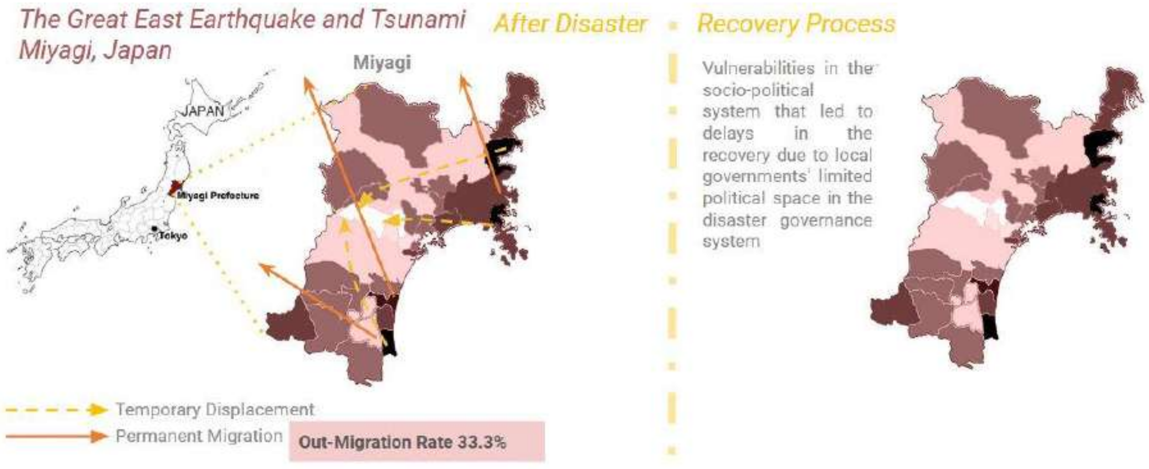


Figure 3. L’Aquila earthquake and migrations (Dilman Gökkaya et al., 2024)

Immediately after the Great East Japan Earthquake (9.0 magnitude) on March 11, 2011, a large tsunami along the Pacific coast of the Tohoku and Kanto regions in Japan killed 18,425 people and injured 6167 people (Kamata et al., 2022) (Table 2). Following the disaster, much like in the case of Italy, displaced individuals relocated to safer areas within Miyagi Prefecture. The major challenge during the recovery process was Japan's extensive disaster recovery plan and procedures. A single, centralized recovery plan limited the involvement of local authorities in policy-making, causing delays in local interventions. In regions where the recovery process was prolonged, temporary relocations turned into permanent migrations (Figure 3).

Table 2. Destruction impact of Great East Japan Earthquake (Adapted from Japanese Reconstruction Agency, 2011)

Category	Impact
Residential Units	400,000 severely damaged or destroyed
Public Buildings	4,000 schools, hospitals, and government buildings
Infrastructure	Major roads, bridges, and utilities disrupted
Displaced People	470,000 people



Vulnerabilities in the socio-political system that led to delays in the recovery due to local governments' limited political space in the disaster governance system

Figure 4. The Great East earthquake and migrations (Dilman Gökkaya et al., 2024)

On 6 February 2023, two major earthquakes struck the Kahramanmaraş province in Türkiye, causing widespread destruction and loss of life in the southeastern part of the country. The first earthquake, with a magnitude of 7.8, occurred at 04:17 local time, followed by a second earthquake of 7.5 magnitude approximately nine hours later at 13:24 (AFAD, 2023). The earthquakes most severely impacted the provinces of Kahramanmaraş, Gaziantep, Adıyaman, Malatya, and Hatay. The earthquakes resulted in the deaths of over 50,000 people and left more than 100,000 injured (UN OCHA, 2023) (Table 3). It was reported that the number of displaced people in 11 provinces was 2,465,122 (IOM, 2023). People preferred to go to cities where they felt safer and where they had relatives. However, some Syrian refugees also returned to Syria after the earthquake (Figure 5).

Table 3. Destruction impact of Kahramanmaraş Earthquake (Turkish Strategy and Budget Presidency, 2023)

Status	Number of Buildings	Number of Detached Units
Undamaged	860,006	2,387,163
Lightly Damaged	431,421	1,615,817
Moderately Damaged	40,228	166,132
Severely Damaged	179,786	494,588
Collapsed	35,355	96,100
Requiring Urgent Demolition	17,491	60,728
Not Assessed	147,895	296,508
Total	**1,712,182**	**5,117,036**

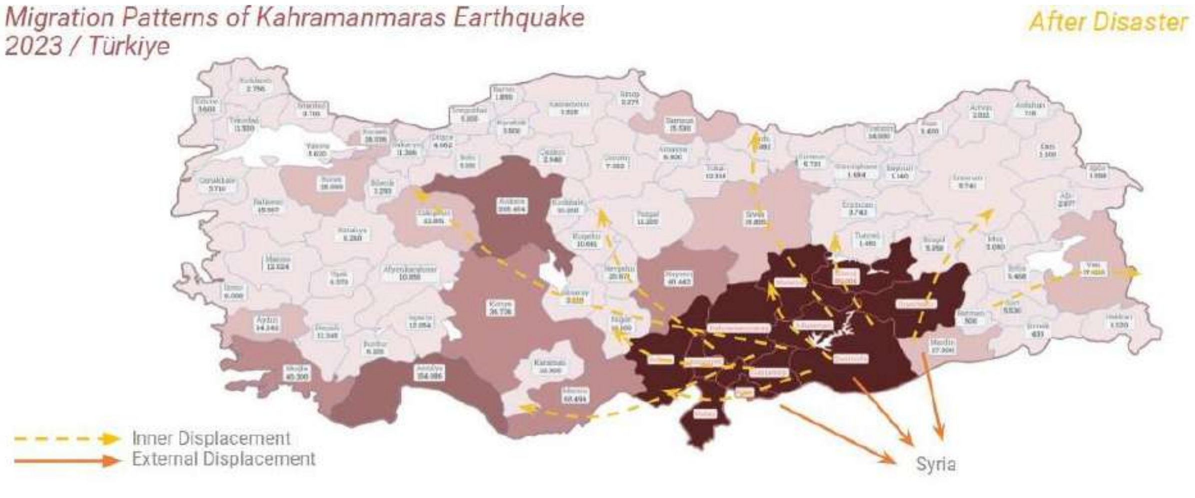


Figure 5. Kahramanmaraş earthquake and migrations (Dilman Gökkaya et al., 2024)

4. Conclusion

The interplay between migration and disasters highlights the urgent need for cities to bolster both their spatial and social resilience. The earthquakes that struck Türkiye on February 6, 2023, vividly illustrate how natural disasters can precipitate widespread displacement, with significant repercussions not only for the affected regions but also for the areas accommodating displaced populations. This study emphasizes that forced migration disrupts the economic and social stability of disaster-stricken areas while imposing additional pressures on host communities, such as heightened demand for housing, infrastructure, and essential public services like education and healthcare.

Addressing these interconnected challenges effectively necessitates a multifaceted approach that balances immediate relief with sustainable long-term planning. To achieve this, it is crucial to develop adaptable policies and practices that anticipate the repercussions of disaster-induced migration. Strengthening local capacities to integrate displaced populations, fostering community cohesion, and promoting equitable resource distribution are vital steps in this endeavor. Furthermore, reconstruction efforts in disaster-affected areas should focus on enhancing resilience, enabling displaced individuals to return and actively contribute to their communities' recovery.

Collaboration among governments, non-governmental organizations, and local stakeholders will be essential in formulating solutions that alleviate the impact of migration while ensuring that urban systems are better prepared to endure future crises. By embedding resilience into every facet of disaster response and urban planning, we can pave the way for more inclusive and sustainable cities capable of adapting to the challenges posed by environmental and social disruptions.

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Water Consumption for Irrigation in the Case of Adanalıoğlu, Çukurova

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Abstract

There are traditional irrigation systems in the Çukurova Agricultural region that do not consider energy and water consumption. With the water lack effect of climate change, this situation creates a huge problem in water and energy consumption. The study aims to determine optimal irrigation strategies and energy consumption for the region. The study addresses the sustainability of industrial farming across seasons, particularly in plain farm areas. Focused on water resources and their distribution, the research categorizes the irrigation topic into systems, distribution, and sources and encompasses an assessment of four principal sources of agricultural irrigation, namely, Open Canal Network (OCN), Collecting Pool (CP), Underground Water (UW), and Pipe Distribution Network (PDN). In the case of UW and CP, the water sources are located within agricultural lands, and the landowners manage their installation. Conversely, for OCN and PDN, the water typically originates from lakes or reservoirs and falls under state-funded infrastructure projects. Despite these irrigation sources varying in scale, the regional scope of this study allows for a proportional analysis of smaller-scale irrigation sources relative to the area.

The government's role in providing infrastructure or utilizing state-owned resources for water sources and distribution is explored. Four main systems of irrigation channels are examined through regional consumption predictions and simulations. The comparison emphasizes energy consumption and water loss, overlooking habitat impact and humidity levels. Adanalıoğlu village in Çukurova, Mersin is the case research area. Data in consumption is calculated at the neighborhood level, considering variables such as well acreage, water pump types, and agriculture type. GIS and QGIS plugins facilitate processing and simulation, utilizing real energy usage data. The study aims to evaluate the efficiency of irrigation systems based on energy and water consumption, providing insights into the most effective approach for sustainable agriculture in the Çukurova Agricultural region. The study assesses the existing system and simulates alternative options to determine optimal irrigation strategies for the region.

Keywords: Agricultural applications, irrigation systems, wastewater, water consumption, Cukurova

1. Introduction

Water and energy management within agricultural infrastructure represents a critical significance yet encompasses a series of complex challenges, particularly in sustaining agricultural practices. Water forms the foundation of agricultural production and constitutes a major portion of global freshwater resources. According to reports by the World Bank (2022), the agricultural sector consumes between 70% and 90% of freshwater, highlighting its vital role, especially in regions with limited water resources, for the sustainability of agricultural production.

Energy management plays a significant role in efficiently utilizing water resources through the operation of pumps and other mechanical systems. As Velasco-Muñoz et al. (2018) indicate, agricultural irrigation processes are energy-intensive activities, and the source and efficiency of energy used in this sector are key determinants of agriculture's carbon footprint.

In this context, integrating water and energy management is a significant management and policy challenge in developing and operating agricultural irrigation systems. Adopting technologies that save water and energy, promoting energy-efficient agricultural practices, and investing in research and development within the water-energy nexus of the agricultural sector are essential.

Moreover, water and energy pricing in the agricultural sector directly influences farmers' decisions and practices. Subsidies, tariffs, and market structures can be decisive in how resources are utilized, and if not carefully balanced, can lead to resource wastage or unsustainable practices (Velasco-Muñoz et al., 2018).

In summary, water and energy management in agricultural infrastructure is not merely a matter of technical and engineering challenges but is also intricately linked with socio-economic and environmental factors, presenting itself as a dynamic and complex field. Therefore, policymakers and practitioners in the sector must adopt a holistic approach that ensures the sustainable and efficient use of both water and energy resources.

In this context, the present study aims to conduct a comparative analysis of agricultural irrigation infrastructure systems based on their energy and water consumption. Despite advances in irrigation infrastructure technologies, archaic methods and inefficient irrigation infrastructures are still widely used. This study will highlight the differences between various irrigation infrastructure systems, demonstrating the economic value added and the long-term positive returns of government investments in these systems, based solely on water and energy consumption. Thus, it will be articulated that agricultural investments not only provide positive value to farmers but also contribute positively to environmental and global sustainability in terms of both energy and water usage.

1.1 Irrigation source

This study encompasses an assessment of four principal sources of agricultural irrigation, namely, Open Canal Network (OCN), Collecting Pool (CP), Underground Water (UW), and Pipe Distribution Network (PDN). In the case of UW and CP, the water sources are located within agricultural lands, and the landowners manage their installation. Conversely, for OCN and PDN, the water typically originates from lakes or reservoirs and falls under state-funded infrastructure projects. Despite these irrigation sources varying in scale, the regional scope of this study allows for a proportional analysis of smaller-scale irrigation sources relative to the area.

The Open Canal Network (OCN) for agricultural irrigation comprises a system of interconnected canals or channels that transport water from sources such as rivers, lakes, or reservoirs to agricultural lands. The network consists of primary, secondary, and tertiary canals, where primary canals carry water from the source, secondary canals distribute it over broader areas, and tertiary canals deliver water to individual fields. Effective in regions with abundant water resources and flat terrains, these networks face challenges such as water loss due to evaporation and leakage. Mitigation strategies include lining canals with impermeable materials. Manual operations are common for controlling water flow, but there is a trend towards more efficient systems like pipelines and drip irrigation for better water conservation (Burt et al., 1997; Keller & Bliesner, 1990; Merriam & Keller, 1978).

A Collecting Pool (CP) for agricultural irrigation is an artificial reservoir that stores water for irrigation purposes. These pools collect rainwater, groundwater, or water from nearby sources and store it for use in agricultural fields. Collecting pools enhances agricultural productivity by increasing water availability during seasonal fluctuations or drought periods. They are often equipped with linings or covers to reduce water loss through evaporation and seepage. Integrated into irrigation systems, they hold potential for improving water use efficiency, particularly in arid regions

With limited water resources, the design and management of collecting pools for agricultural irrigation (Smith, 1992; Jensen, 2007) are crucial for maintaining the quality of stored water and ensuring its effective distribution (Bos et al., 2005).

Underground Water (UW) plays an especially significant role in regions where surface water is scarce. This natural resource, found in aquifers beneath the ground, is accessed through wells, boreholes, or springs and is often lauded for its more stable supply and superior quality compared to surface water (FAO, 2003). Underground water irrigation is particularly vital in arid and semi-arid areas, providing a reliable water source during dry periods and enabling more consistent agricultural production (Siebert et al., 2010). However, the sustainability of using underground water for agriculture is increasingly a concern due to issues such as declining water tables from over-extraction, land subsidence, and reduced water quality (Foster & Chilton, 2003). Effective management and conservation practices are essential to balance agricultural needs with preserving this vital resource (Konikow & Kendy, 2005).

A Pipe Distribution Network (PDN) in land irrigation is an engineered system designed to transport water from a source to agricultural fields efficiently. This system consists of a hierarchy of pipes that decrease in size as they extend from the water source to the fields, including main, intermediate, and lateral pipes (Keller & Bliesner, 1990). Control valves and gates are integrated to manage water flow and ensure precise delivery to specific farm sections. Filtration systems may be used to prevent clogging, and pressure regulators are often necessary, especially in systems using drip or sprinkler irrigation techniques, to maintain optimal operating conditions (Jensen, 2007). In critical water conservation regions, these networks minimize wastage while sustaining agricultural productivity (Burt et al., 1997). The design and maintenance of these networks are crucial for their effectiveness and require regular monitoring to address issues such as leaks or blockages (Bos et al., 2005).

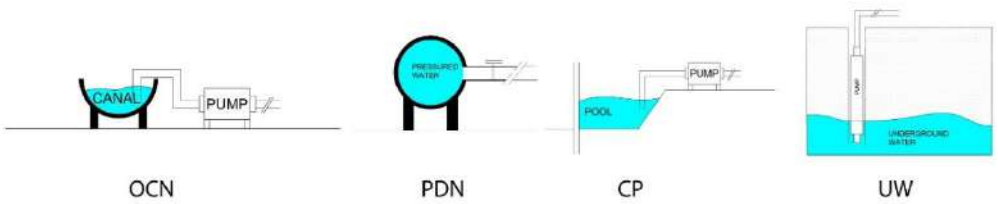

Figure 1. Irrigation Sources Schema (Fırat, 2024)

1.2 Case study area

The Çukurova Region, located in the south of Türkiye along the Mediterranean coast, boasts a rich agricultural history. Under the influence of the Mediterranean climate, the region experiences hot, dry summers and mild, rainy winters. These climatic conditions create some of the world's most fertile soils capable of supporting up to three harvests annually, making Çukurova a pivotal center for agricultural product diversity in Türkiye (Şen, 2023).

Çukurova is a significant hub for various agricultural products in Türkiye, including soy, peanuts, corn, cotton, and citrus fruits. The region also contributes a substantial portion of Türkiye 's citrus exports. Anamur, as Türkiye 's sole subtropical area, facilitates the cultivation of subtropical crops such as bananas, mangoes, and kiwis (Kurukulasuriya & Rosenthal, 2013).

Global climate change directly impacts the agricultural production of the Çukurova Region. Rising temperatures, changes in precipitation patterns, and extreme weather events affect the productivity and production of agricultural products in the region. These changes lead to increased irrigation needs, necessitating the adoption of sustainable agricultural practices (Şen, 2023).

Adanalıoğlu, as part of the Çukurova Region, is directly affected by these changes and plays a significant role in managing agricultural irrigation resources. Characterized by fertile soils and diverse water sources, the neighborhood supports cultivating various agricultural products. Particularly in the summer months, it faces the risk of water scarcity, making irrigation management and water use critically important (Şen, 2023; Kurukulasuriya & Rosenthal, 2013).

The agricultural activities of the Çukurova Region form the foundation of its economic and social structure. Agriculture is a major source of income for the regional population, and the area's agricultural production significantly contributes to Türkiye 's overall agricultural economy. Therefore, the sustainability of agricultural activities in Çukurova is of paramount importance both regionally and nationally (Şen, 2023).

Furthermore, the Çukurova Region is also an important ecological zone in Türkiye. The region's biodiversity, alongside agricultural activities, is crucial for ecosystem health and the preservation of biodiversity. Sustainable agricultural methods aid in protecting this biodiversity and contribute to maintaining ecological balance (Kurukulasuriya & Rosenthal, 2013).

In conclusion, the agricultural activities and ecological value of the Çukurova Region hold significant importance at both regional and national levels. The effects of global climate change are altering irrigation requirements and agricultural methods, directly influencing the region's agricultural sustainability. The biodiversity and ecosystem health of Çukurova, alongside agricultural practices, are critical for the overall ecological balance of the region. Therefore, the agricultural and ecological characteristics of Çukurova, particularly Adanalıoğlu, are of substantial interest for both local and extensive research and policy-making (Şen, 2023; Kurukulasuriya & Rosenthal, 2013).

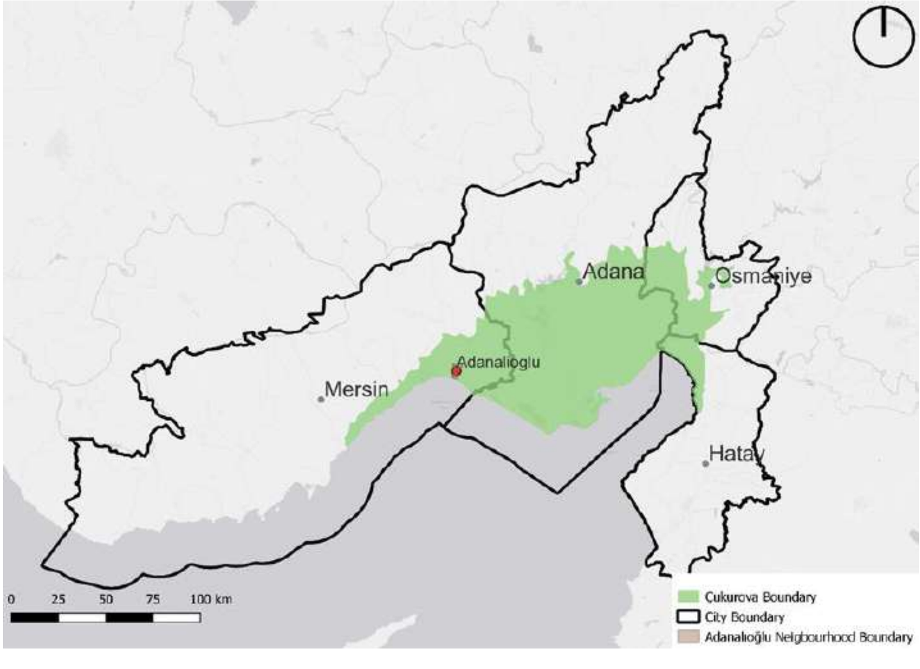

Figure 2. Çukurova Region and Adanalıoğlu Neigbourhood (QGIS.org 2024 by Fırat)

2. Literature Review

Agricultural irrigation is of critical importance in the management of water and energy resources. The World Bank's 2022 report provides a global perspective on this matter, emphasizing the role of water in agricultural productivity and the necessity of its sustainable use. This report delves into the management of water resources, policies, technologies, and the impacts of climate change on agricultural water resources, thereby highlighting the strategic use of water in agriculture.

Jensen's 2007 study expands the concept of irrigation efficiency. The paper goes beyond the mere efficiency of water use, discussing the role of water in agricultural production and its impacts on ecosystems and the water cycle. This work underscores the significance of developing irrigation methods and technologies, presenting strategies for the more effective utilization of water resources.

The research conducted by Kurtulmuş, Büyükcangaz, Kuşçu, and Demir in 2018 analyzes the hydraulic and economic performance of pressurized irrigation systems in Türkiye (Kurtulmuş et al. 2018). This study offers crucial insights for enhancing the efficiency of irrigation systems and the more effective use of water resources. The research emphasizes the necessity of optimizing water and energy use in agricultural irrigation, guiding policies and practices in this sector.

The "CROPWAT" computer program for irrigation planning and management, developed by Martin Smith in 1992, was very useful from the aspect of the Food and Agricultural Organizationof the United Nations (FAO). This program equips decision-makers and researchers in agricultural irrigation with essential tools for the more efficient use of water resources. CROPWAT is recognized as a significant resource for calculating water needs and developing irrigation strategies.

A study by Yacoubi, Slatni, and Playán in 2012 evaluates the performance of sprinkler irrigation systems in Tunisia's Medjerda Lower Valley. This research offers important findings through field assessments of irrigation systems, contributing to enhancing irrigation method efficiencies (Yacoubi et al., 2012).

Lastly, the study titled "Sustainable Water Use in Agriculture: A Review of Worldwide Research" by Velasco Muñoz, Aznar-Sánchez, Belmonte, and Román-Sánchez in 2018 examines global research on sustainable water use in agricultural irrigation. This work provides a comprehensive literature review on the sustainable management of water resources and the development of agricultural irrigation techniques (Velasco Muñoz et al. 2018).

This literature review lays out various aspects of water and energy use in agricultural irrigation and the extensive spectrum of current research in the field. Studies by the World Bank (2022) and other researchers underscore the critical role of water in agricultural production and the importance of its sustainable usage. Research by Jensen (2007), Kurtulmuş et al. (2018), and others present key strategies for enhancing the efficiency of irrigation systems and the effective use of water resources. These studies illustrate that water and energy management pose significant management and policy challenges in the development and operation of agricultural irrigation systems.

In this context, the current study aims to significantly contribute to the literature by conducting a comparative analysis of agricultural irrigation infrastructure systems based on their energy and water consumption. It seeks to address the existing gap in the literature by providing a detailed analysis of inefficient methods still commonly used in agricultural irrigation infrastructure systems, despite technological advancements. The study will distinctly outline the economic value added and the long-term positive returns of government investments in these systems, focusing solely on water and energy consumption. Thus, it will highlight that agricultural investments not only offer positive value to farmers but also contribute positively to environmental and global sustainability.

In conclusion, this study will provide the necessary scientific foundation to develop strategic solutions for making agricultural irrigation systems more efficient and sustainable in terms of energy and water use. It will contribute to the decision-making processes of policymakers and practitioners in this field, underscoring the importance of integrating advanced irrigation technologies and sustainable practices. The findings will facilitate informed decision-making that balances agricultural productivity with environmental conservation, thereby shaping the future of sustainable agriculture on a regional and global scale.

3. Datasets and Methods

The primary method of this study aims to calculate the water loss and energy consumption associated with agricultural irrigation using four key water sources: Open Canal Network (OCN), Pipe Distribution Network (PDN), Underground Water (UW), and Collecting Pool (CP). The study was conducted using Adanalıoğlu Neighborhood as a case study.

Initially, two main factors contribute to water losses: evaporation and water discharged into the sea. Evaporation occurs only in OCN and CP, while water discharge is solely a feature of CP. The Penman-Monteith equation (Jensen et al., 1990) was utilized to calculate evaporation. This equation is expressed as $E = (0.408\Delta(Rn - G) + \gamma(900 / (T + 273))u2(eSat - e)) / (\Delta + \gamma(1 + 0.34u2))$, where E represents the amount of evaporated water (mm/day), Δ is the temperature-based psychrometric constant (kPa/°C), Rn denotes the net radiation balance (MJ/m²/day), G symbolizes the soil surface heat flux (MJ/m²/day), γ is the psychrometric constant (kPa/°C), T signifies air temperature (°C), u2 represents wind speed (m/s), eSat is the saturated vapor pressure related to air temperature (kPa), and e is the actual vapor pressure over the air (kPa). Accurate calculation requires daily data; therefore, for this study, average values from the last five years, from April to October, were utilized based on data archived by the Meteorological Directorate. These averages are accepted as shown in the table below.

Table 1. 2019-2023 April-October Averages of Climatic Values (Firat, 2024; data from Turkish State Meteorological Service and General Directorate of State Hydraulic Works (DSİ, 2020))

Penman-Monteith Equation Variables	**Temperature**	**Humidity**	**Wind Speed**	**Sun Radiation**	**Atmosphere Pressure**
2019-2023 April-October Averages	24.4	78%	2.24m/s	20MJ/m2/day	Ortalama olarak 101.3 kPa

The methodology for estimating daily evaporation is complex, especially given the variability of factors across a large area like Çukurova, requiring numerous inputs to yield accurate results. Consequently, this study used average daily solar radiation, average daytime air temperature, and average wind speed data from the last ten years provided by the Meteorological Directorate. This approach minimized calculations for the summer months. Additionally, for OCN, considering the flowing water, variables like wind direction, changes in water temperature along the route, and water flow rate were disregarded, assuming still water conditions. This allows for estimating how many mm of water is lost daily in a specified area of OCN or CP.

According to Monteith and Unsworth (2007), calculations based on over ten years of average values can accommodate climate change or global warming within an acceptable margin of error.

The quantity of water discharged into the sea was specified in a report by the Mersin Provincial Directorate of Environment, Urbanization, and Climate Change. The canal network used by the Adanalıoğlu region, affiliated with the Mersin Water Union, includes the main canals of Mersin Ov. Pom. Irrigation and Mersin Garden Irrigation. The amount of water supplied from the dam is 52 hm^3, while the amount discharged into the sea is 4.4 hm^3, thus providing direct access to this data (Environmental, Urbanization, and Climate Change Directorate, 2022).

To calculate energy losses, a comparison of the energy consumption data of the water pumps used is necessary. OCN and CP use surface water pumps, UW uses submersible pumps (submersible motors), and PDN uses central large-scale water pumps. Comparing these in the current context is not feasible

due to their functional differences and scale variations. For this purpose, Adanalıoğlu neighborhood was divided into 224 grid sections, each representing a farm or agricultural land of 100 dekare. Areas that didn't form a complete grid, such as the periphery and central areas of the neighborhood, were assumed to be covered by roads and town centers. Consequently, water pumps suitable for each 100-decare unit grid were selected. Consultations with agricultural engineers at three agricultural supply stores in the region determined that while 5-10 hp surface pumps were sufficient for areas between 70-150 dekare, 8-12 hp pumps were adequate for underground water. Therefore, the most commonly sold pumps in the market were chosen for measuring energy expenditure: a 10 hp Impo SK 412/32 underground water pump and a 7.5 hp Sumak SMT1000/3 model surface water pump.

The requirements for the Pipe Distribution Network's pumping system vary significantly depending on the geographic conditions of the region and the use of the water source. Therefore, we will use data from the previously conducted State Water Works' Atabey Plains Irrigation Renewal Project (2020). The primary water source in Çukurova, similar to Atabey, includes dam and collection waters, as well as water from Eğirdir Lake. The similarity in the regions' flat terrain and the intensive water requirements for the cultivated crops make it feasible to use Atabey's data for an average calculation. This project calculated irrigation for an area of 15,734 hectares with three different pump stations and numerous pumps that activate as needed. Therefore, we aim to estimate an average electricity consumption value for Adanalıoğlu (2240 ha) by proportionally comparing it to the Atabey Plains irrigation area.

The final phase of the methodology involves calculating the consumption values for a specific time range, particularly focusing on periods of high water usage. For this purpose, average air temperatures, the water supply, and cutoff dates from the Mersin Water Union were used as a basis. This allowed for the examination of consumption data from a typical irrigation period, starting from April 1st and ending on October 15th.

In the concluding phase of the study, all data will be tabulated to present water and energy consumption figures and the overall situation. The advantages and disadvantages of these methods will be discussed, providing a comprehensive overview of the study's findings.

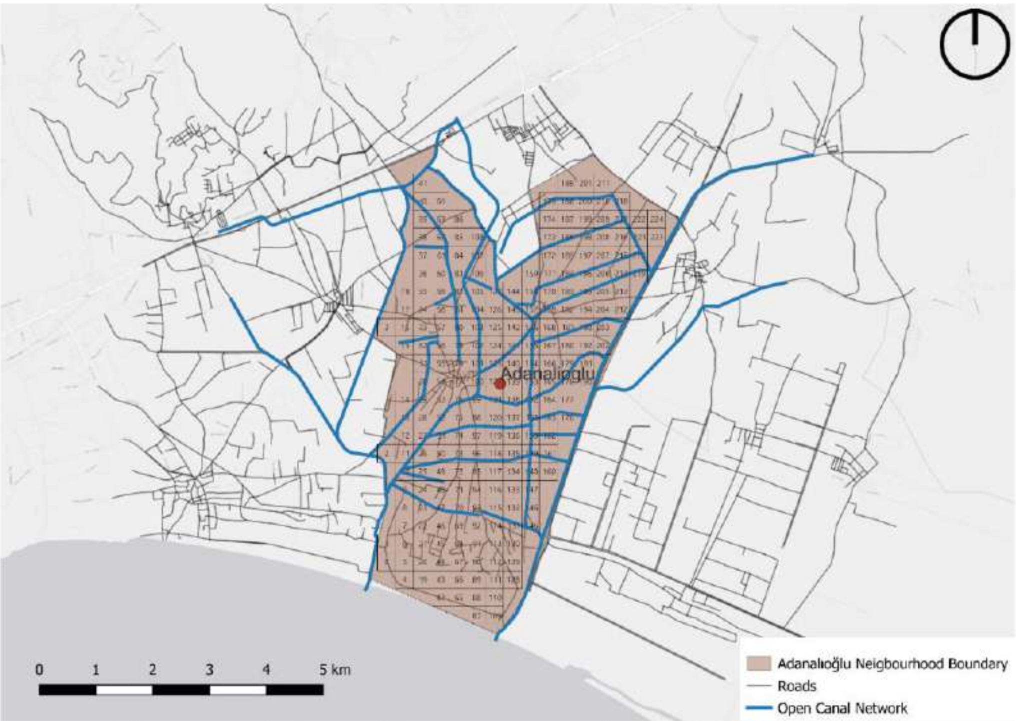

Figure 3. Existing Canal Network & 100 Da Grid Method for Adanalıoğlu Neighbourhood (Firat, 2024; map created using QGIS.org, Version 3.2)

4. Results

The results of the study have been calculated and tabulated, as shown below. Clear conclusions have been reached, effectively fulfilling the primary objective of the study.

Initially, when examining the average data on energy consumption, it is observed that the Pipe Distribution Network (PDN) generally leads to lower energy consumption. Other systems, being designed for individual use, consume more energy in total compared to the centralized water pumps used in PDN. Notably, the consumption data for the Sivas-Yıldızeli project is higher, primarily due to its smaller scale than the other two projects and the topographical differences that necessitate higher energy consumption. However, it is evident from the projects within the scope of this study that the larger the area served by PDN investments, the more significant the reduction in losses can be.

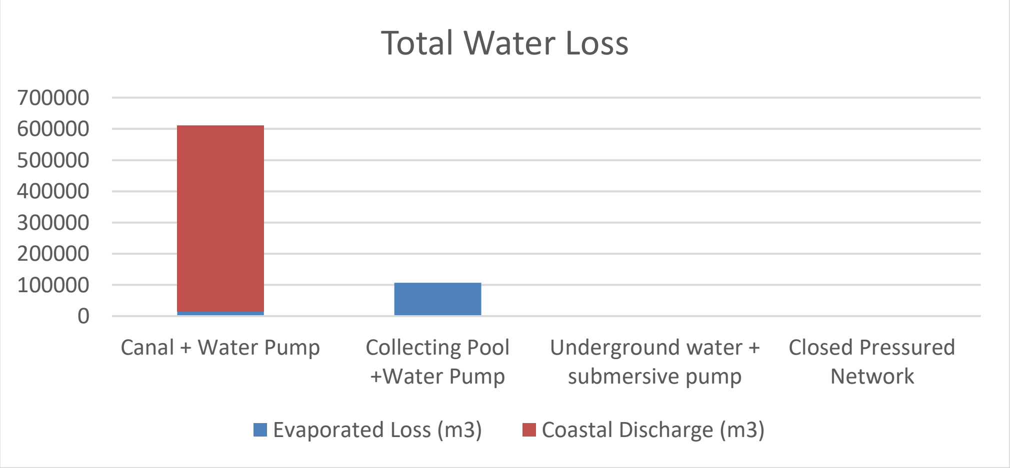

Figure 4. Total Water Loss Chart

These findings underscore the efficiency of PDN in managing energy consumption compared to other irrigation systems, highlighting its potential for sustainable agricultural practices. The study's data provide valuable insights into optimizing irrigation systems, balancing energy use, and identifying areas for improvement in agricultural water management.

Table 2. Table of Energy Consumption Calculation (Firat, 2024; data from General Directorate of State Hydraulic Works (DSİ, 2020) and Turkish Statistical Institute (TUIK, 2020))

Energy Consumption	Pump Energy Consumption in an hour(KW/HOUR)	Area of Existing(ha)	Case Area (ha)	Energy Consumption / Area Ratio	Working Hour	Total Energy Consumption (KW/HOUR)
Atabey Irrigation System (CPN)	10000	16000	2240	1400.0	1080	1512000.0
Konya-Ereğli İvriz Irrigayion System (CNP)	22410	39995	2240	1255.1	1080	1355526.2
Sivas Yıldızeli Ilıca Irrigation System (CNP)	64	72.3	2240	1982.8	1080	2141477.2
Open Canal Network + Water Pump	7.5	10	2240	1680.0	1080	1814400.0
Collecting Pool +Water Pump	7.5	10	2240	1680.0	1080	1814400.0
Underground water + submersive pump	15	10	2240	3360.0	1080	3628800.0

The losses in surface water are more apparent and clearly defined. Within the scope of the study, it was anticipated that pools with a size of 500m2 and a depth of 3 meters per 10 hectares of land would be sufficient in the Adanalıoğlu region, even during the hottest months. Consequently, an estimated 107,010 tons of water is lost to the atmosphere through evaporation. This amount is significant, considering that the relative humidity in the air is around 76%, a relatively high value. According to TUIK's (2020) data on personal water consumption, an average person consumes 228 liters of water per day, meaning this evaporation amount is nearly equivalent to the annual water consumption of approximately 270 households. The losses in the Collecting Pool (CP), due to its smaller surface area, can be considered more acceptable.

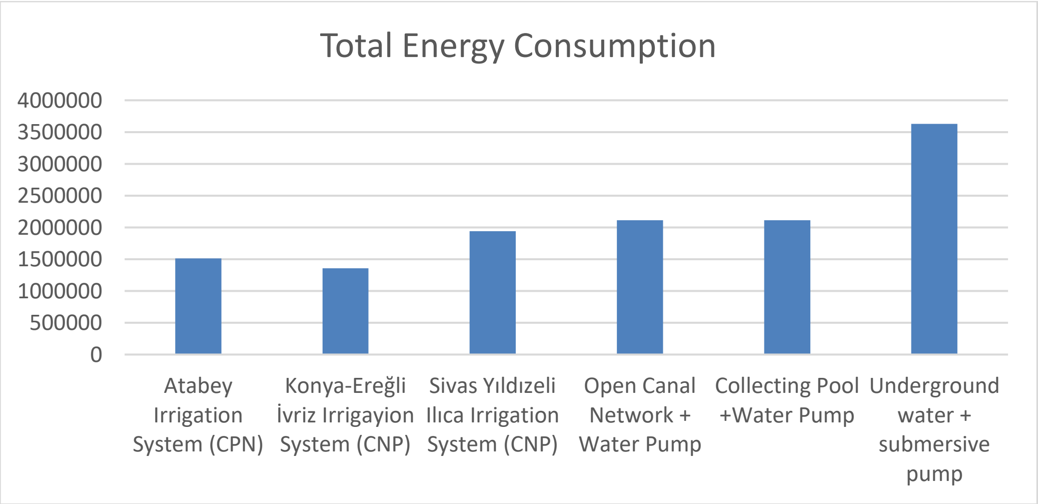

Figure 5. Total Energy Consumption Chart

These findings highlight the substantial impact of evaporation on water resources, especially in regions with large exposed water surfaces. This aspect of the study emphasizes the need for effective water management strategies in agricultural settings to mitigate such significant losses. Understanding and addressing surface water evaporation is crucial for sustaining water availability and ensuring efficient use of water resources in agricultural practices.

Table 3. Table of Water Loss (Firat, 2024; data from General Directorate of State Hydraulic Works (DSİ, 2020) and Turkish Statistical Institute (TUIK, 2020))

İrrigation System	**Time Duration (1st April- 15 October)**	**Area of water surface(m2)**	**Average disintegration (Eto, day/mm)**	**Evaporated Water Loss (m3)**
Canal + Water Pump	197	16128	4.85	15409
Collecting Pool +Water Pump	197	112000	4.85	107010
Underground water + submersive pump	0	0	0	0
Closed Pressured Network	0	0	0	0

Generally, the values for water and energy consumption can be calculated as averages, and no significant deviations appear to be present when these are considered proportionally. This study, conducted with more refined data, offers the opportunity for a detailed analysis at a micro-scale. This comprehensive approach to evaluating water and energy consumption underlines the precision and reliability of the study's methodology. It highlights the potential for in-depth analysis in agricultural water and energy management, emphasizing the importance of detailed data collection and analysis for informed decision-making and policy development in sustainable agricultural practices.

5. Limits of Study

The study necessitated a considerable amount of data. However, accessing all the necessary data through official channels and computing them for a large-scale study proved to be impractical. Therefore, specific standards under defined headings were established for the study.

The selection of Adanalıoğlu as a field study site was due to the Primary agricultural area in the region, including average consumption values, agricultural products, canal networks, and irrigation systems. This knowledge facilitated the formation of the initial data set for the study. However, regional standards were introduced due to the existing number of water pumps, land parceling, and the use of various irrigation systems. This led to the calculation of the number of water pumps sufficient for 10 hectares of land, as the region predominantly engages in citrus and greenhouse farming. Consequently, Adanalıoğlu was divided into 224 equal plots of 100 decares each, making the study feasible.

Calculating the evaporation coefficient using the Penman-Monteith equation required a multitude of climatic and instantaneous data. Performing this calculation daily and factoring in the duration of sunlight would result in values significantly differing based on the climatic conditions of each year. Therefore, the average data from the last four years, based on the irrigation canal opening and closing dates of April 1st and October 15th by the Mersin Water Union, were utilized. Calculating the most extreme scenarios in these four years indicated that water usage could have been 25% less or 18% more, leading to an average deviation of around 20%.

The quantity of water discharged into the sea was only documented in the Water Union's 2022 report, leaving uncertainty about other years' data. The summer of 2022 in the Tarsus Plain was a year of water scarcity, which opened the discussion about the ratios of water discharged into the sea.

In comparing these systems, the irrigation methods employed by individual farm owners were not considered. For instance, conventional (flood), drip, and sprinkler irrigation methods were excluded, focusing only on the main water source and losses of water and energy until reaching the agricultural fields. Thus, the study primarily catered to research on large-scale irrigation investments.

Lastly, the positive and negative impacts of these systems on both the environment and agriculture could be assessed beyond the context of water and energy. For instance, large collecting pools like CP could increase regional humidity levels, potentially leading to micro-habitat changes, a topic warranting separate research. Due to these and other possible variables, the study confined its comparison to water and energy consumption.

6. Discussion

This study has the potential to be enhanced with a series of additional research, positioning it to become a report proposing regional agricultural development. Among the four systems examined within the scope of the study, the Pipe Distribution Network (PDN) has emerged as the most optimal in terms of water and energy consumption. However, a comprehensive discussion with multiple variables is necessary in the existing literature to fully understand the implications. Therefore, the study’s scope, evaluation methods, gaps in the literature, and contributions need to be debated to identify the particular niche this research fills and potential future research topics.

Firstly, the advantages and disadvantages of the Open Canal Network (OCN) and Pipe Distribution Network (PDN) in the Adanalıoğlu region are discussed. The existing irrigation infrastructure in Adanalıoğlu is OCN, while PDN is projected for the larger Çukurova region in the long term. OCN offers several advantages over other systems, such as shorter construction times due to prefabricated production and high material quality. It is also easier to maintain and repair and is almost unaffected by surface flows. Its impermeability allows for disassembly and reuse elsewhere. Water levels are easily controlled using portable siphons, and expropriation costs are low. Additionally, sediment accumulation is minimal, and weed growth is less likely. However, OCN has some disadvantages, such as being economically inefficient for deep drainage needs or small irrigation areas. Overflow due to elevation errors and the breakdown or collapse of a single canal can disrupt irrigation. Water accumulation at canal feet can occur, and construction costs may increase in steep terrains.

On the other hand, PDN also holds advantages over other irrigation systems. There is no land loss or expropriation expense, no weed growth inside the canal, and minimal water loss. Except for additional areas, water loss is significantly low, and the lifespan of the pipes is long. When well-designed, PDN is more durable than other systems. The construction of boundaries in open canals is unnecessary, and it does not hinder mechanized farming. In piped irrigation networks, water control is easier, and water transmission is faster. However, PDN has disadvantages, such as high initial investment costs, unsuitability for areas with poor water quality, and high maintenance costs. Debris in valve exits and chimneys can cause operational problems. Moreover, it is not economically viable for small irrigation areas, and leaks might be undetectable, leading to losses.

Moreover, Collecting Pools (CP) can be filled from wells, canals, PDN, or even by collecting rainwater. Despite high evaporation rates, using CP for collecting natural water sources and providing rested water for agricultural irrigation is a beneficial alternative for both plants and nature. However, in regions like Adanalıoğlu, where land values per square meter are high and the terrain is flat, using pumps for irrigation can be a costly solution for local farmers. Additionally, assuming all farmers in regions like Adanalıoğlu use CP, this could significantly alter the area's humidity levels, creating a potential microclimate, thus requiring further research into its pros and cons.

If access to the map data prepared by the State Hydraulic Works (DSİ) for the region had been possible, the study could have been transformed into a more precise GIS-based research. Especially the region's current irrigation methods, feasibility, and the water needs of the crops produced could have been more accurately estimated for the most suitable irrigation infrastructure investment in the region.

In conclusion, it is possible to state the most suitable system among all those examined within the scope of the study based solely on water and energy efficiency. Otherwise, other environmental factors would be overlooked. Specifically for Adanalıoğlu, factors such as its flat terrain and proximity to the sea offer the opportunity to cultivate a diverse range of crops influenced by the area's near-tropical humidity levels. For instance, crops typically grown in cooler regions, like soy and wheat, and tropical crops like avocado and mango, can be cultivated in the same area. Therefore, in the context of Adanalıoğlu, when comparing irrigation systems, water and energy consumption emerge as critical parameters that need to be considered for long-term planning. This insight highlights the need for tailored irrigation strategies that consider both the unique environmental conditions and the diverse agricultural needs of the region.

7. Conclusion

This comprehensive analysis in the Adanalıoğlu district of Çukurova contributes significantly to understanding energy and water consumption patterns in agricultural irrigation. The findings emphasize the complexity of sustainable irrigation practices and their critical role in maintaining agricultural productivity in the face of changing environmental and climatic challenges.

A comparative assessment of four main irrigation systems, namely Open Channel Network (OCN), Collection Pool (CP), Groundwater (UW), and Pressurized Drip Network (PDN), provides detailed insights into their efficiencies and impacts. The study initially highlights PDN as the most energy and water-efficient system in the long term, attributed to advanced engineering design minimizing water loss and optimizing energy usage. In contrast, traditional systems like OCN and CP exhibit higher water and energy losses due to factors like evaporation and inefficient water distribution mechanisms.

Implementing advanced irrigation systems like PDN to modernize agricultural practices in Çukurova aligns with sustainable agriculture goals, emphasizing prudent natural resource usage and minimal environmental impact. However, transitioning to such systems requires significant investments in local conditions, including soil types, crop requirements, climate patterns, infrastructure, and farmer education.

The research also underscores the influential role of government policies and subsidies in promoting the adoption of efficient irrigation practices. The findings demonstrate that well-structured incentives and support mechanisms can significantly influence farmer decisions, directing them towards more sustainable practices. This is crucial in the context of global climate change, where resource-efficient and environmentally friendly agricultural practices are not just a necessity but a requirement for long-term agricultural sustainability.

Furthermore, our study highlights the potential of technological integration in irrigation practices, such as the effective use of GIS tools for resource management and decision-making. Proficiently utilizing these tools can lead to more precise and data-driven approaches to agricultural irrigation, further enhancing efficiency and sustainability.

In conclusion, this study provides valuable insights into various aspects of irrigation systems in Çukurova and establishes a robust framework for evaluating and optimizing water and energy consumption in agricultural practices. The research not only benefits Çukurova but also lays the groundwork for future research and policy-making aimed at achieving sustainable and efficient agricultural production in similar agricultural regions worldwide. Integrating technology with strategic policy interventions and continuous innovations will be critical in addressing the challenges posed by climate change and ensuring the long-term viability of the agricultural sector.

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Landscape Architects: Superheroes of the 21st Century

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Abstract

21st century faces critical problems such as climate change, environmental degradation, and social injustice. Geographical information systems (GIS) have emerged as powerful tools to deal with this global crisis. Landscape architects and their perspectives have taken their places in the front line during the development of GIS. There are parallels between the role of superheroes as cultural symbols in addressing the challenges faced by our planet and the conceptualization of landscape architects as real-world superheroes. These parallels extend to their use of GIS technology as a powerful tool to tackle pressing global issues. This paper explores some common GIS implementations in the fields of urban planning, disaster management, climate action, and sustainability. It explains how landscape architects can become the superheroes of modern society. Besides, transforming the potential of landscape architects to create a sustainable and equitable future with the support of GIS is put forward. To sum up, this paper explains how landscape architects act as the superheroes of the 21st century, providing decision-makers with tools to mitigate global crises and promote societal well-being

Keywords: Geographical information systems, green infrastructure, nature-based solutions, urban planning, sustainability.

1. Introduction

Superheroes have been the reflections of societal needs and fears throughout history. The concept of superhero emerged during the Big Depression (1929-1940) period in the USA, when economic and social problems were dominant. The creation of Superman in the late 1930s became a symbol of hope for people struggling with unemployment and despair. Superheroes like Captain America symbolized patriotism and resilience against tyranny during World War II. The following years gave rise to superheroes like Iron Man, which were based on technological innovations and advancements rather than superpowers. This change emphasizes the increasing dependency on technology to address social challenges. Shortly, superheroes have evolved to respond to a diversity of societal problems, ranging from fictional enemies to global conflicts and technological transformations.

If superheroes are commodified, the GIS technologies can be seen as having evolved, just like the scientific innovations that turned Iron Man into a superhero. GIS has become an inevitable tool for addressing the needs of modern societies. GIS was initially developed for military and cartographic missions and then expanded to various areas such as urban planning, disaster management, public health, and environmental protection applications. Just like the superheroes adapted to new enemies, landscape architects continuously improve to struggle against global problems. Within this context, landscape architects empowered with GIS capabilities can be regarded as new superheroes fighting against climate change, disasters, inequity, drought, environmental problems, etc. GIS technologies provide tools that enable the integration and analyses of spatial and non-spatial data for performing sustainable planning, environmental protection, and equitable resource distribution.

2. The Superhero Roles of Landscape Architects

2.1. Climate action

Climate change is one of the most significant problems addressed by the landscape architecture profession. Landscape architects develop green infrastructure and carbon reduction strategies to minimize the impacts of climate change (Paudel, 2021; Wu, 2019). Netusil et al. (2022) underline the role of projects such as green roof solutions in minimizing energy consumption and lowering the urban heat island effect.

Climate change poses vital threats, including rises in sea levels, extreme weather events, and loss of biodiversity. GIS-aided landscape planning is indispensable for developing climate change mitigation and adaptation strategies. For example, GIS use enables site selection and impact analysis for implementations such as green infrastructure projects, green roofs, and rain gardens. These solutions can both improve stormwater management in urban areas and reduce the urban heat island effect (Sharma et al., 2018; Cristiano et al., 2023). Landscape architects can mitigate biodiversity loss and support ecosystem services through rain gardens, green corridors, and ecological restoration projects (Zhang et al., 2019). These implementations present both environmental and societal benefits in climate change action.

Moreover, landscape architects use GIS to monitor and visualize climate-related data such as deforestation rates, carbon emissions, and temperature anomalies. These data and outputs enable policymakers to develop targeted interventions and monitor progress toward climate goals, including the United Nations Sustainable Development Goals (SDGs).

2.2. Disaster management and resilience

In the process of building resilient cities, the role of landscape architects is diverse. Godschalk (2003) explains that resilient cities require the establishment of a sustainable network between the physical systems and societies. Landscape architects help increase environmental and social resilience through green infrastructure implementations (Desouza & Flanery, 2013).

In the disaster management process, landscape architects can provide support during pre and post-disaster periods. Turer Baskaya (2015) discusses how disaster-sensitive landscape planning can minimize the risks, using the İstanbul case. Green roofs, permeable surfaces, and water reservoirs can significantly reduce the impacts of natural disasters such as floods and erosion (Cristiano et al., 2023; Twohig et al., 2022).

Natural and man-made disasters have destructive impacts on societies. As ecological approaches are in harmony with the planet and its systems, the ecological perspectives of landscape architecture play an important role in the basic stages of disaster management, such as preparedness, recovery, and mitigation. These approaches help determine the high-risk areas through hazard mapping and vulnerability analysis in the pre-disaster planning phase. For example, GIS-supported analysis can support the development of resilient urban infrastructure solutions such as permeable pavements and retention basins.

2.3. Urban planning, sustainability, and nature bases solutions

Sustainability is one of the core values of landscape architecture. Beck (2009) emphasizes the contributions of green areas to public health and life quality. Green infrastructure implementations are critical for stormwater management, reduction of carbon emissions, and increasing biodiversity (Filazzola et al., 2019).

Landscape architects also make significant contributions to energy efficiency efforts. Gancorova (2014) highlights the role of energy-efficient design in protecting natural resources.

In this context, landscape architects develop strategies for suitable placement of renewable energy infrastructure.

Nature-based solutions (NBS) are innovative solutions that are used to provide sustainability and resilience in urban and rural areas. Frantzeskaki (2019) emphasizes the significance of NBS in urban planning and climate change mitigation, while Filazzola et al. (2019) address the contributions of green infrastructure to urban biodiversity.

Rapid urbanization results in challenges such as resource scarcity, environmental degradation, and societal inequalities. GIS-supported landscape architecture works integrate ecological, social, and economic data into decision-making processes and thus enable sustainable urban planning. For example, these works facilitate the development of green corridors that increase biodiversity, improve air quality, and provide recreational areas.

Energy efficiency is a critical aspect of sustainable urban design. Landscape architecture implementations provide optimal site selection for solar farms and wind turbines and thus help reduce the ecological footprint (Aksoy et al., 2023; Çetin et al., 2022; Çetin et al., 2021). These efforts are in harmony with more comprehensive targets related to building resilient and inclusive urban environments.

In short, landscape architecture has gained growing importance in the 21st century, particularly with its mission and contributions to sustainable cities, resilience, and environmental justice. The major components of the profession's foundation include NBS, green infrastructure design, ecosystem service protection, and social inclusion (Frantzeskaki, 2019). In addition, landscape architecture contributes to societal justice and equality. Behzadfar et al. (2010) examined the impacts of cooperation between landscape architects and urban designers on environmental design. Green areas providing equitable access strengthen social bonds and encourage equity among the communities (Beck, 2009). Design processes welcoming local community participation increase the admittance of the projects and improve social harmony (Mahajan et al., 2022). These approaches provide a higher quality of life and social justice.

Lastly, landscape architects contribute to public awareness and policy-making processes to tackle the climate change crisis. This is supported by urban designs and environmental protection measurements (Ramesh, 2016).

3. Conclusions

The parallels between the superheroes and landscape architects empowered with GIS capabilities are not just metaphoric, but they also emphasize the transformative potential of innovative tools to address global challenges. These initiatives not only encourage individuals and institutions to combat climate change, manage disasters, promote social equity, and build sustainable futures but are also directly implemented by landscape architects themselves. In this context, if the landscape architecture point of view is adopted as the superhero of the 21st century, societies can be more encouraged to make use of these approaches and tools to build a more resilient and equitable world. Just like the superheroes inspire and encourage people, landscape architects present concrete solutions for today's urgent problems. The problems turning landscape architects into the superheroes of the 21st century include;

- pre and post-disaster efforts, including preparedness, recovery, and mitigation phases,
- sustainable design strategies and green infrastructure solutions that reduce the risks while increasing social resilience,
- management of planning and design processes to protect the ecosystems and meet society's needs, particularly during the reconstruction phase after the disasters,

- contributing to ecosystem protection, energy efficiency, water management, and increasing social welfare,
- efficient use of natural resources and increasing the quality of life through green area design solutions,
- increasing the resilience of the cities against environmental and social shocks through NBS, innovative design strategies, and public participation.

Green infrastructure implementations enable adaptation to climate change impacts while building public spaces that enhance social solidarity. NBS also presents sustainable solutions for environmental, social, and economic challenges since they make the very use of ecosystem processes. Landscape architects provide solutions to problems such as climate crisis, biodiversity loss, and rapid urbanization through rain gardens, green roofs, and ecosystem corridors. Landscape architects play a crucial role in mitigating the impacts of climate change through green infrastructure projects and adaptation strategies. They develop sustainable and environmentally friendly designs while supporting climate action through educational activities that raise public awareness.

To sum up, landscape architects make significant contributions to social justice and equality thanks to their mission to design accessible and secure public areas. With an inclusive design approach, they design projects to increase the quality of life, especially for disadvantaged regions. From all these aspects, landscape architects facilitate the achievement of the SDGs by enhancing the sustainability, equity, and liveability of urban and rural areas. The solutions include the protection of natural resources, ensuring equitable access, and implementation of green infrastructure. Landscape architects support the social, economic, and environmental objectives of SDGs.

Note

AI tools were utilized in the English editing of this text.

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AFAD Open-Air Earthquake Awareness Museum & 6 February Memorial

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Abstract

Disasters result from the intersection of natural hazards and human vulnerability, with impacts varying based on the scale of the event and community resilience. Effective disaster management requires comprehensive approaches encompassing mitigation, preparedness, response, and recovery. Museums and memorials can play critical roles in these efforts, with museums raising awareness and providing education during the preparation phase and memorials fostering healing and remembrance during recovery. This study outlines the vision project commissioned by AFAD as a pilot for the earthquake museums planned after the devastating 2023 Türkiye earthquakes. The project aims to foster a "dialogue with earthquakes" in Türkiye, where seismic activity is a recurrent threat, by promoting scientific understanding, awareness, and volunteerism. Additionally, the project includes a proposed earthquake monument to commemorate lives lost and honor contributors to rescue efforts. The project development involved a literature review of global earthquake museums and memorials, alongside consultations with AFAD to determine site requirements, exhibit elements, and program needs. The study resulted in a conceptual landscape design, including a master plan, museum programming, planting plans, and visualizations. This project highlights the integration of education, commemoration, and recovery as essential components of disaster management.

Keywords: Disaster management, memorial design, therapeutic landscape, design project

1. Introduction

"Disaster" is a natural hazard combined with human vulnerability (Cannon, 1994) The extent of the impacts depends on the scale of the disaster and the community's resilience, leading to loss of life, injuries, and damage to infrastructure, housing, cultural heritage, productive landscapes, and biodiversity. Effective disaster management must involve steps for mitigation, preparedness, response, and recovery (IFRC, 2024). Museums and memorials play a crucial role in the preparation and recovery stages of disaster management.

Memorials, as anthropogenic places designed in landscapes or urban contexts always with an associative character, serve for remembering and mediation and at the same time for forgetting and oblivion of negative emotions. They bring a new identity and new integrity to places and enable conciliation and healing of people and society (Bojana et al., 2017). On the other hand, museums educate the public through exhibitions, interactive displays, and educational activities, fostering awareness of specific subjects. In this context, museums can play a role in the preparation phase of disaster management by providing educational opportunities and raising public awareness, while memorials can play a role in the recovery phase through commemoration, remembrance, meditation, and healing.

This vision project is conceived as a pilot study for the earthquake museums that Disaster and Emergency Management Authority (Afet ve Acil Durum Yönetimi Başkanlığı, AFAD) plans to establish in many cities following the 2023 Türkiye earthquakes, and it has been requested by the institution from our design team. The aim of this project is to invite the Turkish society, where most cities are located on active fault lines and have been affected by devastating earthquakes throughout history, to engage in a "dialogue with earthquakes" based on scientific knowledge, to understand the nature of earthquakes, raise awareness, and contribute to the preparation phase of disaster management by encouraging volunteer work. Additionally, the proposed earthquake monument in the project area aims to commemorate the people we lost in the earthquakes centered in Kahramanmaraş on February 6 and Hatay on February 20, and to honor the civil society that contributed to the search and rescue efforts. In this paper, the stages and outcomes of the project will be explained.

2. Material and Method

AFAD is a public institution operating under the Interior Ministry of the Republic of Türkiye. It is responsible for disaster and emergency preparedness, response, and post-event recovery efforts, as well as for ensuring coordination among relevant organizations. The study area is situated within the headquarters campus of AFAD in Ankara, the capital city of Türkiye (Figure 1). Covering approximately 13 hectares, the campus includes a designated southern section where the development of an open-air earthquake awareness museum and an earthquake monument is planned.

Figure 1. Project area (Adapted from a Google satellite image)

In this context, a literature review was conducted to examine various examples of earthquake museums and memorials. Consultations with AFAD representatives provided insights regarding the site, objects to be exhibited, estimated budget, and program requirements. Based on these findings, a conceptual approach was formulated, and a landscape design was developed at the vision project level. The study resulted in outcomes including a 1:200 scale master plan, a museum program, planting plans, and various conceptual visuals.

3. Findings and Discussion

The main approach of the project is “Dialogue with Earthquake.” The goal is to design a museum space within an environment that ensures climatic comfort, provides shade against the sun, is controlled against wind and reflections, and includes an impressive plant design with color, texture, and scent characteristics. This space is intended to be informative, promotional, thought-provoking, and awareness-raising, while also encouraging responsibility and voluntary work.

The design focuses on two main themes. The first is to commemorate those who lost their lives in the two earthquakes that occurred on February 6, 2023, with a 9-hour interval, centered in the districts of Pazarcık and Elbistan in Kahramanmaraş, with magnitudes of 7.8 Mw and 7.5 Mw, respectively. It also aims to honor those who participated in search-and-rescue operations. In this context, design details have been considered that will not create negative effects on visitors, taking into account the potential trauma that may occur after the earthquake.

The second key concept/theme is to design an open-air museum that can raise awareness about earthquakes. In this regard, the focus is on the expected features of an open-air museum: exhibition, education, experiential learning, and living history. The museum is planned to be flexible enough to offer engaging experiences for visitors during both summer and winter months, with activities organized in open or closed spaces at different times.

The primary target audience for the project consists of preschool and elementary school children, as well as high school and university students. These students will increase their awareness of earthquakes by learning about the scientific aspects of earthquakes. The secondary target audience includes local community members and civil society organizations that will use the museum for events or educational programs aimed at preparing communities for earthquakes. Furthermore, the museum is planned to serve as an “open-air educational space” for people of all ages and professions, as well as local and foreign tourists visiting the city.

The open-air museum is functionally divided into the following areas:

1. An entrance and reception area that includes the exhibition object (the rail), Memorial Square, Information Center, and cafeteria;
2. The main axis, called the Seismic Wave Path, which includes the educational containers, earthquake simulator, and the exhibition object (crushed vehicle);
3. The event area, which features the Indoor Event Area and Outdoor Classroom, specifically designed for activities aimed at children and youth;
4. The Snowdrop Path, bordered by exhibition objects (rescue vehicles and sample living containers) and a snowdrop plant bed representing those who lost their lives in the earthquake;
5. A pathway surrounded by medicinal and aromatic plants, following the slope of the land.

Circulation between these areas will be provided with a “bordered route” arrangement, with entry and exit from the same point (Figure 2). Museum entry will be controlled through a single entrance. A reservation system is recommended for museum visitors, especially for groups.

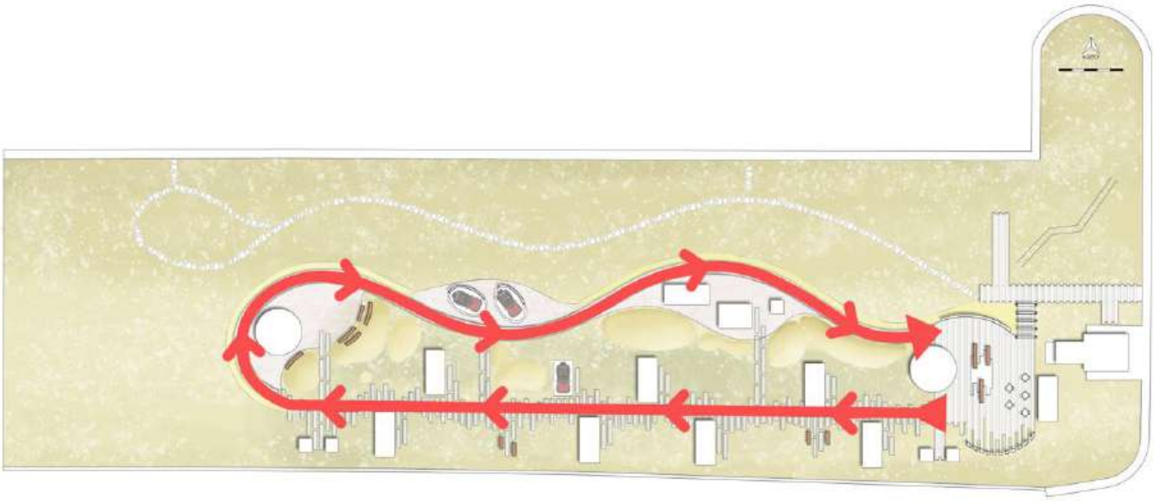

Figure 2. Circulation plan

A defined and prominent reception area/Memorial Square has been designed (Figure 3). This reception area is defined as a symbolic memorial space at the entrance to the museum area, and the square is surrounded by the Seismic Wave Wall and Monumental Columns. In the square, there is a memorial wall featuring the seismic waves of the February 6th earthquake. Opposite this wall, concrete columns are positioned, each representing a province affected by the earthquake.

Figure 3. Memorial Square

Corroded steel (corten steel) plates fixed to the front face of the concrete columns are proposed as Monumental Columns (Figure 4). Symbols, names, etc., can be laser-cut onto these plates. In this context, the names of the people we lost in the earthquake, for example, could be inscribed on the columns representing the provinces.

Figure 4. The proposed monumental columns

With controlled entry to the museum, visitors are directed towards the main axis. The shaping of this axis has been guided by seismic waves (Figure 5). The exhibition objects and containers are arranged in a specific sequence. Each object and container has been assigned a number, and the space allocated for each, along with seating areas, has been designed. The containers along the Seismic Wave Path are positioned in sequence under the themes of "The Nature of Earthquakes," "The Effects of Earthquakes," and "Living with Earthquakes." In this way, visitors to the site will spend time in a sequential layout, experiencing awareness on topics such as understanding and recognizing earthquakes, taking scientific measures against earthquakes (including urban planning, building design, and issues like volunteering and individual responsibility).

Figure 5. the Seismic wave path (main axis)

The interior design of the containers is flexible, with two types of scenarios developed (Figure 6). Design suggestions can be developed depending on the institution's resources, the variety of educational materials, and the presentation techniques.

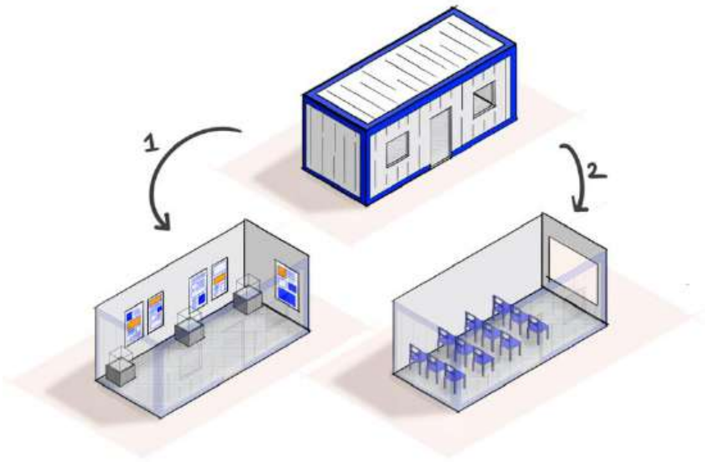

Figure 6. Container usage scenarios

On the western boundary of the project area, there is a globe-shaped enclosed event area (Figure 7). In this space, alongside the training provided in the containers, activities and games are planned to raise awareness about earthquakes. An open-air classroom is proposed to be integrated with the event area. This space is designed to be used for various activities aimed at small visitor groups and can be adapted to meet different needs. The area is semi-circular in shape, enclosed by several steps, and can be used for purposes such as an open-air classroom, exhibition space, ceremony/memorial space, etc.

Figure 7. Event area and open-air classroom

In selecting plants, groups that stand out for their color effects, scent, boundary-defining properties, shade creation, and ability to form ambiance have been considered. Additionally, the species chosen for the area were selected based on their seasonal color effects (evaluating characteristics such as leaf color, flowers, scent, and fruit at different times during winter, spring, summer, and autumn), with the goal of maintaining the color impact of the area throughout the year (Figure 8). The use of grass species that require excessive water and maintenance has been avoided in the project area, and instead, species that require relatively less maintenance, are ground-covering, and stand out for their color and scent effects, while supporting urban biodiversity, have been chosen. These species include *Rosmarinus officinalis* (rosemary), *Salvia sp.* (sage), *Thymus sp.* (thyme), and *Santolina chamaecyparissus* (lavender cotton). The composition of these species has been used in the area between the Seismic Wave Path and Snowdrop Path, as well as in the plant mounds created within this area.

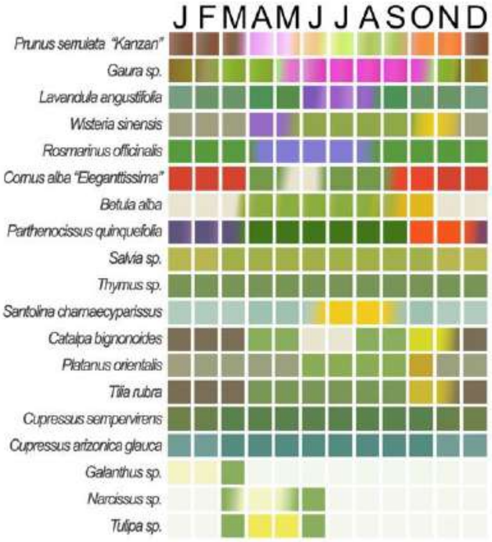

Figure 8. Seasonal Color Effects by plant

Water usage in landscape design is an important component of the design. However, considering the climatic conditions of the project area and the approach towards water conservation in the face of climate change, the direct use of water elements has been avoided in the design. On the other hand, due to the difficulty of maintenance and the low sustainability of water elements, they have not been used directly but symbolically. For this purpose, an area symbolizing water flow with gravel stones has been created, where early spring plants emerging from the soil, such as *Galanthus sp.* (snowdrop), *Narcissus sp.* (daffodil), and *Tulipa sp.* (tulip), have been chosen. The *Galanthus sp.* (snowdrop) plant, which emerges from the soil at the end of January and beginning of February with its white flowers, is dedicated to those who lost their lives in the 6th February earthquake. In this context, snowdrop plants have been used unilaterally between gravel stones along the informal walking path in the project area. As the effect of *Galanthus sp.* diminishes, *Narcissus sp.* and *Tulipa sp.* will emerge from the soil. Along the Snowdrop Path, two aid vehicles used in rescue operations at different times and donated by foreign countries are also exhibited (Figure 9). Additionally, examples of container houses established in earthquake-affected areas are available for visitors to experience along this axis (Figure 10).

Figure 9. Exhibited rescue vehicles

Figure 10. The Snowdrop Path

4. Conclusion

If disasters are regarded as unavoidable or destined, planning and management strategies will be inadequate. Effective disaster management must encompass steps for mitigation, preparation, response, and recovery. In this context, museums and memorials play a vital role in the preparation and recovery stages of disaster management (Uslu et al., 2024).

This project was commissioned by AFAD as a pilot study. A comprehensive review of earthquake museums and memorials was conducted, complemented by consultations with AFAD representatives to gather insights on the site, exhibit objects, budget, and program requirements. This informed the development of a conceptual approach and a vision-level landscape design.

Aim of the project was to create a thought-provoking and educational space that not only raises awareness about earthquakes but also honors the lives lost in the devastating February 6, 2023, earthquakes. Key outputs included a master plan (Figure 11), museum programming, planting plans, and conceptual visuals.

Figure 11. Master plan and sections

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ACTING FOR ALL

Differential Analysis of World Cultural Heritage on Urban Housing Price Space: Taking West Lake Cultural Landscape of Hangzhou as an Example

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Abstract

World Cultural heritage sites have a significant impact on housing prices(HP), but this effect is spatially heterogeneous. Using the West Lake in Hangzhou as an example, we analyzed information related to 7,781 second-hand houses for sale within Gongshu District, Xihu District, and Shangcheng District of Hangzhou in 2022 to explore the spatial differentiation and influencing factors of HP in the study area. We also analyzed the scope and intensity of the West Lake's influence on HP. The study's results indicate that:(1) There are variations in the impact different types of characteristics have on HP, with the most significant factors being distance to Westlake and age of house, with house prices decreasing by 0.684% and 0.429%, respectively, for every 1% increase in the corresponding elements; (2) West Lake has a significant external impact on HP within a maximum range of 5391m, with an impact threshold of 8629m. (3) Within the West Lake Maximum Impact Area, the affected house space is primarily distributed on the south side at West Lake, with a significant gradient decreasing spatial characteristics.

Keywords: World cultural heritage, housing price, spatial difference, urban development

1. Introduction

In comparison to other urban landscape determinants, the influence of World Cultural Heritage on the housing price (HP) displays a multifaceted and stratified pattern. As pivotal regions for urban development and construction, World Cultural Heritage sites are enveloped by an array of comprehensive basic service facilities and commercial amenities, which considerably elevate the regional value and subsequently propel the escalation of HP within the vicinity. A substantial corpus of research has definitively demonstrated that natural landscape elements, encompassing green spaces, wetlands, and coral reefs, exert a pronounced influence on the HP, with this effect extending to a radius spanning several kilometers. The average HP tends to exhibit a declining trend as the distance from heritage-value elements increases (Jing et al, 2018, Waltham & Sheaves et al.,2015), underlining spatial heterogeneity in this relationship (Markus et al,2016). Moreover, a suppressive effect may emerge beyond a critical threshold distance, further underscoring the nuanced interplay between natural landscapes and HP dynamics (Yi & Rui et al., 2010, Devaus et al.,2018).

Existing research has convincingly demonstrated the profound influence of World Heritage sites on the spatial distribution patterns of housing prices. A compelling illustration of this phenomenon can be found in the historic Old Town of Regensburg, Germany, where its dual heritage designation and distinctive geographical characteristics conspicuously contribute to a discernible spatial segmentation of HP. Turning to Hangzhou,China, the Grand Canal emerges as a prominent factor shaping HP, exhibiting a heterogeneous effect that varies systematically with both distance and region (Wen et al., 2012). Moreover, the West Lake introduces a directional bias in its influence on HP, further emphasizing its unparalleled significance in this context (Shen et al., 2016). From an accessibility perspective, the West Lake, when considered as a distinctive landscape element akin to green spaces, wetlands, and other water bodies, emerges as a pivotal determinant in shaping the prices of house. The distance separating a residence from the influential factors exhibits an inverse proportionality with its average price, with a definitive threshold distance at which a detrimental impact on pricing becomes conspicuous (Yu et al., 2022, Chaeyeon et al., 2019). Beyond this threshold, the detrimental effect becomes increasingly apparent. This phenomenon underscores the nuanced interplay between location, heritage status, and property valuation.

In conclusion, contemporary research endeavors primarily focus on quantifying the profound influence of World Cultural Heritage sites on HP, delving into the magnitude of this effect and its implications for pricing dynamics. Nevertheless, amidst the relentless progression of urban development and the continuous enhancement of related service facilities, coupled with the escalating sophistication of service functionalities, the extent to which other characteristic variables, beyond the solitary factor of proximity, influence HP is progressively intensifying. Consequently, there arises a pressing need to delve into the nuanced spatial differentiation of the influence imparted by World Cultural Heritage sites on HP, as well as to scrutinize the synergistic impacts stemming from the interplay of related characteristic variables.

2. Material and Method

2.1 Analysis of factors influencing housing prices

The Hedonic Model employs a rigorous multiple linear regression equation framework to quantify the magnitude and direction of the influence exerted by diverse characteristic factors on HP. By adopting HP as the dependent variable, the model progressively incorporates three pivotal characteristics, leading to the formulation of three distinct hedonic price regression models. These models serve as analytical tools to delve into the underlying factors that shape HP. The Hedonic Model's analytical scope encompasses three modeling paradigms: linear, semi-logarithmic, and logarithmic, each offering a nuanced perspective on the relationships between characteristic factors and HP. The model is formulated as follows:

$$\text{Linear：} P=\alpha_0+\sum_{i=1}^{n}\alpha_i\,\beta_i+\varepsilon \tag{1.1}$$

$$\text{Semi}-\text{Logarithmic：} lnP=\alpha_0+\sum_{\mathrm{i}=1}^{\mathrm{n}}\alpha_i\,\beta_i+\varepsilon \tag{1.2}$$

$$\text{Logarithmic：} lnP=\alpha_0+\sum_{\mathrm{i}=1}^{\mathrm{n}}\alpha_i\,ln\beta_i+\varepsilon \tag{1.3}$$

Where P denotes the HP, α_0 represents the constant term, α_i signifies the coefficient of the characteristic variable, β_i is the characteristic variable, and ε is the error term. A total of 13 independent variable factors, encompassing three major characteristics, are selected and introduced into the Hedonic Price Model.

2.2 Analysis of spatial differentiation patterns

To elucidate the threshold of influence exerted by West Lake on HP within the study area, we define the threshold as the juncture point between the regression model and the average HP value. This point signifies the distance from West Lake below which the HP begins to be influenced by the lake's proximity. To analyze the varying relationship between HP and its distance from West Lake, we employ a quadratic function model. The model is formulated as follows:

$$\theta = \alpha_0 + \alpha_1 l + \alpha_2 l^2 + \varepsilon \tag{3}$$

Where θ represents the logarithmic form of HP, l represents the logarithmic form of the distance from HP within the study area to West Lake, α_0 is the constant term, α_1 and α_2 are the regression coefficients, and ε is the error term. This model can be used to explore the range of distance thresholds within the study area where HP are influenced by the cultural landscape of West Lake.

2.3 The maximum influence distance of West Lake on housing prices

The First Turning Point (FTP) methodology is utilized to delineate the outermost extent at which the West Lake exerts a discernible influence on HP. Curve fitting analysis reveals that a cubic polynomial function aptly captures the intricacies of this relationship. Consequently, the cubic polynomial function $T(l)$ is formulated as follows to represent the phenomenon under investigation. The model is formulated as follows:

$$T(l) = al^3 + bl^2 + cl + d \tag{4}$$

Where l represents the distance between the urban neighborhood and West Lake, and $T(l)$ represents the price of the neighborhood at a distance l from West Lake. The first derivative of the function $T(l)$ ($T'(l)$) reaches a maximum influence distance at a certain point where it equals zero. This point is considered as the first turning point, representing the maximum value that influences the change in HP. Once the distance exceeds this point, the HP in the neighborhood will begin to show a downward trend. Therefore, when($T'(l)$)=0 or $(T'(l))_{min}$ reaches its minimum, it represents the maximum distance at which West Lake influences HP.

2.4 The maximum influence distance of West Lake on housing prices

The First Turning Point (FTP) methodology is utilized to delineate the outermost extent at which the West Lake exerts a discernible influence on HP (Jian et al,2022). Curve fitting analysis reveals that a cubic polynomial function aptly captures the intricacies of this relationship. Consequently, the cubic polynomial function $T(l)$ is formulated as follows to represent the phenomenon under investigation. The model is formulated as follows:

$$T(l) = al^3 + bl^2 + cl + d \qquad （4）$$

Where l represents the distance between the urban neighborhood and West Lake, and $T(l)$ represents the price of the neighborhood at a distance l from West Lake. The first derivative of the function $T(l)$ ($T'(l)$) reaches a maximum influence distance at a certain point where it equals zero. This point is considered as the first turning point, representing the maximum value that influences the change in HP. Once the distance exceeds this point, the HP in the neighborhood will begin to show a downward trend (Xiong et al,2021;Ke et al,2018). Therefore, when($T'(l)$)=0 or $(T'(l))_{min}$ reaches its minimum, it represents the maximum distance at which West Lake influences HP.

3. Findings and Discussion

3.1 Hedonic model analysis

Three regression models were systematically constructed, progressively incorporating a comprehensive suite of 13 diverse variables. As evident from Table 1, all three models successfully navigated through significance tests, with VIF for each variable remaining below 5, thereby mitigating concerns related to multicollinearity. Notably, Model 2 emerged with a significantly higher adjusted R^2 compared to Model 1 and Model 3, highlighting its superior goodness-of-fit and predictive prowess.

Table 1. Estimation results of Hedonic model

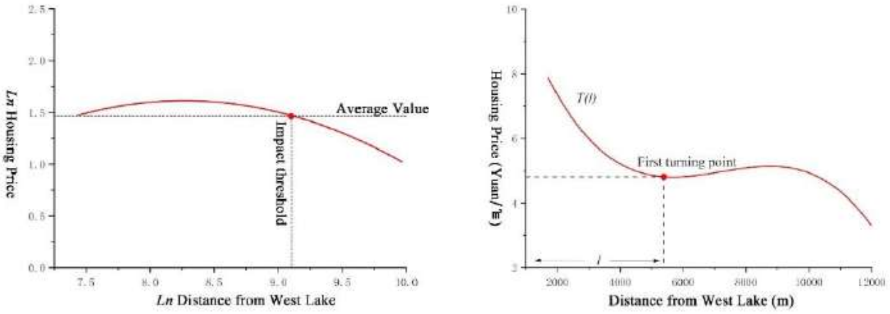
	Model1			**Model 2**			**Model 3**		
	coeff	**Sig**	**VIF**	**coeff**	**Sig**	**VIF**	**coeff**	**Sig**	**VIF**
Age	-0.441^{***}	0.000	1.966	-0.429^{***}	0.000	1.966	-0.446^{***}	0.000	1.778
Plot	-0.004	0.663	1.098	-0.014	0.142	1.098	-0.016	0.102	1.139
Green	0.172	0.172	1.044	0.026^{**}	0.006	1.044	0.054^{***}	0.000	1.080
Orient	0.013^{*}	0.010	1.003	-0.023^{*}	0.012	1.003	-0.028^{**}	0.002	1.005
Flour	0.099^{***}	0.000	1.008	0.112^{***}	0.000	1.008	0.103^{***}	0.000	1.009
Num metro	0.036^{***}	0.000	1.082	0.033^{**}	0.001	1.082	0.027^{**}	0.005	1.069
Num school	0.151^{***}	0.000	3.133	0.161^{***}	0.000	3.133	0.106^{***}	0.000	2.162
Dis hospital	0.129^{***}	0.000	1.369	0.115^{***}	0.000	1.369	0.152^{***}	0.000	2.162
Num life	-0.133^{***}	0.000	3.239	-0.165^{***}	0.000	3.239	-0.116^{***}	0.000	3.201
Num sport	0.067^{***}	0.000	1.825	0.067^{***}	0.000	1.825	0.044^{***}	0.001	2.261
Dis shop	-0.021^{*}	0.031	1.087	-0.035^{***}	0.000	1.087	-0.081^{***}	0.000	1.089
Dis Downtown	-0.002	0.913	2.481	0.024	1.655	2.481	0.000	0.991	2.324
Dis Westlake	-0.609^{***}	0.000	3.252	-0.684^{***}	0.000	3.252	-0.678^{***}	0.000	3.686
Constant	6.771			1.915			6.122		
F	260.333			312.689			300.459		
R²	0.304			0.344			0.337		
Count	7711								

Note：$P^{***} < 0.001$， $P^{**} < 0.01$, $P^{*} < 0.05$.

Firstly, among the architectural features, the variables of Age, greening ratio, floor level, and Orientation all achieved statistical significance. Notably, Age exhibits a negative correlation with price and has a comparatively substantial impact on the HP. For every 1% increase in the age of the house building results in a 0.429% decrease in price, whereas the other architectural features exhibit positive correlations. This finding highlights the substantial influence of Age on HP within the study area, outweighing the effects of the housing environment and floor level. Secondly, all six variables pertaining to neighborhood characteristics successfully met the significance threshold, indicating their statistical relevance. Among the neighborhood characteristic variables, the density of living facilities and the distance to shopping facilities displayed notable negative correlations with HP, whereas the remaining characteristic variables exhibited positive correlations. Lastly, regarding location characteristics, the distance from the housing area to West Lake exhibited a significantly higher impact coefficient on HP compared to other characteristic variables, emphasizing the prominent influence of West Lake on HP within the study area.

3.2 Analysis of the impact of West lake on housing prices

Employing a quadratic function model to analyze the differentiation pattern between the distance of a housing area from West Lake and HP, Figure 1a reveals a threshold distance of 8629 meters, beyond which West Lake's influence on HP diminishes. Specifically, when the distance from house to West Lake is less than this threshold, the impact is pronounced; however, upon exceeding this threshold, the influence weakens. The fitted curve in Figure 1b depicts the relationship between HP and the distance from West Lake, with the FTP identified at a distance of 5391 meters from West Lake. This curve illustrates a trend wherein as the distance from West Lake gradually increases, HP experiences an initial rapid decline, followed by a slow rise, and ultimately another decline. This observation aligns with existing research (Yong et al,2023), confirming that HP in Hangzhou varies according to the proximity to West Lake. As the distance from West Lake varies unevenly in an outward radial pattern, the spatial sensitivity of HP to this distance initially declines sharply, then increases slowly, and finally declines once more.



a) West Lake to housing price promotion threshold

b) Maximum impact distance for West Lake

Figure 1. Analysis of the impact of West lake on housing price

3.2 Assessing the magnitude of West Lake's ınfluence on housing prices

Among the selected variables, the location characteristic variables have a significant impact on the HP. The West Lake serves as the landscape center of Hangzhou, while the Qianjiang New City is the administrative center. The HP gradually decreases with the increasing distance from the West Lake and Downtown (Geng et al., 2015). According to Table 1, the regression coefficients of continuous variables correspond to the prices of housing characteristics. The regression coefficient of the distance to the West Lake on HP is -0.684, indicating that for every 1% increase in the distance to the West Lake, the corresponding price of HP will decrease by 0.684%. Overall, the distance to the West Lake has the greatest influence on HP, with its significance and scope being notably greater than that of Downtown in Figure 2, indicating that the West Lake plays a dominant role in shaping the spatial distribution of HP among the location characteristics.

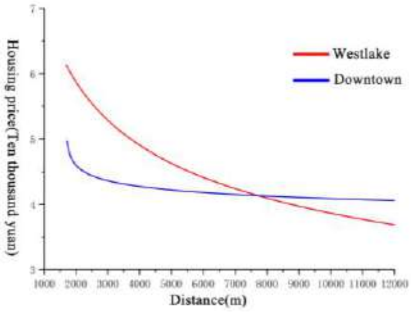


Figure 2. Price versus distance curve

4. Conclusion

Significant spatial heterogeneity characterizes the variation in HP, with individual housing characteristic variables exerting diverse impacts across distinct locations. Notably, the "distance to the West Lake" emerges as a pivotal location-specific factor, exerting a marked influence on HP. Specifically, a concentric pattern emerges, with HP gradually declining as the distance from the West Lake increases. This spatial differentiation is evident in the premium pricing of HP in central regions, contrasting with lower prices in peripheral areas. Furthermore, there is a pronounced spatial clustering and correlation within urban hubs like Hubin, Beishan, and Wulin, highlighting the centrality of these areas. The West Lake, as Hangzhou's landscape epicenter, has historically served as a cornerstone in urban planning, thereby exerting a paramount influence on HP. This is underscored by the general willingness of residents to incur higher housing costs for superior living environments. Proximity to landscapes, particularly the scarce resource of the West Lake, significantly elevates land values. Consequently, the distance from this iconic landmark exacerbates its impact on land prices, underscoring the premium associated with its vicinity.

Among the trio of characteristics influencing the differentiation of HP, the proximity to the West Lake stands out as a prominent factor. The influence of the West Lake on HP is significant, with a threshold distance of 8629m and a maximum effective distance of 5391m. A 1% increase in distance from the lake corresponds to a 0.684% decrease in HP, with the influence extending to distant streets like Dongxin, Xiaohe, Xiangfu, and Wenxin. Additionally, a discernible north-south disparity exists, with the northern side being a focal point for urban growth and development, where HP are more conspicuously and radially impacted by the West Lake. The intensity of this influence underscores the heightened demand for landscapes in economically vibrant urban regions, leading to a heightened marginal value for lake vistas. Moreover, the study area is replete with diverse commercial and service amenities, contributing to varying intensities of the West Lake's effect on HP, thereby inducing spatial heterogeneity. From a HP appreciation perspective, residents are inclined to pay a premium for West Lake access only in residential areas that offer comprehensive infrastructure, efficient transportation networks, and a high quality of life.

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The One-Meter Socialization for Children in Parks

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Abstract

With the development of society, children's demand for natural activities and outdoor socializing in parks is becoming increasingly prominent, especially in the context of building child friendly cities. The renewal planning of various urban parks is facing new opportunities and challenges. This study used the SOPARC observation method and localized scales for field research and semi-structured interviews to investigate the social activities of children in Shaping Park, Chongqing. Based on the needs of children of different age groups for activities and space, this paper explores how to promote social interaction among children in urban parks and proposes five corresponding strategies, hoping to provide a basis for future child friendly renewal planning.

Keywords: One-meter socialization; child-friendly; urban park renovation; shaping park

1. Introduction

The requirements for public space construction in the new era have further increased, and at the same time, children in the new era are also facing many difficulties: nature-deficit disorder, children's social anxiety... etc (Tang and Woolley, 2023).

There are many studies have shown that outdoor social activities for children can help alleviate their anxiety and depression, and promote their physical and mental health development (Kang et al., 2016; Azlina and Z.A, 2012; Pereira et al., 2024; Miranda et al., 2016). In the context of urban renewal, how to transform various outdoor public spaces into child friendly spaces from the perspective of promoting children's socialization has become a topic of research significance.

Children have a small ‘one meter body’, but their social activities should not be limited by this small physiological scale, but should have a broader space. So this is ‘the one meter socialization’ for children in parks.

Figure 1. Location analysis of Shaping Park

Figure 2. The 11 selected sites

1.1 Research object

Shapingba District is a main district in Chongqing, with abundant educational and cultural resources. Shaping Park is located on the south side of Tianchen Road in Shapingba District, covering an area of approximately 181000 square meters (Figure 1). It is the only large green space and comprehensive park in the high-density urban area of Shapingba. It is backed by Geleshan Mountain north of the train station, surrounded by multiple communities and schools, and has a very advantageous geographical location.

1.2 Aim of study

This study takes Chongqing Shaping Park as an example and selects 11 venues with the most frequent children's activities (Figure 2), focusing on children's social interaction in these 11 venues. Starting from six aspects: space, water, plants, terrain, amusement facilities, and service facilities, explore how various spatial elements or specific features and their combination relationships affect children's social interactions, especially those that are beneficial. Based on the research results, corresponding spatial update strategies have been proposed, providing a universal approach for subsequent public space updates in the context of urban renewal.

2. Material and Method

This study is based on the principle of not interfering with the spontaneous social behavior of children in the venue. Non intrusive SOPARC system observation method (Wang et al., 2024) and field research method were used. The localized SOPARC scale was used to collect social data of children in different 11 sites, and EXCEL was used for data analysis. The obtained data was visualized to summarize the current situation of children's social development in various types of spaces in Shaping Park, and provide a basis for proposing five updated strategies to improve children's social development in the future.

2.1 Localized SOPARC scale

Localize the SOPARC scale and split it into two tables, namely the Children's Social Behavior Record Table (Table 1) and the Venue Feature Record Table (Table 2). Use these two tables to record the 11 selected sites.

Based on existing literatüre (Yang et al.,2023; Xu, 2010) and in conjunction with site characteristics, the Children's Social Behavior Record includes information of including Children's gender, age range, Methods of conducting social activities, Social activity participants, Social relationship, Types of social activities, Nature of social activities, Whether a guardian is present, and the duration.

Table 1. The Children's Social Behavior Record

Date:________________time: ______________place:_____________registrar: _______________

Children's gender	**1-Male, 2-female**
Children's age range	A- 3 to 6 years old, B- 7 to 12 years old, C- 12 to 14 years old
Methods of conducting social activities	1-individual communication, 2-group communication, 3-team communication
Social activity participants	1-children of the same age, 2-children of different ages, 3-adults
Social relationship	1-Cooperation, 2-competition, 3-free
Types of social activities	1-sidelines activities, 2-verbal communication, 3-body movement
Nature of social activities	1-functional, 2-constructive, 3-dramatic, 4-regularity, 5-exploratory
Whether a guardian is present	1-guardian participation in activities, 2-guardian watching, 3-no guardian
duration	A- within 0.5h, B- 0.5~1h, C- above1h

The second is to record the characteristics of the site, referring to existing relevant literatüre (Lo et al., 1998; Wang et al., 2022; Tang and Woolley, 2023; Kamal and Gabr, 2023; Woolley, 2008) and optimizing and improving it based on this study, starting from six aspects: space, water, plants, terrain, amusement facilities, and service facilities. Establish corresponding secondary and tertiary indicators from the six main indicators, determine the characteristic definitions of each tertiary indicator, and form the final scale.

Table 2. Site Characteristics Record Form

Primary indicators	Secondary indicators	Tertiary indicators	Feature definition
space	accessibility	enter the mouth	1-It has an iconic entrance point
		boundary	1-with an obvious boundary, 0-with no obvious boundary
	Spatial form	Geometry	1-round, 2-square, 3-polygon, 4-irregular
		natural features	1-Good integration with the periphery, 2-general integration with the periphery
	Space public	Space interface	1-open, 2-semi-open and semi-closed, 3-closed
		Group composition	1-only children, 2-children, young or elderly, 3-children, young and elderly
		visual field	1-Open vision without occlusion, 2-a small part of the direction is blocked, 3-most of the direction is blocked
	Space atmosphere	beam	1-strong light, 2-sufficient light, 3-dark light
		hue	1-bright color, 2-neutral color, 3-gray color
		colour	1-Single color, 2-one to three colors, 3-three or more colors
water	type		1-Natural water body, 2-pool, 3-fountain
	form		1 — Rule, 2 — Nature
	position		1-Site center, 2-Site edge
	accessibility	Number of connected roads	1-> 3 connecting roads, 2-1-3 connecting roads, 1 connecting road
		Whether it can go down to the water bank	1-Yes, 2-No

	Can be interactive	Whether it can be touched	1-Yes, 2-No
		Is it sound	1-Yes, 2-No
		Whether it is available for pedestrian crossing	1-Yes, 2-No
plant	position		1-Site center, 2-Site edge
	form		1-point ornament, 2-current arrangement, 3-face dense planting
	Volume height		1-tall, 2-moderate, short
	Interactive attributes	Whether the visual features are apparent	1-Color or flowers and leaves, 2-not obvious
		Whether it is touchable or not	1-easy to touch, 2-can be touched, 3-untouchable, such as barbed
		Does it smell	1-have a smell, 2-have no smell
	Vegetation style	Horizontal enclosure	1-near-full surround, 2-semi-surround, 3-non-surround
		Vertical depression and closure	1-near full cover, 2-half cover, 3-not cover
topography	type	unitary type	1-flat land, 2-platform, 3-slope land
		mixed mode	1-two kinds of compound, 2-three or more kinds of compound
	variability	Elevation change	1-large number of steps or long slopes, 2-small number of steps or slopes, 3-none
		space variation	1-Space for lifting and sinking, 2-space for lifting or sinking, 3-None
	Surface coverage	Natural materials	1-sandy soil, 2-stone, 3-grass moss and other plant materials
		Non-natural materials	1-soft nonnatural materials such as rubber, 2-hard unnatural materials such as concrete
recreation facility	safety	material quality	1-Safe and soft material, 2-safe and hard material, 3-dangerous material
		Maintenance degree	1-New facilities, 2-well-maintained old facilities, 2-maintain general old facilities
	Can be interactive	altitude	A-below 0.5m, B-0.5 to 1 m, C-1 m
		Volume scale	1-large volume, for many children to play, 2-moderate volume, for 3-5 children to play, 3-small volume, for 1-2 children to play
	Thematic	Whether it is attractive or not	1-Famous animation IP, 2-animals, 3-plants, 4-Other children's themes, 5-No obvious themes
	flexibility	Is it removable	1-Mobility, 2-Mobility, 3-Momobility
service facility	seat	quantity	A-greater than 3, B-1-3, C-0
		position	1-Site edge, 2-Site center, 3-spread
	toilet	quantity	A-≥1；B-0
		position	1-Site edge, 2-Site center
	room of mother and infant	quantity	A-≥1；B-0
		position	1-Site edge, 2-Site center

2.2 Field research

The field research was conducted on sunny weekends from 9:00-12:00 in the morning and 14:00-18:00 in the afternoon (Figure 3). During a 7-day on-site survey, the recorder collected 11 site feature tables and 209 data on children's social activities at 11 sites.

Figure 3. On site photos of the 11 sites

3. Findings and Discussion

During a 7-day on-site survey, the recorder collected 11 site feature tables and 209 data on children's social activities at 11 sites (Figure 4). Among them, venue C and D have the largest proportion, accounting for 24.7% and 23.6% respectively, followed by venue A with 22.5%, venue B with 19.1%, and venue E with the smallest proportion, only 10.1%.

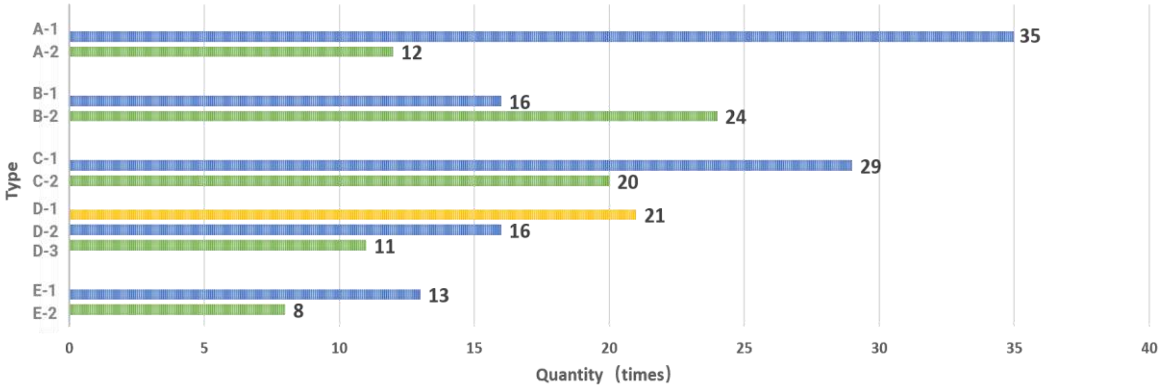

Figure 4. The amount of data collected at each site

The observer recorded the specific characteristics of children's social activities in each venue of same types, and summarized and compared the items with significant differences (Figure 5).

Overall, The openness of space and view, accessibility and interactivity of water, visual characteristics of plants, natural surface covering materials, and maintenance level of facilities are significantly positively correlated with the frequency of children‘s social activities in Shaping Park. In spaces with more natural characteristics, the quality of children's social interactions is also higher, which is similar to the conclusions of existing studies (Woolley and Lowe, 2013).

Based on the final results of the research, the study establishes a child-friendly social system of ‘one meter socialization’, which includes ‘one meter world’, ‘one meter game’, ‘one meter creativity’, ‘one meter game’, and ‘one meter game’, ‘One meter of creativity’, ‘one meter of volunteer’, ‘one meter of integration’ three aspects of the park children's social promotion strategy.

(1）Based on the ‘one-meter world’: implanting a one-meter high enjoyable point, line and surface space in the park renewal to create an activity area exclusively for children, which can include children's mixed-age socialization, nature education, competitive sports, exploratory experience, composite activities and other functional needs, and provide material and spatial support for children's socialization.

(2）Create a ‘one-meter game’: add a children's game corner in the park, provide colorful interactive games, especially projects that require teamwork, and set up some small competitions to encourage cooperation and communication between children, while cultivating their social skills, teamwork and leadership.

(3）Stimulate ‘one-meter creativity’: add inspiring creative facilities, such as DIY workshops, interactive art walls, small musical instruments, children's creative exhibitions, etc., and provide painting, handmade, sculpture and other art materials and tools, so as to stimulate children's creativity and imagination, enhance their ability to express themselves, and promote creative exchanges among children. The program also promotes creative exchanges among children.

(4）Establishment of ‘One Meter Volunteer’: set up a training base for children's volunteers to stimulate children's enthusiasm to participate in social welfare activities, such as voluntary cleaning, accompanying widows and orphans, education on garbage classification, publicizing green travel, and planting trees, etc., to cultivate children's spirit of dedication and sense of teamwork, and to promote exchanges and cooperation among them in volunteer service. Promote the exchange and cooperation of volunteer service among them.

(5）Promote ‘one-meter communion’: create a social atmosphere of tolerance and communion, and promote interaction and communication among children of different ages and backgrounds. Children can learn to respect and understand others, and develop the qualities of friendliness and cooperation by organizing multicultural activities, group games and cooperative projects.

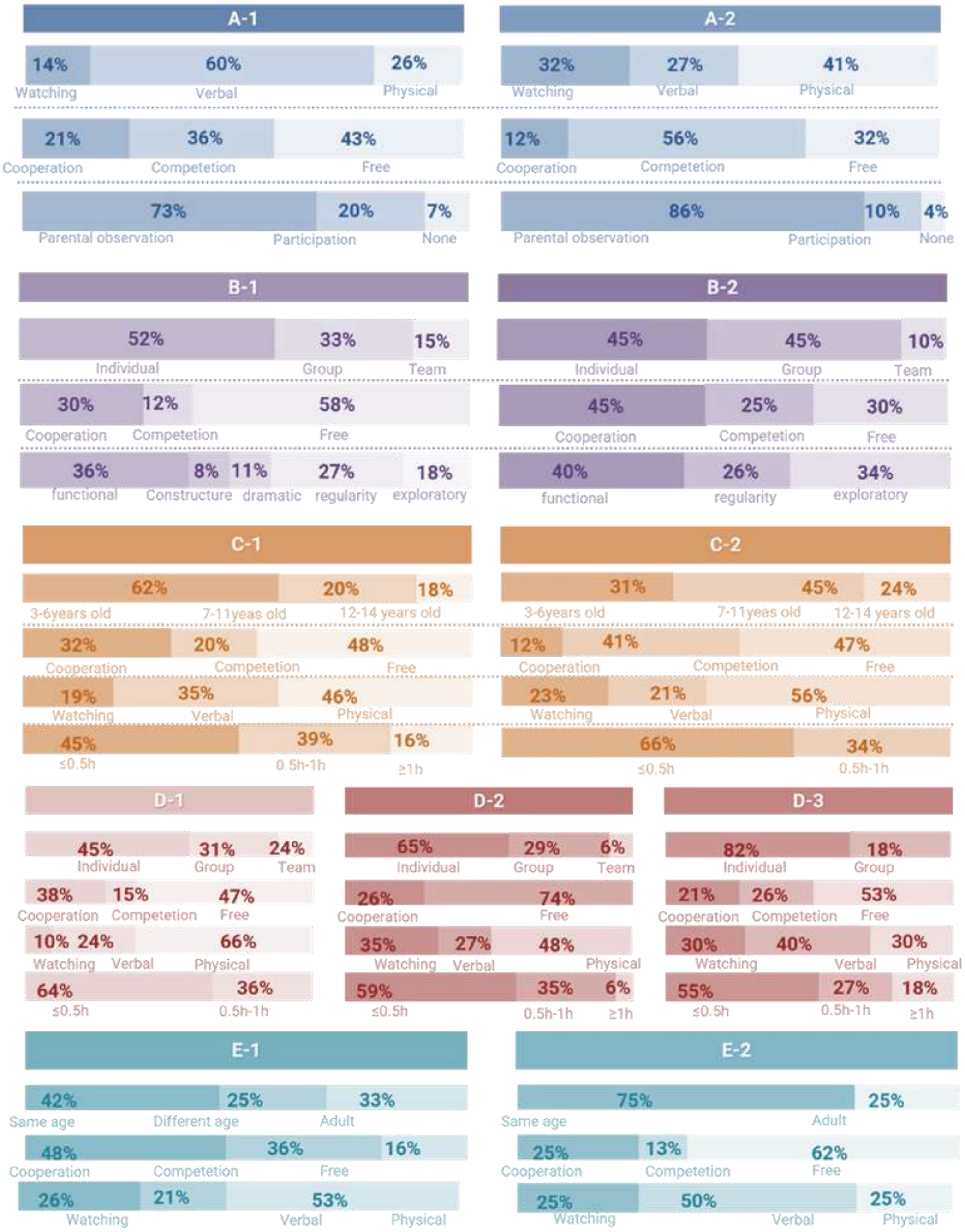

Figure 5. Comparative analysis of children's social activities in similar venues

4. Conclusion

Although the SOPARC observation method for observing children's social activities in Shaping Park and analyzing appropriate spatial characteristics has certain innovation, it is still not perfect and mature enough, such as insufficient universality and sample size based solely on Shaping Park as an example.

This study ultimately identified the spatial characteristics of outdoor spaces that promote children's socialization, and proposed five corresponding measures, hoping to apply them to future child friendly urban renewal such as pocket parks, comprehensive parks, and urban grey space renewal, providing a more solid spatial foundation for children's one meter socialization and indirectly promoting children's socialization development.

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Rethinking Bottom-Up Conservation Practices: Beyond Simplistic Binaries

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Abstract

This paper challenges the traditional binary understanding of "top-down" and "bottom-up" approaches in heritage conservation, arguing that the "bottom" group is not a homogeneous entity but a complex, multi-layered structure. While the "bottom-up" approach is often associated with grassroots movements, this paper explores why these solutions are not always initiated from the bottom and why they are often more complicated than they appear. Through case studies of the Blue House in Macao, post-Katrina recovery in New Orleans, and hydropower development along the Mekong River, this paper highlights the heterogeneity of the "bottom" groups involved in conservation practices, (including heritage and ecological conservation). The analysis shows that external stakeholders, often overlooked, play a crucial role in bridging the gap between "top-down" and "bottom-up" approaches. Moreover, while public consultations are essential, they are not always fair, leading to the marginalization of key voices. Furthermore, this paper argues that development and conservation must find a balance, taking into account the needs of local communities and cultural heritage while fostering economic growth. Through a comprehensive analysis of these issues, the paper calls for more inclusive and sustainable conservation practices that prioritize the voices of vulnerable groups and ensure a balanced approach to development.

Keywords: Bottom-up, top-down, duality, layer-cake structure, heritage, vulnerable groups

1. Introduction

The concept of bottom-up conservation emphasizes public participation in managing cultural heritage by involving local communities and stakeholders in decision-making. It focuses on public engagement, community-driven initiatives, and local knowledge, aiming to foster collaboration among communities, professionals, and policymakers. However, bottom-up approaches depend on top-down management to provide frameworks and align with broader policies. While these methods may seem opposing, they are interdependent and can complement each other to address the complexity of real-world challenges (Rodwell, 2008).

Traditional heritage conservation methods often centralize power among professionals, potentially sidelining other stakeholders (Gibson et al., 2019). Professionals hired by developers may prioritize commercial interests over user needs (King, 2012), highlighting the need for more inclusive approaches. Public consultations frequently overlook the most vulnerable groups, such as the poor and marginalized, excluding them from decision-making (Gibson et al., 2019; Van et al., 2012). Gibson et al. suggest involving vulnerable populations in heritage recovery through participatory methods, enabling them to influence outcomes (Gibson et al., 2019). However, such efforts still require top-down support to ensure effective implementation.

Vulnerable groups face unique barriers in heritage conservation. Recognizing and addressing their needs is essential for equitable and inclusive heritage management.

This paper will challenge the binary understanding of "top" and "bottom," arguing that the so-called "bottom" is a heterogeneous layer-cake structure, consisting of multiple layers of complexity. Additionally, this paper explores why a bottom-up solution may not necessarily begin at the bottom and is a complex process that cannot be simplified or flattened.

2. Heterogeneity of the bottom Group: From Duality to Layer-Cake Structure

When it comes to understanding the concepts of "top-down" and "bottom-up," one often falls into a dichotomy. People tend to simplify things by associating "top" with the elite, government, and relevant authorities, while connecting "bottom" with non-elite and non-governmental groups such as the public, communities, etc. While this understanding has some validity, it is very superficial because it naturally pits these two sides against each other, ignoring the complex relationships between different stakeholders. In fact, the "bottom group" we are discussing in this paper can be divided into many different stakeholders with complicated and intertwined interests, such as developers, experts, and residents. There may even be non-related stakeholders causing interference. Furthermore, these stakeholders in the "bottom group" can be divided into different layers, with varying social status, power, and perception. In other words, the so-called "bottom group" can be further divided into several concepts of "top" and "bottom," which might be mutually convertible. Thus, the "bottom group" in heritage preservation practices is not a black-and-white opposition to the "top" group, but rather a layer-cake structure.

Therefore, the generalization of "bottom-up" erases the heterogeneity of the "bottom" group. This means that the current "bottom-up" conservation practice may not necessarily start from the true bottom layer.

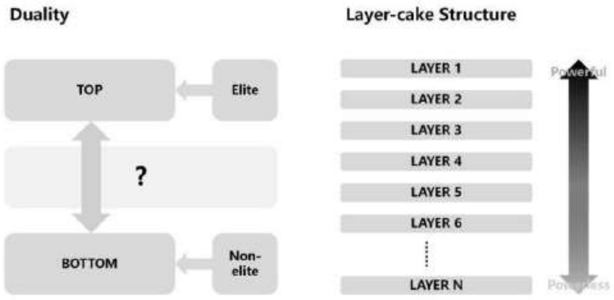

Figure 1. Duality and layer-cake structure

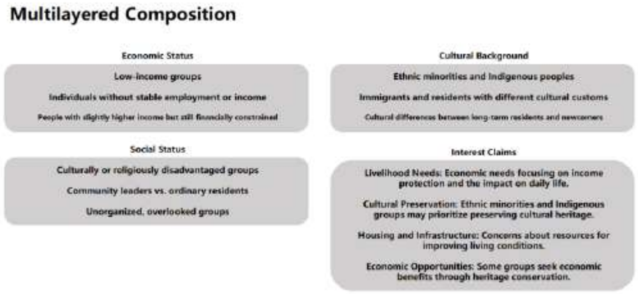

Figure 2. Multilayered composition

3. Who Are the Promoters? Beyond the Top and Bottom: Conservation of Blue House, Macao

Macao, a former Portuguese colony and now a Special Administrative Region of China, is home to a rich cultural heritage that includes both tangible and intangible elements. At that time, the city's heritage management system, however, was criticized for being very top-down, with little input from the public. Because according to local laws, a building can be delisted without going through a rigorous evaluation or consultation process. This is particularly evident in the case of the Blue House, a historic building in the heart of the city.

The Blue House (Lam Uk Chye), a two-story structure dating back to the 1920s, serves as an exemplar of traditional Chinese architecture, showcasing the distinctive fusion of Portuguese and Chinese cultures prevalent in Macau. Despite its historical significance, the heritage management system in Macao did not have a legal obligation to preserve the Blue House. This resulted in the Social Welfare Bureau of Macao's reconstruction plan for the area in 2006, which posed a threat to the existence of the building. The concerned government agency consulted the Cultural Affairs Bureau (CAB) in 2006 about the height of the new building rather than the historical value of the original historic building, the Blue House. However, The CAB believes that the Blue House should be preserved. Unfortunately, because the Blue House is no longer listed as a cultural heritage site, the Cultural Affairs Bureau has no authority to preserve it.

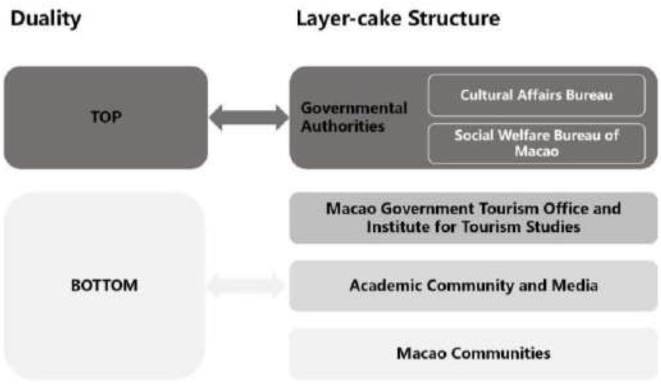

Figure 3. Different layers in Blue House case

Notably, the backing from historians, journalists, and cultural institutions played a pivotal role in mobilizing public support for the preservation of the Blue House. As the incident gained public attention, criticism emerged from the public, fueled by the perceived disrespectful attitude of relevant authorities towards historical heritage. Consequently, media exposure became a conduit for the public's sentiments, resulting in heightened awareness and increased support for the conservation of the Blue House. Social media emerged as a vital force in advocating grassroots conservation practices. While not direct stakeholders in the building's preservation, social media users successfully amplified the voices of those directly involved, generating widespread support for its safeguarding. Ultimately, the conflict underwent a transformation and resolution, achieved through a combination of expert opinions and active public engagement. Additionally, CAB engaged in negotiations through public consultations amid social disputes. The Social Affairs and Culture of the Macao government commissioned extensive research, including large-scale surveys and expert evaluations, confirming the cultural significance of the Blue House in Macau. A public opinion telephone survey revealed widespread support for cultural heritage, despite some respondents being unfamiliar with the Blue House.

It is important to note that the process of saving the Blue House was not a simple case of bottom-up influence. Rather, it was a complex process that involved multiple upward and downward lines of influence. The public's exposure of the reconstruction plan, for instance, prompted the public turned questioning into actions. Meanwhile, this promoted governmental bodies to reconsider their plans and take into account the public's concerns. The Macao Cultural Affairs Bureau, in particular, played a crucial role in mediating between different stakeholders and facilitating a compromise that would allow for the conservation of the Blue House. While the heritage management system may be top-down, the public's voice can still be heard through various media outlets, including social media. Ultimately, the conservation of cultural heritage requires a comprehensive and collaborative approach that involves multiple stakeholders and lines of influence. In this context, the opportunity to drive the development of the situation largely stemmed from the news media, serving as a medium for the brewing events, rather than the public. The initial reports may not necessarily have originated solely from a desire to preserve cultural heritage, nor did they necessarily represent the interests of the highest or lowest echelons. Instead, they simply described the factual news. Nevertheless, such public opinion facilitated progress in conservation practices. In this scenario, as ordinary members of the public, given Macao's predominantly top-down context, they faced challenges in propelling the overall conservation practices forward. However, news media outlets, including broadcasts, acted as a bridge between the "top" and "bottom," providing a platform. Therefore, while this represents a successful bottom-up case of architectural preservation, it didn't actually originate from the grassroots.

Moreover, it is not difficult to observe that if we designate the more powerful and influential institutions as the so-called "top," it can be further subdivided into government agencies such as the Cultural Affairs Bureau and Social Welfare Bureau, each with distinct interests and actions. On the contrary, the least powerful "bottom" group includes the surveyed public, media users, and others. There are also entities within this group that support demolition. However, between the aforementioned "top" and "bottom," which can be subdivided itself, many other groups exist, such as The Institute for Tourism Studies, historians and journalists. This forms a layered structure akin to a layer cake, rather than a simple top-down division.

4. The Voice from the Bottom Unheard: Post-Katrina New Orleans’s Section 106 Process

Hurricane Katrina, which struck New Orleans in August 2005, caused widespread devastation, with floodwaters reaching up to 20 feet in some areas. The storm breached the levee system, flooding neighborhoods and destroying homes and businesses, particularly in impoverished areas. Many residents, unable to evacuate or rebuild, were displaced, and the city’s economy took a severe hit. The disaster highlighted deep inequalities, disproportionately affecting poor and minority communities. Despite these challenges, New Orleans has shown remarkable resilience. Several organizations, particularly the Preservation Resource Center (PRC) of New Orleans, played an active role in the post-disaster recovery efforts. Through its "Operation Comeback" initiative, PRC worked to restore old homes in multiple historic neighborhoods, prevent the deterioration of impoverished areas, and protect the city’s historical identity. (Christoff, 2006).

The calamity caused widespread destruction to the city, affecting numerous historical edifices, among them were various public housing structures that were more than 50 years old and could be listed. As a result, the demolition of B.W. Cooper, C.J. Peete, Lafitte, and St. Bernard which were collectively named "Big Four" in New Orleans. These public housing complexes had to go through the section 106 of the National Historic Preservation Act (NHPA), which concerns about the historical resources. However, these reviews failed to achieve true public consultation. For instance, many residents had left New Orleans after the disaster, but the Housing and Urban Development (HUD) frequently held consultation meetings in not accessible locations for these residents, meaning that many could not participate. As a result, the voices of these absent people were not heard, and the eventual outcome was also disappointing. Despite developers' willingness to repair some of the historic public housing, the effects of this result were minimal from both a community preservation and building preservation standpoint. This is due to the destruction of a significant number of historic buildings and a reduction in the number of low-income housing units, which has resulted in many people becoming homeless.

Undoubtedly, the public consultation process mandated by Section 106 did not offer sufficient opportunities for stakeholders, particularly residents who is the most crucial group in the public housing discourse to safeguard the consequences of the decisions made. Given its strong political will to redevelop from the top down, HUD might not consider alternative options other than demolition as required by the regulation. While an active protection process should help different members of the public, that is, the "bottom" groups like residents, conservation advocates, and developers make proper decisions about the future of a historical resource, the decision-making process is often not a single-line process but a complex process of multiple forces competing with each other. Therefore, the final so-called "bottom-up" consultation or decision-making result is often dominated by stronger forces, deviating from or even violating the actual intentions of the "bottom" groups.

The destruction of historic buildings not only erases the city's rich cultural heritage but also has practical implications for its inhabitants. These buildings often provide affordable housing for low-income residents who cannot afford to live elsewhere. Thus, their demolition can exacerbate the city's housing crisis and lead to displacement and homelessness. It is essential to ensure that the voices of all stakeholders are heard during the public consultation process, especially those of low-income residents who may not have the resources or connections to make their opinions known. Additionally, it is crucial to balance the need for development with the conservation of the city's history and cultural heritage.


Exclusion of displaced residents.

Weak public consultation.

Developers' limited preservation efforts.

Imbalanced "top-down" decision-making.

Marginalized voices ignored.

Need to balance development & heritage.

Figure 4. Key issues in Section 106 process case

5. Who Benefits? Cambodia's Hydropower Dams on the Mekong River

Inscriptions in local languages on the façades of abandoned indigenous houses: We will not leave our homeland. But such appeals and visions are weak.

In response to the long-standing issue of energy shortage that has plagued many countries, Cambodia government has placed hydropower development as a crucial component of their national development agenda. However, the construction of hydropower projects often comes at the expense of local communities, which may be subjected to involuntary resettlement, actual loss of housing and land, loss of cultural identity and heritage, disruption of livelihoods, and destruction of established community networks. The Kamchay dam, a China-funded hydropower project in Cambodia, highlights the impact of hydropower development on local communities. Many residents were forced to leave their original homes due to the sale of their lands for the construction of the new hydropower dams along the Mekong River in Cambodia. Consequently, many locals had to relocate to poorly-constructed resettlement areas and temporarily reside there. While the Kamchay dam project may be promising for Cambodia in the long term, it is evident that the local community has already suffered the threat of their livelihoods and income before it can bring economic benefits.

As depicted in the documentary "Once Upon a River," the impact of the construction of the hydropower project on the local community has been substantial. ET Rina, one of the interviewees, expressed her frustration on camera about the difficulty of economic activities such as fishing in the new resettlement areas. The woman also mentioned that they applied to the relevant departments to stay in a more convenient place for a longer period of time, but it was not easy. The reduction of wetlands, filling up of water bodies, and flooding have adversely affected the low-income residents who rely on farming and fishing. These vulnerable communities have not only faced a decrease in income, but also a lack of access to basic necessities such as electricity for their daily needs. Ironically, the hydropower station that forced these residents to leave their ancestral heritage did not provide any direct positive results for these bottom group. However, some communities have found an alternative solution to their energy needs by turning to solar power. One mother, interviewed in the documentary, mentioned that solar technology has alleviated some of their electricity problems. The problem of unfair development leaves the most vulnerable the least to benefit from the immediate consequences of losing their homes, heritage, and construction. On the contrary, the relatively wealthy residents get greater benefits as a result. For example, additional income was obtained by providing transportation services. From a top-down perspective, both the poor and the ladies belong to the bottom side, but the interests of the most vulnerable bottom group are often sacrificed, and their power is difficult to promote Bottom-up conservation practice.

the development of hydropower construction projects might be essential for meeting the energy demands of a country, but it should not be at the expense of the local communities. Governments and project developers must take into account the potential impact of such projects on the environment and local communities, including their livelihoods, cultural identity, and heritage. It is essential to ensure that the affected communities are consulted and actively participate in decision-making processes. The use of technological means such as solar energy to empower vulnerable communities is positive, but sustainable development still depends on comprehensive and sound policies and development mechanisms. On the one hand, an equitable international organization should be established to jointly manage ecological resources; on the other hand, it is necessary to fully pay attention to the demands of the most vulnerable groups at the bottom, so that the economy can be recycled instead of unsustainably develop the economic, sacrificing their interests.

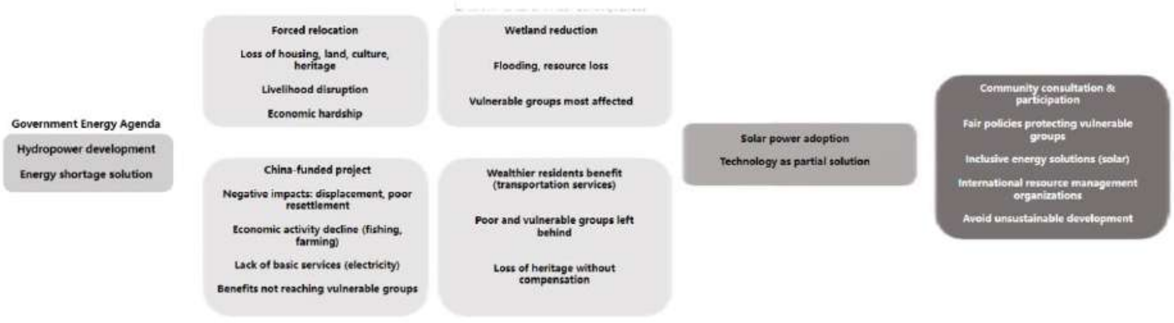

Figure 5. Flow chat of Cambodia's hydropower dams case

6. Conclusion

This paper challenges the binary understanding of "top" and "bottom" by showing that the latter is a complex, multi-layered structure. It explores why bottom-up solutions are not always initiated from the bottom and are complicated. The author analyzes the Blue House case in Macau, New Orleans's and Mekong River to show the heterogeneity of the bottom groups.

Conservation is a vital practice in preserving our cultural heritage for future generations. However, it is not always the bottom-up approach of grassroots movements that drives it forward. Firstly, sometimes, it is the media or other unrelated stakeholders who link the top and bottom of conservation practices. The Blue House case study shows that effectively utilizing modern media for public scrutiny and discussion is an excellent feedback method for a bottom-up approach. Many voices from the bottom can be heard by the public through the media, and the value of cultural heritage can be defined not only by elites or experts but by the masses. Secondly, in public consultations, while a positive process, unfair practices do exist. This results in many voices from the bottom being ignored, often vital groups with a close relationship to historical heritage. Therefore, it is crucial to provide as equitable and thorough participation environments as possible for every party involved in heritage preservation practices. Otherwise, the so-called bottom-up process is not truly from the bottom-up. Thirdly, development and conservation need to find a balance. Development is essential, particularly in countries facing challenges such as resources and funding. However, it is essential to consider whether the so-called development is sustainable for the local economy, population, community, and society. We must consider the conservation of ecology and cultural heritage while promoting development. Besides providing fair compensation to the bottom masses, it is more important to establish a sustainable economic model. Additionally, we must provide channels for resolving the grievances of these vulnerable bottom communities. Development must not come at the expense of sacrificing disadvantaged, fragile communities, their heritage, or their cultural identity. Sustainable development requires comprehensive policies and mechanisms. An equitable international organization is needed to manage ecological resources, and vulnerable groups must be prioritized to ensure a sustainable economy.

In the future, conservation practices require a balance between bottom-up and top-down approaches. While modern media has facilitated public participation and discussion, public consultations must be more equitable to prevent the neglect of bottom voices. We must pursue development while keeping ecological and cultural conservation in mind which require comprehensive policies and mechanisms. Also, equitable international organization is needed to manage ecological resources in the boundary of each country. Moreover, vulnerable groups must be prioritized to ensure a sustainable economy. Only then can we ensure the preservation of our cultural heritage for future generations.

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The Intersection of Urban Agriculture and Public Space Across Cultural Contexts: United States and Nepal

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Abstract

As populations around the globe continue to urbanize, the roles that both public space and urban agriculture play in safe, healthy, and equitable cities are becoming increasingly apparent. Exploring the intersection between public space and urban agriculture can imbue planners and designers with the necessary tools to create culturally appropriate, productive public spaces with the ability to respond to a range of input from community members, stakeholders, and culture at large.

Keywords: Public space, urban agriculture, informal settlement

1. Introduction

The need for publicly accessible green space in the urban environment is universal. However, cities in the global south are grappling with the effects of unprecedented rates of urban population growth. As this trend continues, the informal settlement is becoming ubiquitous with these cities, and the need to plan for the sustainable development of these settlements is becoming an increasingly mainstream belief. Though primarily concerned with shelter, the informal settlement must also answer questions of how to most efficiently utilize the limited open space afforded to the community. David Gouverneur's informal armature framework discusses this concept. One of the goals of the informal armature framework is to bridge the gap between the formal and informal city, both physically and socially, through physical infrastructure, public space, and civic engagement (Gouverneur, 2018). This framework stresses the importance of flexible, programmatically diverse public space in informal settlements to ensure continual recognition of the space's value. This in turn makes the space 'defendable' and discourages encroachment of housing into the space (Gouverneur, 2018). Urban agriculture has the potential to satisfy this imperative requirement while also providing a means of civic engagement and stewardship for informal settlement community members.

Though the benefits of urban agriculture are well established, its role in acting as public space is still unfolding. Communally managed farms, as opposed to traditional allotment-style farms in which individuals care for specific plots, have the potential to provide public space to their communities if they have diverse programming and holistic designs. Landscape architect N. Clair Napawan's comparative case studies of urban farms in San Francisco establish criteria for assessing the ability for urban farms to act as successful public space, including but not limited to their relationship with surrounding context, accessibility, seating, and programming (Napawan, 2015).

This research has explored the intersection between two landscape typologies – productive landscape and public landscape – in the distinctly different cultural contexts of Syracuse, New York, United States and Kathmandu, Nepal. Ongoing research will continue throughout the Fall of 2024 by exploring the most culturally appropriate ways to apply the findings to Kathmandu's informal settlements.

2. Material and Method

Methodology was conducted first in Syracuse, New York, USA then in Kathmandu, Nepal to assess the effects of cultural differences on the results. Qualitative case studies were conducted, applying Napawan's framework to urban and peri-urban agricultural landscapes. Diagrammatic representations of the agricultural sites and a selection of public spaces were developed for spatial comparison of the physical elements of the two landscape typologies. Speculative designs were generated that combined spatial elements from both agricultural and public space typologies. Speculative designs act as a tool to assess the effects of a variety of inputs into the design process. In Syracuse, sites were chosen for the speculative design process through a geospatial analysis of existing public amenities such as public parks/plazas, bike infrastructure, and trees to determine areas of interest that reflected the greatest need for additional public open space. Due to limited resources and geospatial data for informal settlement communities in Kathmandu, sites for speculative design were chosen based on existing previous research (Dangol & Day, 2017). Future work with organizations such as SPOSH (Society for the Preservation of Shelters and Habitation) will allow for greater understanding of the current distribution of informal settlements in Kathmandu.

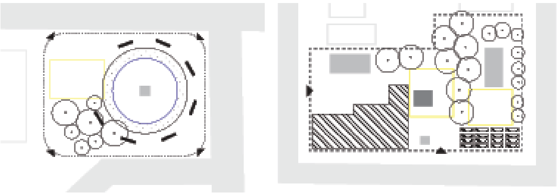

Figure 1. Examples of Syracuse public space (left) and urban farm (right) diagrams (NTS)

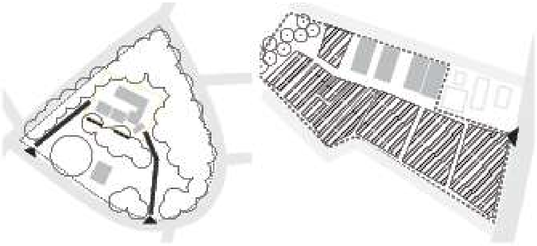

Figure 2. Examples of Kathmandu public space (left) and urban farm (right) diagrams (NTS)

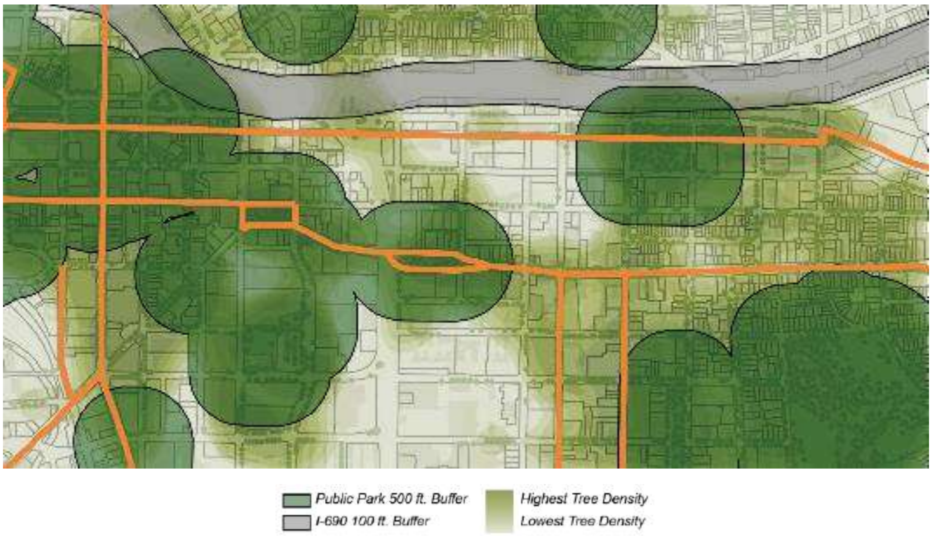

Figure 3. Example of geospatial analysis to determine areas of interest for speculative design process

3. Findings and Discussion

The application of this framework across cultural contexts results in culturally responsive productive public space. Similarities and differences in cultural approaches to public space and productive space design in the case of Syracuse and Kathmandu are outlined below (Table 1).

Table 1. Similarities and differences in cultural approaches to public space and productive space design in the case of Syracuse and Kathmandu

	Public Space	Productive Space
Syracuse	• High visibility • Connection to street	• Raised beds
Kathmandu	• Dense vegetative buffer or topography change from street	• Terracing • Permaculture
Both	• Generous circulation • Ample seating	• Row Crops

Figure 4. Urban farm in Syracuse (left) and Kathmandu (right)

Figure 5. Public space in Syracuse (left) and Kathmandu (right)

Cultural input

Many of the cultural differences between the United States and Nepal can be understood through the top-down/bottom-up dichotomy. Many of the urban public and productive landscapes in the United States have been established through top-down actors such as planners, developers, and organizations; in Nepal, bottom-up practices such as grassroots community movements are the most common method of enacting change. Syracuse's public spaces are typically plazas or parks. They are secular in nature and frequently feature a monumental or memorial focal point. Kathmandu's high population density and community-oriented culture contributes to a vibrant network of both formal and informal public space that utilizes everything from ancient temples to ordinary street corridors. The city's most enduring public spaces are religious sites that have been protected from rapidly encroaching development.

Urban agriculture, acting as a reflection of a region's culture and history, differs dramatically between West and East. In post-industrial Syracuse, urban agriculture has filled in vacant spaces left behind by urban depopulation. Many of Syracuse's urban farms prioritize education and community outreach programs as opposed to being solely focused on producing crops. It is common for urban farms in the United States to be managed by larger organizations such as farmer cooperatives or non-profit organizations. Governmental and nongovernmental organizations alike are increasingly investing in metrics frameworks to capture data relating to urban agriculture's effects on the urban economy and culture. In contrast to Syracuse, many of Kathmandu's large-scale peri-urban farms began as rural farms but are now surrounded by urban development. Small-scale urban agriculture in Kathmandu remains a largely fragmented, bottom-up practice. Urban farms in Kathmandu are highly productive, often using permaculture techniques. A 2011 case study assessing the management practices and community involvement of four urban and peri-urban farms in the Kathmandu Valley determined that although all four of the farms act as some degree of public space, the farms managed by homogeneous communities such as the indigenous Newars are more internally focused on their own community whereas farms managed by heterogeneous communities are more externally focused and open to a diverse range of actors (Shrestha, 2011).

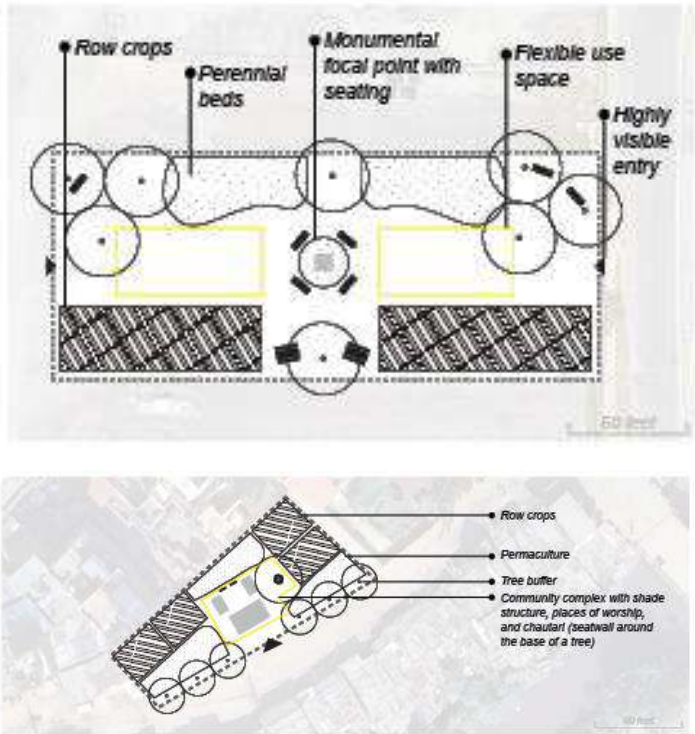

Figure 6. Examples of productive public space speculative design diagrams for Syracuse (top) and Kathmandu (bottom) (NTS)

Applying the framework to an ınformal settlement context

In Kathmandu, informal settlements are demographically dominated by rural migrants who were farmers before relocating to the city in response to political turmoil and an increasingly urbanized economy (Mitchell & Iglesias, 2020). For this reason, including rural agricultural landscapes in the case studies may lead to deeper cultural ties between land and steward. Kathmandu's informal settlements are primarily located upon the former floodplains of the recently embanked Bagmati River and its tributaries (Mitchell & Iglesias, 2020). A relatively permanent presence has been established, however the build-evict-build cycle continues to influence the distribution of the settlements. Extensive community outreach is recommended to bring this framework into an informal settlement context. Understanding the specific demographics of each informal settlement community can point to the most appropriate sources of landscape case studies. Community mapping exercises can reveal how the residents experience and understand their community. Future work with SPOSH will lead to a deeper understanding of the highly complex political and cultural contexts of these communities.

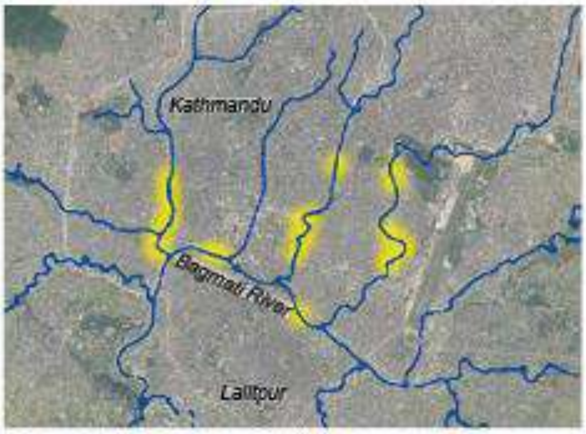

Figure 7. Approximate locations of informal settlements in Kathmandu

4. Conclusion

Informal settlements are an increasingly prominent presence in many cities of the global south such as Kathmandu. Culturally sensitive and creative solutions are needed to guide the growth and maintenance of these communities. Speculative design is a valuable research tool for designers to explore opportunities that respons to a range of inputs. This practice by designers working alongside govenment agencies and policy makers has the potential to generate positive change not only for informal settlements but for any community.

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Analysis of Open-Green Areas According to Universal Design Principles: The Case of Sakarya

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Abstract

Everyone in society has different needs according to their abilities and skills. The Universal Declaration of Human Rights emphasizes that all people should have equal rights. Universal design principles provide an important approach to ensure that public spaces are accessible to all, regardless of age, ability, or mobility, allowing everyone to use these spaces inclusively. These principles aim to improve individuals' quality of life and promote social equity by providing equal access to public spaces. This study evaluates the compliance of Sakarya National Garden, Barış Manço Children's Park, and Children Rights Street, located in the Adapazarı district of Sakarya, with universal design principles. The study aims to determine the accessibility and inclusiveness of these areas for different user profiles. Data were collected through fieldwork and observations based on universal design principles and analyzed according to specific criteria. The analysis revealed that these spaces do not fully meet universal design principles. Recommendations were developed to enhance the inclusivity of these areas, enabling all user groups to benefit equally.

Keywords: Universal design, open and green areas, accessibility.

1. Introduction

Public spaces are areas open to everyone, providing opportunities for socializing and building community (Habermas, 2003). As public spaces, urban open and green areas contribute positively to individuals' physical and mental health while strengthening social ties and community bonds (Cohen et al., 2007; Cohen-Cline et al., 2015). For every individual to participate actively in urban life, it is important that public spaces are designed with consideration for individuals with special needs.

As reported by the World Health Organization, about 16% of the global population consists of individuals with different disabilities (World Health Organization [WHO], 2022). This rate represents 4.8 million people, or 6.9% of the population, in Türkiye (Ministry of Family and Social Services, 2011). The Universal Declaration of Human Rights emphasizes that all individuals should have equal rights (United Nations [UN], 1948). In the view of the United Nations, people with disabilities have equal rights with all individuals, and this is guaranteed by the Convention on the Rights of Persons with Disabilities. (United Nations [UN], 2006). Local governments, the private sector, and civil society organizations are responsible for ensuring equal opportunities for people with disabilities.

The universal design approach, First introduced in 1998, it focuses on creating spaces accessible and usable by people of all ages and abilities. (Gök & Özdemir, 2022). Architect Ronald Mace, who himself had a physical disability, introduced the principles of universal design to provide equal access for people across all age groups and abilities. These principles aim to ensure accessibility for all individuals, irrespective of their physical, cognitive, or sensory limitations. (Mace, 1985). At its core, universal design must be functional, safe, and fit for purpose. Its greatest feature, which sets it apart from other designs, is the opportunities it offers to all individuals in all circumstances. (Uslu et al., 2017).

Universal design is a globally recognized approach aimed at enhancing quality of life in urban design. When designing urban open and green spaces, universal design principles can be considered from the following perspectives.

- Equitable Use: Universal design aims to be accessible for all individuals, including people with disabilities, the elderly, pregnant women, children, and those with temporary mobility restrictions.

- Flexibility in Use: Universal design should meet the diverse needs of users of different age groups, ability levels, and interests. This may include playgrounds with varying difficulty levels, sensory elements, and features reflecting diverse cultural values.

- Simple and Intuitive Use: Universal design should provide a user-friendly and easily understandable structure. Designs should be free from complex elements and hard-to understand features.

- Perceptible Information: Necessary information should be presented clearly and accessible through signs, labels, and other explanatory materials.

- Tolerance for Error: To enhance user safety, the design approach should minimize the likelihood of mistakes.

- Low Physical Effort: Universal design should include arrangements that reduce the physical effort required by users. Ramps, elevators, and accessible restrooms are essential elements that meet this requirement.

- Size and Space for Approach and Use: Spaces should be sized and arranged to allow comfortable access and use. This includes physical solutions such as wide doors, ramps, and appropriate sidewalk arrangements (Story et. Al., 1998, World Disability Union [WDU], 2022).

Universal design benefits the physical environment and cultural structure. These principles, which include all segments of society in public spaces, help create inclusive and accessible public areas. In this context, the coming together of people of different ages and abilities in shared spaces is a result of universal design principles. This study examines three distinct areas in Sakarya to highlight universal design principles, which are often overlooked in urban open and green spaces. The findings reveal the critical importance of universal design principles in the design of urban open and green spaces.

2. Material and Method

The study area is Sakarya National Garden, Barış Manço Children’s Park, and Rights of the Child Street, located in the Şeker neighborhood of Adapazarı district, Sakarya province. Surrounding the approximately 74,000 m² area are various educational institutions ranging from kindergarten to high school. The design of Barış Manço Children’s Park and Rights of Child Street offers activity opportunities aimed at children and young people. The design of Sakarya National Garden also includes facilities for both young people and adults. When the areas are evaluated individually, they do not provide opportunities for all members of society. Since it is known that universal design principles aim to ensure equality for all individuals in society, the three areas were examined. The boundary of the area is shown in Figure 1.

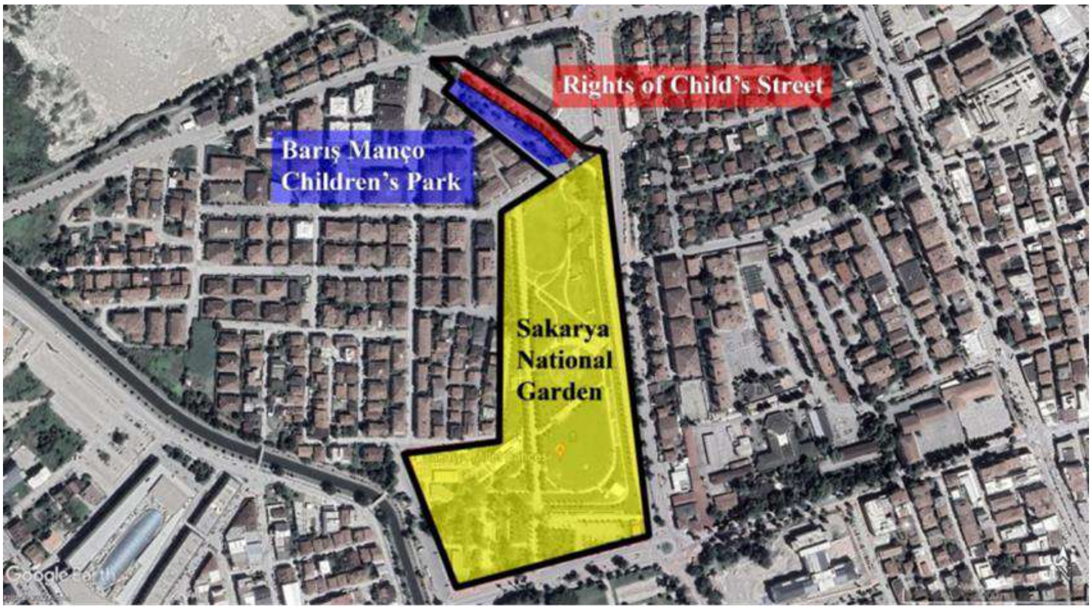

Figure 1. Study areas (Author's personal collection)

The study area has been evaluated within the framework of standards from the perspective of Universal Design principles. A literature review was conducted to compile studies prepared in a similar framework, and a checklist was created to identify qualitative and quantitative data. The presence of universal design principles in the area was assessed with standards considering various disability groups, the elderly, and children. Measurements and observations were conducted to determine the area's compliance with universal design principles. The indicators listed in Table 1 were examined separately for each park.

Table 1. Evaluation criteria according to Universal Design Principles (Uslu et. Al.., 2017; Tandoğan 2021; Gök & Özdemir, 2022; Tuğluer & Ekren, 2022; Alptekin, 2022; Kavuran & Uslu, 2022)

Universal Design Principles	Indicators	Standards
Equitable Use	Usability for all individuals.	Equal and shared access for all uses
	Suitability for use by different genders	Designs suitable for shared and separate use by different genders
	Suitability for different disability groups	Designs addressing the needs of visually, hearing, and physically impaired individuals
	Suitability for different age groups	Designs catering to adults, young people, and children
	Suitability for shared use by individuals with varying abilities	Spaces and urban furniture suitable for wheelchairs and strollers
Flexibility in Use	Multi-functional urban furniture	Seating areas of varying heights, directions, and widths; lighting fixtures of different sizes; multi-directional waste bins; panels and directional signs with Braille and symbols

	Multi-functional playground	Modular playgrounds
Simple and Intuitive Use	Simplicity in park circulation	Direct access to spaces through the shortest path
	Simplicity in playground	Selection of playgrounds appropriate for the age and abilities of children
	Simplicity in urban furniture	Easy-to-use urban furniture selection
	Simplicity in space usage	Designing spaces to prioritize accessibility and user-friendliness
Perceptible Information	Suitability for users with different language and literacy skills	Use of Braille alphabet
		Use of symbols
	Tactile surfaces	Ramps, stairs, pathways, and entry and exit points
Tolerance for Error	Safety, privacy, and tolerance for all users	Avoidance of designs that could pose risks
		Avoidance of hazardous material selection
		Development of protective designs against potential hazards
		Warning systems for hazards
Low Physical Effort	Ergonomic design for all users	Selection of ergonomic urban furniture
		Ergonomic design in playground
		Ergonomic structural landscape design
	Design that minimizes effort	Shortcut paths
		Landing applications
		Resting areas
Size and Space for Approach and Use	Compliance with standards in structural design	Pedestrian paths ≥ 150 cm
		Ramps ≥ 180 cm
		Sidewalks ≥ 150 cm
		Stairs ≥ 180 cm
		Ramp gradient ≤ 8%

		Curb height ≤ 15 cm
		Accessible parking ≥ 4.90 x 3.50 m
		Appropriate material selection
		Positioning accessible parking close to area entry
	Compliance with standards in planting design	Selection of suitable plant species
		Placement of plants in appropriate locations
		Suitability in plant compositions

3. Findings and Discussion

An analysis of Sakarya National Garden, Barış Manço Park, and Rights of Child Street within the scope of universal design principles and standards has revealed the following findings. In Sakarya National Garden, an evaluation of the equity principle revealed that spaces, structures, and structural solutions have been designed to accommodate visitors of different genders, abilities, and levels of mobility. The absence of spaces specifically targeting children is remarkable. Seating elements across the area were generally selected at diverse heights to ensure accessibility for individuals with physical limitations and all age groups. In addition, the distance between seating elements was designed to accommodate wheelchair users, thus supporting the principle of flexibility in use (Figure 2a-2b).

a) b)

Figure 2. Seating element suitable for everyone's use (Author’s personal collection)

Analysis revealed that the circulation within the park, spatial organization, and the arrangement of urban furniture were designed in accordance with the principle of simplicity and intuitiveness. However, the absence of tactile surfaces and directional signs hinders effective use of the area. Although there is a sign introducing the alphabet for the hearing impaired at the entrance, no additional applications or accessibility adjustments have been made throughout the park to assist hearing-impaired individuals in obtaining information or finding directions. In this context, the perceptible information principle has not been adequately met. The lack of protective equipment around the ornamental pools in Sakarya National Garden, combined with their location adjacent to pedestrian walkways, poses a safety risk (Figure 3a-3b). Additionally, the variety of materials and inconsistent surface textures create an uneven surface profile, making walking difficult for physically disabled individuals, the elderly, and children (Figure 3c). This finding indicates that the principle of tolerance for error has not been sufficiently implemented.


a) b) c)

Figure 3. On the floor with the same level ornamental pool and variable ground materials (Author’s personal collection)

The presence of alternative circulation routes within the park and the placement of seating units along the pathways indicate that the design aligns with the principle of low physical effort. However, the width of secondary pathways being less than 150 cm and the gradient occasionally exceeding 10% reveal implementations that do not meet standards (Figure 4a-4b). In the area where accessibility and standard compliance principles are partially achieved, the arrangements of park areas, entry points to structures and spaces, seasonal landscaping adjustments, and the positioning of plant compositions are considered appropriate.

a) b)

Figure 4. Building entrances with ramps (Author’s personal collection)

In Rights of Child Street, the design ensures ease of use for all visitors, aligning with the principle of equity. Observations indicate that the needs of individuals with disabilities were considered in the design. A shared play area was created for people of diverse age ranges and varying types of disabilities. The urban furniture has clearances suitable for wheelchairs and strollers, allowing visitors with diverse needs to spend time together, thereby ensuring the principle of flexibility in use (Figure 5a-5b).

a) b)

Figure 5. Design solutions for spaces and opportunities for different genders and needs (Author's personal collection)

The layout of the area is simple and intuitive, facilitating ease of use. When evaluating the principle of perceptible information, it was determined that there are no tactile surfaces and directional signs in the area. The pedestrian path surrounding the area is uneven and varies in width, increasing the risk of falls. Furthermore, the improper placement of infrastructure elements on the ground suggests that the principle of tolerance for error has not been met. Although circulation within the area is easy and the urban furniture and playgrounds are designed ergonomically, adhering to the principle of low physical effort, the pedestrian pathway on Rights of Child Street does not meet standard dimensions, and the heights of the curbs vary. Circulation within the area is not adequately supported by the pedestrian paths, leading to unrestricted movement within the area. Due to this design oversight, existing urban furniture and playgrounds were found to obstruct circulation. Additionally, there is no designated parking space for vehicles of individuals with disabilities. The division between the parking area and the space by a curb negatively affects access for individuals with physical challenges.

An examination of the design of Barış Manço Park reveals that the universal design principles have not been followed. The design lacks consideration for different genders and abilities, failing to fulfill the principle of equity. The uniformity of the urban furniture creates difficulties for users of various ages and disability types. However, playgrounds do take into account the requirements of various age groups, partially meeting the principle of flexibility. In Barış Manço Park, the layout and circulation are highly complex, with unclear entry and exit points and several dead-end paths, which hinders simplicity and intuitiveness (Figure 6a-6b).

a) b)

Figure 6. Entrance to the park and dead end (Author's personal collection)

The absence of directional signage and tactile surfaces indicates that the principle of perceptible information is not met. Due to inconsistencies in surface materials and leveling, it is difficult for physically disabled individuals, the elderly, children, and parents with strollers to navigate the area, suggesting that the tolerance for error principle has not been applied.

The design and implementations within Barış Manço Park also complicate internal circulation, and the playgrounds are not inclusive for all users, demonstrating that the principle of low physical effort has not been realized. In terms of accessibility and compliance with standards, the entrance gate does not meet standard dimensions, making it challenging for individuals with physical limitations and parents with strollers. Pathways inside the park are narrower than the standard measurements, with uneven surfaces, holes, and bumps. The gradient of ramps is inconsistent, varying from the beginning to the end. The park lacks a designated parking area, and the location of plants obstructs pedestrian movement on walkways due to improper placement. The design of plant compositions does not align with landscape design principles. Access is also restricted by the perimeter fence. Drain covers and electrical connections are exposed and close to public use areas, and structural damage within the park have not been repaired.

4. Conclusion

The results from the checklist used to evaluate the study area according to universal design principles indicate that the criteria were not adequately met. It was found that the study area was not designed in compliance with universal design principles and, therefore, does not ensure equal accessibility for all members of society. Implementing criteria for different disability groups would also make the area accessible and convenient for individuals of all ages and genders, while facilitating the adaptation of people from various cultural backgrounds. Sakarya National Garden is the most recent project completed within the study boundaries. Considering the scope and scale of the project, some attention was given to universal design principles during the design phase, but it was not fully applied throughout. Accordingly, it is anticipated that small but permanent solutions can address these deficiencies within the study area. Improvements to internal pathways and preventive measures in hazardous zones will be effective in mitigating these issues. Particularly, the placement of directional signs at key intersections would make the area more functional. Establishing tactile surfaces for visually impaired individuals would also enhance the inclusiveness of the space. Rights of Child Street meets some universal design criteria; however, structural design deficiencies were identified. These shortcomings may be attributed to the area's location between two separate parcels. However, redesigning the park with existing urban furniture could help resolve these deficiencies. By creating a clear axis within the area, circulation can be separated from usage zones, eliminating pedestrian path-related hazards. Additionally, accessible solutions for visually impaired individuals should be provided in the area. Barış Manço Children's Park was the first park constructed within this area. Changes over time have negatively affected its usability. Including these developments, Barış Manço Park emerges as a space that has almost entirely neglected universal design principles. The lack of maintenance and repairs of structural and plant design elements further reduces the applicability of these principles. Considering all these deficiencies, combining Barış Manço Children's Park with Rights of Child Street and reconfiguring both areas could transform them into inclusive public spaces.

The study findings indicate that universal design is not given sufficient attention in urban areas. These spaces are designed without a thorough analysis of user profiles. However, improvements made in these areas would enable effective use by all visitors. In a country like Türkiye, with an increasingly aging population and a significant youth demographic, creating urban open and green spaces in accordance with universal design principles should be a strategic priority to promote social cohesion and improve the quality of life for all individuals. Such areas should serve not only as physical but also as social spaces, contributing to community gathering, social interaction, and the development of a shared sense of belonging. This approach would enable the creation of accessible and inclusive cities for everyone. In this regard, it is essential to meticulously follow the planning, design, implementation, and maintenance processes of urban open and green spaces. The sustainability of universal design principles is only achievable through compliance with criteria at each stage and regular monitoring.

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Construction of Aging-friendly Streets from the Perspective of Street Soundscape

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Abstract

With the intensification of the aging population problem in society, urban streets, as important areas for elderly activities, have significant importance in designing soundscapes that are suitable for aging. This study is based on the perspective of soundscape creation, taking the old urban area of Xicheng District, a mega city in China, as an example, and selecting 5 sample streets for research. Through soundscape evaluation experiments, questionnaire surveys, and behavioral observation records, the study explores the soundscape characteristics of urban life-oriented streets and their impact on the behavioral activities of the elderly. The following three conclusions are drawn: (i)The behavioral characteristics and auditory comfort of the elderly on the streets are most affected by sudden environmental noise. (ii) The elderly have the highest degree of love for natural sounds such as bird songs. (iii) The visual comfort and auditory comfort of streets are correlated. At the same time, this study takes these as the entry point for the construction of aging-friendly streets, proposes strategies for creating aging-friendly street spaces, and explores effective ways to achieve widespread social equity construction.

Keywords: Street landscape, aging-friendly design, soundscape

1. Introduction

Urban renewal is an important initiative to promote high-quality urban development, which is closely related to the improvement of the living environment and the people's sense of access and happiness. And the street is an important public space in the city, a space that is used very frequently in the daily life of residents.

As a socially vulnerable group, the importance of the elderly's sense of well-being and access cannot be ignored in the context of China's increasing aging. According to the data of the seventh national census in 2020, the total number of elderly people aged 60 and above in China is 264 million, which has accounted for 18.7% of the total population. Elderly people have weaker senses and weaker mobility than young adults, and they have higher requirements for the safety and comfort of their daily activities, so the age-friendly design of streets is particularly important.

The concept of soundscape was first proposed in the late 1960s by the Canadian musician Schaeffer (Schafer, 1996), which mainly studies people's feelings about the external acoustic environment and the impact of sound on people's subjective feelings. In China, with the growth of the demand for a better living environment, soundscape is gradually being paid attention to. A number of studies have shown that soundscape is another important factor that affects the human psychological state and activity characteristics in urban street environment in addition to the visual landscape, which is important for improving the comfort and pleasure of the street, and it is an important entry point for creating age-friendly streets.

Currently, there is a certain research foundation on streetscape features and urban soundscape, but there are relatively few studies on ageing-friendly streets based on soundscape creation. The research on specific groups of people on streets focuses on the design of child-friendly streets (Hui, 2021), and some studies focus on the ageing of streets, but mainly on the study of the walkability of streets for the elderly (Yuan, 2022) and the optimisation of street space under the demand of activities for the elderly (Zhang, 2021) .

Based on this foundation, the study selects five streets located in Xicheng District of Beijing, an old urban area of a mega city in China, exploring the soundscape characteristics of streets and their influence on the behavioral activities of the elderly. Utilizing these insights as a starting point for constructing ageing-friendly streets, the study proposes a strategy to create such street spaces and explore effective ways of achieving social equity for the wide range of social equity construction.

2. Material and Method

2.1 Overview of the study area

Beijing was listed as an aging city as early as 1979 and entered the aging society in 1990. As of 2019, Xicheng District has a household population of 429,000 people aged 60 and above, ranking third in Beijing. The health of the elderly is of particular concern, and Xicheng District is a National Health Promotion Zone and a National Pilot Healthy Urban Area. In addition, Xicheng District, as an old urban area, left complex and diverse environmental problems, such as the repair of cottage compounds, the transformation of old neighborhoods, the compensation of the debt of human settlements, and the collision of tradition and modernity, and there is an urgent need to improve the transformation of old neighborhoods and the public environment.

Figure 1. Overview of the study area (Chen, 2024)

Streets are mainly categorized into traffic oriented streets, lifestyle oriented streets, and comprehensive streets streets. Among them, lifestyle oriented streets are those streets with low traffic flow and layout of restaurants, retail and other businesses along the route, which serve the daily life of local residents. Since the activities of the elderly are mainly concentrated in the vicinity of residential areas and the types of behaviors are mostly daily life activities(Zhou, 2021), this study chose five lifestyle oriented streets in Xicheng District as the research samples.

2.2 Research methods and data collection

In this study, five sample streets were selected in Xicheng District, and one observation point was selected every 50 m. The experimental data were collected from April 13 to April 25, 2021, during the daytime when the weather was good.

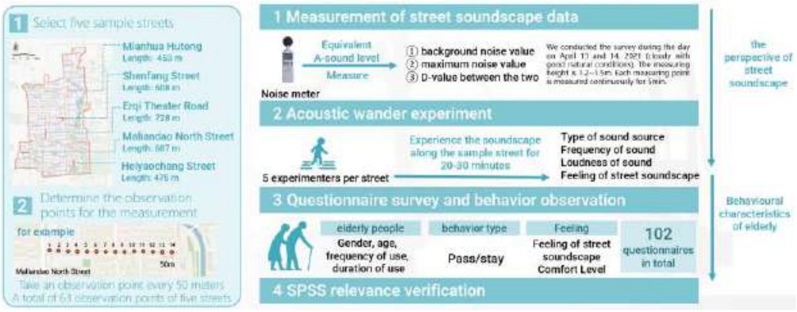


Figure 2. Technology roadmap (Chen, 2024)

First, a noise meter was used to obtain the equivalent A sound level at the observation points, which was used to represent the noise level at each observation point, and the background noise and maximum noise were measured. Secondly, a sound walking experiment was conducted to analyze the characteristics of the street soundscape. Five participants, all of whom were 20-25 years old, healthy and with normal hearing, were selected from each sample street and recorded various sound sources, their frequencies and loudness during the 20-30 minute walking experiment. After that, based on the questionnaire survey and , the basic information of the elderly people in the streets of the old city was counted, and a total of 102 questionnaires were filled out, of which 100 were valid; the basic information of the elderly was obtained (gender, age, identity), the activities of elderly in the streetsand the subjective feelings of the streets. Behavioral observation method was used to count the behavioral characteristics of the elderly.Finally, SPSS analysis was used to further explore the effects of street soundscape features on the behavioral activities of elderly people.

3. Findings and Discussion

3.1 The perspective of street soundscape

3.1.1 Exposure characteristics of acoustic environment in sample streets

According to the *Acoustic Environment Quality Standard*, the background noise of Heiyaochang Street, Shifang Street and Erqi Theater Road in Xicheng District exceeds the daytime (between 6:00 and 22:00) noise limit of 55dB for residential areas.

Figure 3. Analysis of soundness characteristics of 5 sample streets (Chen, 2024)

Background noise value of independent street was slightly higher than mixed traffic street (Figure 3), which was attributable to the fact that the pedestrian-vehicle The wider sidewalks of the sample streets with pedestrian-vehicle divisions generate more traffic noise. Regarding the maximum noise value and its difference with the background noise value, the mixed traffic street is higher than the independent street (Figure 3), due to the fact that mixed traffic street generate more loud and sudden noises such as honks and whistles, which leads to a more drastic change in the noise value of this type of streets.

3.1.2 Sound source characteristics of sample streets

The types of sound sources can be categorized into human activity sound, traffic sound, mechanical sound and natural sound. In terms of the proportion of each type of sound source, the sounds on the sample streets in Xicheng District were dominated by traffic-type sound sources, which accounted for 50% to 60%, followed by human activity sounds, which accounted for about 20% to 30%, and natural sounds accounted for a relatively small proportion of the sound sources (Figure 4). Comparing the percentage of sound source types in each street, it can be found that the percentage of traffic-type sound sources is relatively large in the independent street, while human activity sounds are more frequent in the mixed traffic street.

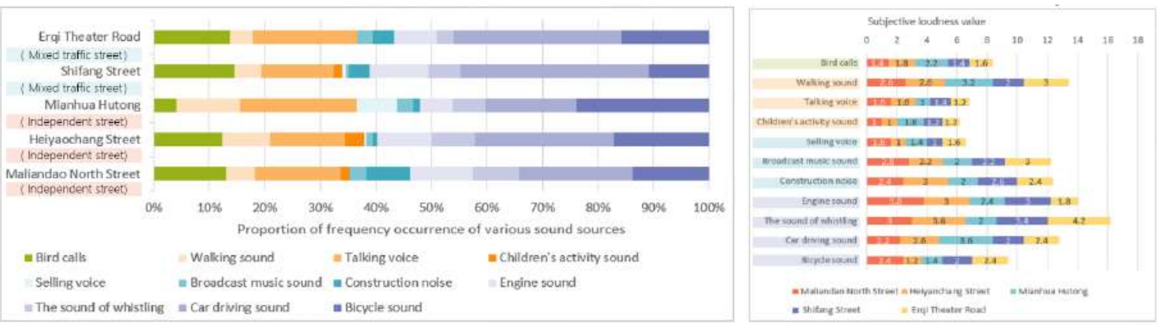


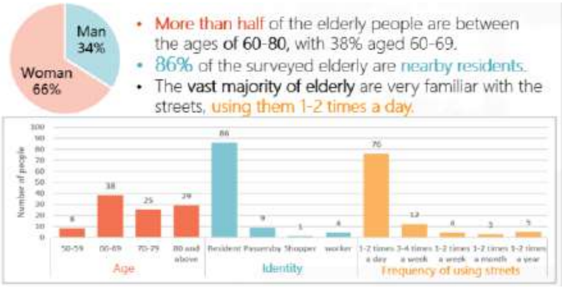
Figure 4. Proportion of frequency occurrence of different sound sources in sample streets (Chen, 2024)

In terms of the loudness of each type of sound source, the subjective loudness of the traffic sound is overall larger, followed by the sound of human activities sound and natural sound (Figure 4). Comparing the loudness of sound sources on different streets, it can be seen that the overall loudness of honking sounds on the mixed traffic street is greater, while the opposite is true for automobile driving sounds.

3.2 Behavioral characteristics of elderly people

3.2.1 Overall evaluation of street landscape by elderly people

A total of 100 valid questionnaires were collected and statistical information about the respondents (Figure 5). In terms of gender ratio, 34% of the elderly respondents were male and 66% were female, which may be due to the fact that women are more willing to be interviewed and more inclined to talk to people than men. In terms of age, more than half of the elderly were between 60 and 80 years old. In terms of identity types of people, 86% were residents of the neighborhood, 9% were passersby, 1% were shoppers, and 4% were working people. It can be seen that residents of nearby settlements accounted for the majority of people, which reflects the fact that living streets are an important activity place for elderly people in the neighboring settlements, while the categories of passers-by and shoppers, who use the sample streets less, accounted for a relatively small number of people. In terms of the frequency of street use, the proportion of elderly people who use the street 1 to 2 times a day is 76%.



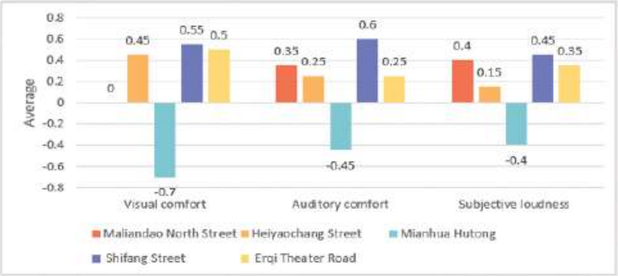


Figure 5. Statistical information of respondents from 5 sample streets (Chen, 2024)

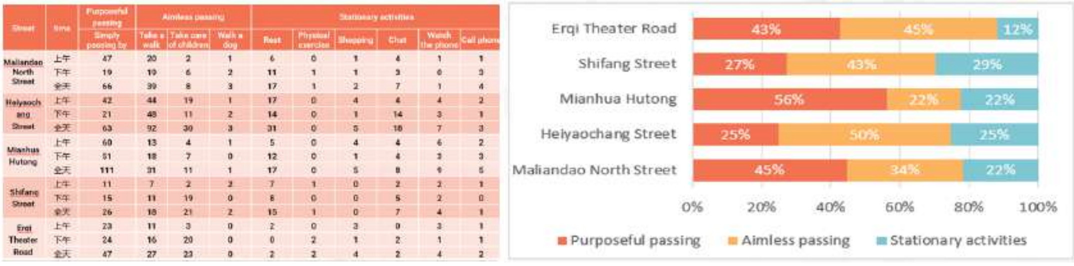
Figure 6. Subjective feelings of elderly towards 5 sample street landscape (Chen, 2024)

3.2.2 Subjective feelings of elderly people towards street landscape

Elderly people's subjective evaluation of Cotton Hutong is negative and the absolute value of the value is large, indicating that the street environment of Cotton Hutong is not liked by elderly people, which may have the influence of safety issues (Figure 6). Elderly people's subjective evaluations of other streets are mostly positive, with Shifang Street receiving the highest rating for visual comfort, which is roughly in line with the objective situation, while Shifang Street is still rated higher in terms of auditory comfort and subjective loudness. When the visual landscape of the street is good, the green visibility is high, and the orderliness is strong, the soundscape comfort is higher.

3.2.3 Behavioral types of elderly people on sample streets

Behavioral observations show that the number of elderly people passing by with a purpose is more in the morning than in the afternoon, indicating that elderly people prefer to carry out necessary activities in the morning, such as going out to buy groceries, and according to the statistical information of the sample of questionnaire interviewees, the time of elderly people going out in the morning is mainly concentrated in the period from 9:00 to 11:00 am. (Figure 7)The number of elderly people passing by without purpose is then more in the afternoon than in the morning, and walking and bringing children are the main activities, and the activity time in the afternoon is evenly distributed from 13:00 to 17:00, and the number of elderly people going out after 17:00 gradually decreases (Figure 7).The number of stopping activities varies based on the conditions of each sample street, and may be related to the street infrastructure and the amount of space available for stopping, with sitting as the main activity.



Street	time	Purposeful passing	Aimless passing			Stationary activities					
		Simply passing by	Take a walk	Take care of children	Walk a dog	Rest	Physical exercise	Shopping	Chat	Watch the phone	Call phone
Maliandao North Street	上午	47	20	2	1	6	0	1	4	1	1
	下午	19	19	6	2	11	1	1	3	0	3
	全天	66	39	8	3	17	1	2	7	1	4
Heiyaochang Street	上午	42	44	19	1	17	0	4	4	4	2
	下午	21	48	11	2	14	0	1	14	3	1
	全天	63	92	30	3	31	0	5	18	7	3
Mianhua Hutong	上午	60	13	4	1	5	0	4	4	6	2
	下午	51	18	7	0	12	0	1	4	3	3
	全天	111	31	11	1	17	0	5	8	9	5
Shifang Street	上午	11	7	2	2	7	1	0	2	2	1
	下午	15	11	19	0	8	0	0	5	2	0
	全天	26	18	21	2	15	1	0	7	4	1
Erqi Theater Road	上午	23	11	3	0	2	0	3	0	3	1
	下午	24	16	20	0	0	2	1	2	1	1
	全天	47	27	23	0	2	2	4	2	4	2

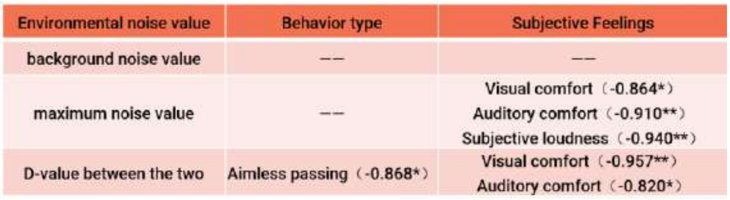
Figure 7. The proportion of elderly people in various behavior types (Chen, 2024)

3.3 The impact of street soundscapes on the behavior of elderly people

3.3.1 The impact of street acoustic environment exposure characteristics on the elderly

Regarding the relationship between ambient street noise and the activities of elderly people, the passing by with a purpose and stopping activities were hardly affected by the ambient noise value, probably because purposeful passing mainly depends on the necessary life activity paths of elderly people, so it does not change with the change of ambient loudness, while stopping activities are related to the facilities of the site. The percentage of people passing by without purpose is affected by the difference between the maximum noise value and the background noise value, and when this indicator increases, the percentage of people passing by without purpose decreases, which suggests that elderly people prefer to walk in streets with less sudden noise.

Table 1. Correlation between the loudness of the street acoustic environment and the behavior of the elderly (Chen, 2024)



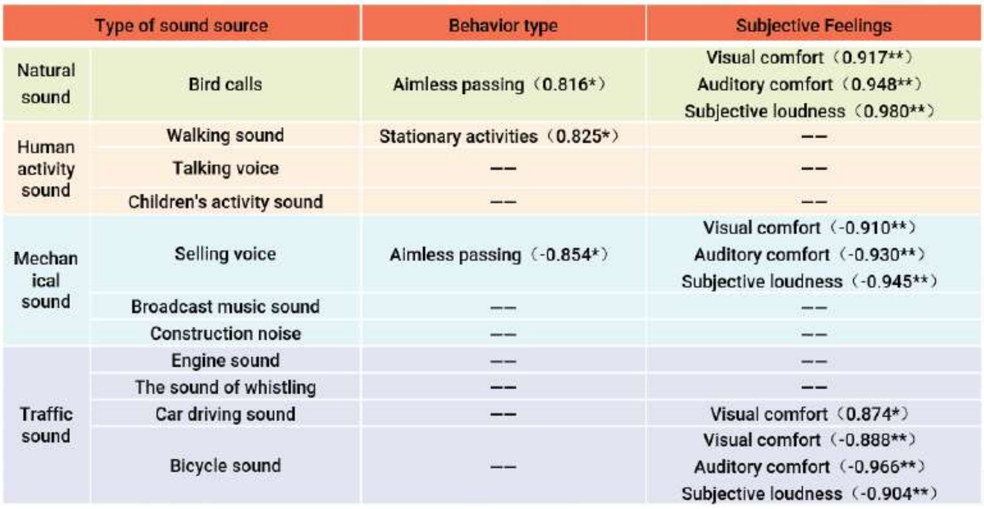
Environmental noise value	Behavior type	Subjective Feelings
background noise value	——	——
maximum noise value	——	Visual comfort（-0.864*） Auditory comfort（-0.910**） Subjective loudness（-0.940**）
D-value between the two	Aimless passing（-0.868*）	Visual comfort（-0.957**） Auditory comfort（-0.820*）

Regarding the subjective feelings, visual comfort is affected by the maximum noise value and the difference between the maximum noise value and the background noise value, which suggests that the acoustic environment of the street also affects the visual perception of the elderly. Subjective loudness was affected by the maximum noise value, indicating that elderly people are not sensitive to the background noise value of the environment, but do not like environments with high levels of sudden noise, a result that can further explain the activity characteristics of elderly people.

3.3.2 The impact of sound source characteristics on the elderly

Regarding the relationship between the perceived frequency of sound sources and the activities of elderly people, the proportion of purposeless passing was influenced by the proportion of selling voice and bird calls, which were negatively correlated with selling voice and positively correlated with bird calls, suggesting that elderly people do not prefer streets with more vendor sounds to streets with better natural environments for activities such as walking. The percentage of stopping activities was influenced by the percentage of walking sounds, which may be due to the fact that streets with more walking sounds have higher pedestrian flow, which will bring more people to the stopping sites.

Table 2. Correlation between the perceived frequency of street sound sources and the behavior of the elderly (Chen, 2024)



Type of sound source		Behavior type	Subjective Feelings
Natural sound	Bird calls	Aimless passing（0.816*）	Visual comfort（0.917**） Auditory comfort（0.948**） Subjective loudness（0.980**）
Human activity sound	Walking sound	Stationary activities（0.825*）	——
	Talking voice	——	——
	Children's activity sound	——	——
Mechanical sound	Selling voice	Aimless passing（-0.854*）	Visual comfort（-0.910**） Auditory comfort（-0.930**） Subjective loudness（-0.945**）
	Broadcast music sound	——	——
	Construction noise	——	——
Traffic sound	Engine sound	——	——
	The sound of whistling	——	——
	Car driving sound	——	Visual comfort（0.874*）
	Bicycle sound	——	Visual comfort（-0.888**） Auditory comfort（-0.966**） Subjective loudness（-0.904**）

Regarding the relationship between the perceived frequency of street sound sources and elderly people' subjective evaluation of streets, the frequency of automobile driving sound was positively correlated with visual comfort, which may be due to the fact that streets with more automobile driving sound tend to be wider, with sidewalks and other facilities that are well equipped and managed. The frequency of bicycle sounds is negatively correlated with the subjective evaluation of the elderly. The frequency of selling voice was negatively correlated with the subjective evaluation of elderly people, while the frequency of bird calls was positively correlated, which further validates the relationship with the type of behavior of elderly people.

4. Discussion and Conclusion

4.1 Key soundscape factors ınfluencing behavioral types in elderly people

Through the above research, it was found that street soundscape characteristics mainly affect the behavioral characteristics of elderly people from the following three aspects:

I） The auditory comfort and subjective loudness of the elderly are mainly affected by the maximum noise level, that is, sudden noise can have a negative impact on the elderly's evaluation of the comfort of street landscapes.

II) Natural sounds such as bird calls can often enhance the comfort of elderly people's travel (Huang,2023), but their proportion is relatively small; However, traffic noise can have a negative impact on the travel experience (Yue,2022), but its proportion is relatively high. Unlike other scholars' research(Guo,2022), in this study, the elderly had a low acceptance of walking sounds, which may be due to their limited mobility and the potential impact of crowded and noisy environments on their safety.

III) Visual comfort is affected by the maximum noise value and the difference between the maximum noise value and the background noise value, indicating that the sound environment of the street can also affect the visual perception of the elderly. Visual landscape evaluation can also affect auditory comfort(Huang,2023), and the characteristics of the sound environment can also affect visual comfort. This suggests that the visual comfort and auditory comfort of street landscapes are mutually reinforcing.

4.2 Strategies for creating soundscapes in aging-friendly streets

Through the above research, this paper proposes the following three strategies for the creation of an age-appropriate street soundscape:

Figure 8. Strategies for creating soundscapes in aging-friendly streets (Chen, 2024)

Minimize or isolate the sudden noise generated by traffic. Previous studies have shown that people have a lower preference for traffic noise (Du,2022) and shorter exposure to traffic noise can have negative effects on health. The larger sudden noise on the street mainly comes from the sound of honking on the streets where people and vehicles are mixed, so the streets should try to take the way of pedestrian-vehicle diversion, to reduce the noise at the same time for the elderly travel to provide security. Secondly, green belts can be added between sidewalks and driveways to absorb traffic noise, and some studies have shown that the combination of hedges and trees is more conducive to blocking noise pollution, and the closer the noise source, the better the blocking effect (Akay,2022).

Focus on improving the ecology of the street to increase the proportion of natural sounds, especially bird calls. Improving the ecological environment of streets, planting food and nectar plants, adding biodiversity conservation measures, and attracting the arrival of birds in order to increase the sound of bird calls (Liu.2022) can improve the comfort of streets for the elderly, increase the frequency of their activities on the streets, and bring a positive effect on the health of the elderly.

Emphasize the creation of visual landscape and acoustic landscape. The results of this study show that visual landscape evaluation affects auditory comfort and acoustic environment features also affect visual comfort. Therefore, ensure the quality of street trees, improve the coverage area of street plants, increase green visibility, and enhance visual comfort. Add adjustable duration bird and insect chirping playback devices, integrate with the visual landscape, and subtly enhance the harmony of the soundscape (Zhang, 2022).

4.3 Conclusion

This study is based on the perspective of soundscape creation, selecting 5 sample streets in Xicheng District, Beijing. Through soundscape evaluation experiments, questionnaire surveys, and behavioral observation records, the study explores the soundscape characteristics of urban life oriented streets and their impact on the behavioral activities of the elderly. The following three conclusions are drawn: (i)The behavioral characteristics and auditory comfort of the elderly on the streets are most affected by sudden environmental noise. (ii) The elderly have the highest degree of love for natural sounds such as bird songs. (iii) The visual comfort and auditory comfort of streets are correlated. At the same time, this study takes these as the entry point for the construction of aging-friendly streets, proposes strategies for creating aging-friendly street spaces, and explores effective ways to achieve widespread social equity construction.

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ENGAGING WITH THE DIGITAL

Urban Villages in Greater Bay Area: A Big Data Study

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Abstract

The rapid urbanization of the Greater Bay Area has highlighted urban villages as unique cultural phenomena within urban spaces. This study uses big data analytics to examine the spatial distribution and usage patterns of urban villages, providing insights for urban planning, landscape design, and community development. Utilizing multi-source data, including Baidu Maps, POI, Baidu Heat Maps, and Dianping, this research applies ArcGIS kernel density analysis to investigate the spatial patterns of urban villages, emphasizing their interactions with nearby commercial and service facilities. Case studies of Liede and Tangxia Village reveal clustering trends in the central-southern region and a coupled relationship between urban villages and nearby commercial establishments. The findings not only confirm the significance of urban villages within the context of rapid urbanization but also highlight their close connections with surrounding commercial and service infrastructure. This research provides theoretical and practical contributions to urban planning, landscape design, and community development, offering a deeper understanding of the role of urban villages in the Greater Bay Area's sustainable development.

Keywords: Big data, kernel density analysis, POI distribution, Guangdong-Hong Kong-Macao Greater Bay Area, urban villages

1. Introduction

Objectives

This study employs big data analysis to explore the spatial distribution and usage patterns of urban villages in the Guangdong-Hong Kong-Macao Greater Bay Area, aiming to support their sustainable development through data-driven insights.

Aims of study

1. The objective is to systematically reveal the spatial distribution characteristics of urban villages.
2. Analyze the interrelationships between urban villages and the surrounding environment.
3. Enhance comprehension of the utilization of urban villages.
4. Provide support for scientific planning and management.
5. Enhancing the Utility of Urban Big Data Applications.

2. Material and Method

Research scope

This study concentrates on the urban villages situated within the expanse of the Guangdong-Hong Kong-Macao Greater Bay Area, encompassing a diverse range of nine prefecture-level municipalities—Guangzhou, Shenzhen, Foshan, Dongguan, Huizhou, Zhaoqing, Zhuhai, Zhongshan, and Jiangmen—alongside the distinct administrative regions of Hong Kong and Macau.

Data acquisition

The research draws upon an array of datasets sourced from diverse channels, including geospatial information from Baidu Maps, official communications from governmental entities, Points of Interest (POI) data from Amap, crowd analytics from Baidu Heat Map, and consumer feedback from Dazhong Dianping. This compilation of data spans various informational spectra, from cartographic details to official declarations and consumer evaluations, thereby establishing a robust and multi-dimensional dataset.

Urban village locations

The geographic location data of urban villages in the Greater Bay Area were primarily obtained through the following methods: First, a search related to "village" was conducted on Baidu Maps to obtain a broad and comprehensive distribution of urban villages. Second, relevant government documents were integrated from various authoritative sources, including the Guangzhou Municipal Government, Shenzhen Planning and Natural Resources Bureau, Foshan Natural Resources Bureau Chancheng Branch, Foshan Natural Resources Bureau Nanhai Branch, Foshan Urban Renewal Bureau, Foshan Gaoming District Government, Foshan Sanshui District Government Office, Dongguan Natural Resources Bureau, Huizhou Huicheng District Agriculture and Water Resources Bureau, Huizhou Huidong County Government Office, Zhuhai Natural Resources Bureau, Hong Kong Special Administrative Region Government - Development Bureau, among others. By collecting data from these authoritative channels, reliable and government-approved data were obtained, providing a credible geographical information foundation for in-depth research on urban villages in the Greater Bay Area. Subsequently, the acquired address information was converted into latitude and longitude data, imported into ArcGIS, and marked as point locations for urban villages, followed by a spatial distribution kernel density analysis of urban villages.

Points of interest (POI) data

In this study, the Points of Interest (POI) data are primarily sourced from Amap (Gaode Maps). POI data encompasses a wide range of urban elements, including residential areas, commercial establishments, public services, and transportation hubs. This data is vital in understanding the spatial relationship between urban villages and surrounding facilities. By analyzing the proximity and accessibility of these facilities, the study provides insights into the livability and functionality of urban villages in the Greater Bay Area.

Heat map data

The heat map data from Baidu provides information on population density and activity levels within specific regions. This data is particularly useful for identifying areas of high human activity, which often correlate with commercial hubs or densely populated residential areas. By overlaying heat map data with urban village locations, the study can discern patterns of human movement and activity in relation to urban villages, offering a deeper understanding of their role within the urban fabric.

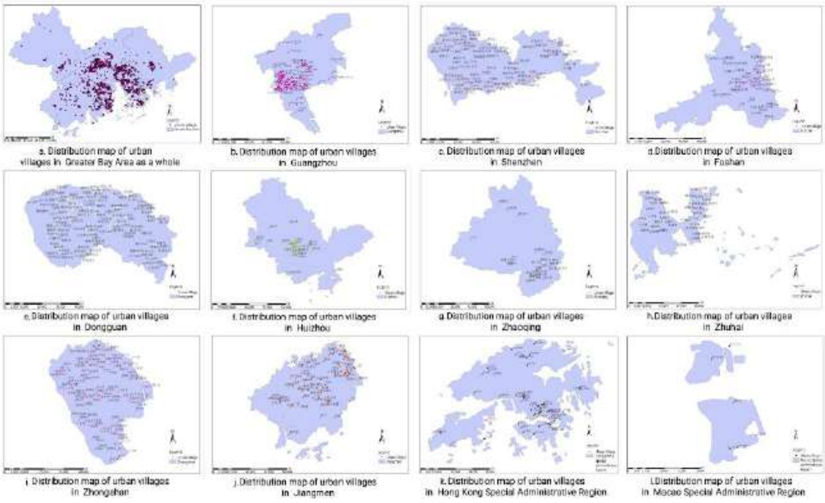
Public review data

Data from Dazhong Dianping, a popular online review platform, is utilized to gauge public sentiment and satisfaction with various urban facilities within and around urban villages. This data includes user reviews of restaurants, shops, and services, providing a qualitative dimension to the study. By analyzing this data, the study can assess the quality of life within urban villages and identify areas for improvement in urban planning and service provision.

3. Findings and Discussion

Distribution map of urban villages in Greater Bay Area

The data exported through ArcGIS processing shows that there are 1,292 urban villages in Guangdong, Hong Kong and Macao Greater Bay Area, of which 214 are in Guangzhou, 218 are in Shenzhen, 77 are in Foshan, 242 are in Dongguan, 47 are in Huizhou, 70 are in Zhaoqing, 75 are in Zhuhai, 164 are in Zhongshan, 106 are in Jiangmen, 73 are in Hong Kong, and 6 are in Macao. Through the illustration, the number and distribution of urban villages in different cities can be clearly understood (Figure. 1).



a. Distribution map of urban villages in Greater Bay Area as a whole

b. Distribution map of urban villages in Guangzhou

c. Distribution map of urban villages in Shenzhen

d. Distribution map of urban villages in Foshan

e. Distribution map of urban villages in Dongguan

f. Distribution map of urban villages in Huizhou

g. Distribution map of urban villages in Zhaoqing

h. Distribution map of urban villages in Zhuhai

i. Distribution map of urban villages in Zhongshan

j. Distribution map of urban villages in Jiangmen

k. Distribution map of urban villages in Hong Kong Special Administrative Region

l. Distribution map of urban villages in Macao Special Administrative Region

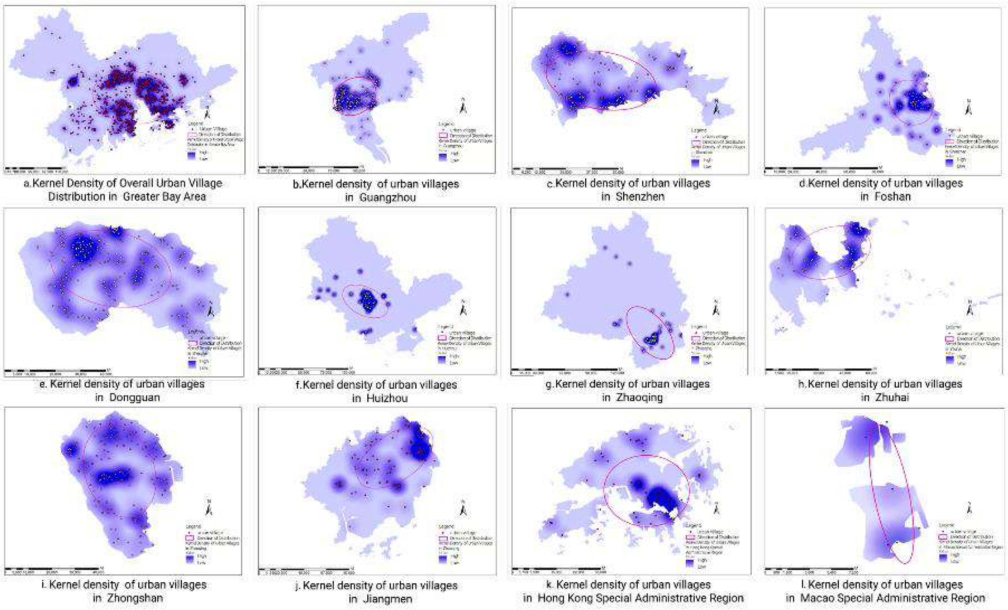
Figure 1. Distribution of urban villages in the Guangdong-Hong Kong-Macao Greater Bay Area

Analysis of the utilization of Urban Villages in Greater Bay Area

Distribution characteristics analysis of urban villages in Greater Bay Area:

The distribution characteristics of urban villages in the Guangdong, Hong Kong and Macao Greater Bay Area were revealed by kernel density analysis and geographic distribution direction analysis through ArcGIS. Overall, the urban villages are mainly distributed in the south-central region, covering Guangzhou, Shenzhen, Foshan, Zhongshan and Dongguan, showing a tendency of concentrating around the Bay Area. Urban villages in Guangzhou are mainly concentrated in the southwestern Baiyun, Tianhe, Haizhu, Huangpu, Yuexiu and Liwan Districts, forming a clear cluster distribution. This visual representation illustrates the high-density, interwoven nature of urban villages in Guangzhou, highlighting their unique spatial and architectural characteristics within the urban fabric (Figure. 2).Urban villages in Shenzhen are mainly distributed in Nanshan District, Luohu District, Yantian District, Futian District in the south and Guangming New District in the southwestern part of the city, showing a trend of east-west linear distribution Urban villages in Foshan City are mainly concentrated in Chancheng District and Shunde District in the east, forming a pattern of multi-point distribution in the central and eastern parts of the city. Urban villages in Dongguan City are mainly concentrated in the northwestern part of Dongguan City, showing a northeastern ring-like scattered distribution. The urban villages in Huizhou City are mainly distributed in the central Huicheng District and Huiyang District, mainly showing a northwest to southeast bulk distribution. The urban villages in Zhaoqing City are mainly concentrated in the southern Duanzhou District, forming a pattern of bulk distribution. Urban villages in Zhuhai are mainly clustered in Doumen and Xiangzhou Districts in the north, mainly showing a chain-like distribution pattern along the northern boundary line. In Zhongshan City, urban villages are densely concentrated in the central urban area, forming a ring-shaped distribution. In Jiangmen City, they are primarily located in the northeastern Pengjiang, Jianghai, and Xinhui Districts, following a northeast-to-southwest distribution pattern. Urban villages in Hong Kong are mainly distributed in the south-central part of the region, covering Tsuen Wan, Sha Tin and Sai Kung Districts in the New Territories, and Wong Tai Sin, Kowloon City and Kwun Tong Districts on the Kowloon Peninsula, as well as the Eastern District on Hong Kong Island. It also includes the Eastern District of Hong Kong Island, forming a pattern of mainly clustered distribution in Central and South China. Macao's urban villages are mainly located in the southern part of Coloane Island, mainly showing a trend of linear distribution in a north-south direction (Figure. 3).

Figure 2. Aerial view of Kecun Urban Village in Guangzhou, illustrating dense architectural texture and surrounding urban context (Source: Xiaohongshu, 2023)



a. Kernel Density of Overall Urban Village Distribution in Greater Bay Area

b. Kernel density of urban villages in Guangzhou

c. Kernel density of urban villages in Shenzhen

d. Kernel density of urban villages in Foshan

e. Kernel density of urban villages in Dongguan

f. Kernel density of urban villages in Huizhou

g. Kernel density of urban villages in Zhaoqing

h. Kernel density of urban villages in Zhuhai

i. Kernel density of urban villages in Zhongshan

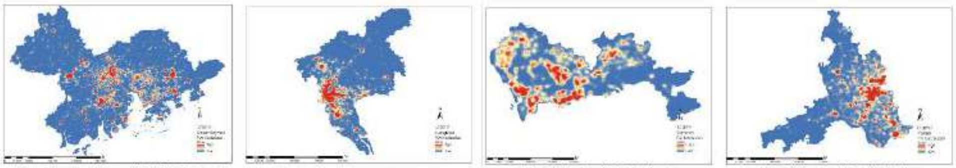
j. Kernel density of urban villages in Jiangmen

k. Kernel density of urban villages in Hong Kong Special Administrative Region

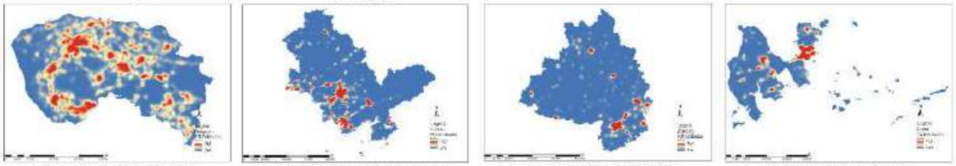
l. Kernel density of urban villages in Macao Special Administrative Region

Figure 3. Kernel density of the Guangdong-Hong Kong-Macao Greater Bay Area

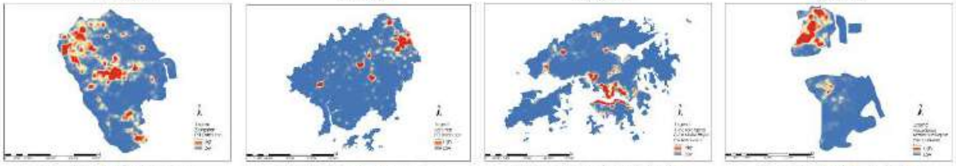
Through the kernel density analysis of POI data by ArcGIS, it can be found that POIs are mainly densely distributed in the south-central region, covering Guangzhou City, Shenzhen City, Foshan City, Zhongshan City and Dongguan City. POIs in Guangzhou are mainly concentrated in the southwest Baiyun, Tianhe, Haizhu, Huangpu, Yuexiu and Liwan districts. POIs in Shenzhen are mainly clustered in Baoan, Longhua, Nanshan, Luohu, Yantian, Futian and Guangming New Districts in the west. POIs in Foshan are mainly clustered in Nanhai, Chancheng and Shunde districts in the east. Dongguan City has a scattered chain distribution of POI intensive areas, with the largest intensive area located in the northwestern Dongguan City District. POIs in Huizhou City are mainly clustered in Huicheng District and Huiyang District in the center. POIs in Zhaoqing are mainly clustered in the southern districts of Duanzhou, Sihui, Dinghu and Gaoyao. POIs in Zhuhai are mainly clustered in Xiangzhou District in the north. POIs in Zhongshan City are mainly clustered in the central main city cluster and the northwestern cluster. POIs in Jiangmen City are mainly clustered in Pengjiang District, Jianghai District and Xinhui District in the northeast. POIs in Hong Kong are mainly clustered in Yau Tsim Mong, Sham Shui Po, Kowloon City, Wong Tai Sin and Kwun Tong districts on the Kowloon Peninsula and Central and Western, Wan Chai and Eastern districts in the northern part of Hong Kong Island. POIs in Macau are mainly clustered in Macau proper (Figure. 4).



a.Kernel Density of Overall POI Distribution in Greater Bay Area
b.Kernel density of POI distribution in Guangzhou
c.Kernel density of POI distribution in Shenzhen
d.Kernel density of POI distribution in Foshan



e.Kernel density of POI distribution in Dongguan
f. Kernel density of POI distribution in Huizhou
g.Kernel density of POI distribution in Zhaoqing
h.Kernel density of POI distribution in Zhuhai



i. Kernel density of POI distribution in Zhongshan
j. Kernel density of POI distribution in Jiangmen
k.Kernel density of POI distribution in Hong Kong Special Administrative Region
l. Kernel density of POI distribution in Macau Special Administrative Region

Figure 4. Kernel density of POI distribution in the Guangdong-Hong Kong-Macao Greater Bay Area

Comparative analysis of the kernel density map of the distribution of urban villages and the kernel density map of POIs reveals a certain coupling relationship between them. First of all, the kernel density map of urban village distribution clearly shows its clustering trend in specific areas of the city, mainly focusing on specific areas of the city. And it is observed that the kernel density maps of the neighboring commercial and service facilities also show higher densities in the same areas. The consistency of this trend suggests that the formation of urban villages may be closely related to factors such as employment and services in commercially prosperous areas. Second, the observed coupling between urban village distribution and POI density likely stems from mutual reinforcement. Commercial and service facility clusters attract residents, leading to the formation of urban villages, while the demand from these residents stimulates further commercial and infrastructural development, creating a symbiotic relationship.

Analysis of the utilization of urban villages in Greater Bay Area

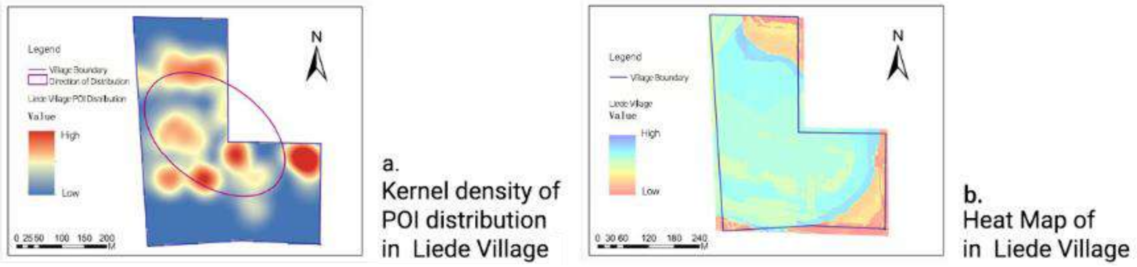
Through the starring results of the Dianping website, we selected Liede Village and Tangxia Village in Guangzhou as the representative urban villages to analyze the usage status of urban villages. When comparing the user evaluations of these two urban villages, we found that Liede Village and Tangxia Village present unique characteristics in various aspects (Table 1).

Table 1. Statistical tables on the current usage of Liede Village and Tongxia Village

Urban Village Name	**Area / km²**	**Number Of Ratings**	**Satisfaction Score (Out of 5)**	**Key Review Keywords**	**Remarks**
Liede Village	3.6	159	4.5	"Ancient and aromatic," "Clean and tidy," "Grand," "Convenient transportation," "Great environment,""Provides dining," "Competitive"	Adjacent commercial area
Tangxia Village	11.2	17	3.0	"Strong smell of smoke,""Tasty but oily,""Poor supporting facilities"	Well-developed night market

Liede Village has a significant geographical advantage of being adjacent to the business district, which attracts a large number of people and provides it with a unique advantage. Concurrently, feedback from visitors and inhabitants of Liede Village frequently uses descriptors like “antique”, “clean and tidy”, and “high class”, suggesting that the village has managed to uphold its cultural heritage while also showcasing distinctive attributes within an urban context. The consensus is that Liede Village's enduring traditional essence is complemented by its distinctive allure, which is evident against the backdrop of contemporary urban life. Keywords such as “catering” and “competitions” mentioned in the user comments indicate that Liede Village provides a wide range of entertainment and leisure services to satisfy different levels of needs. In contrast, Tangxia Village is characterized by its night market. The activities of the night market have been recognized to a certain extent, with comments mentioning “heavy fireworks” and “delicious taste”, indicating the unique charm and attractiveness of the night market. However, the comments also pointed out that “poor supporting facilities” may be the main reason affecting satisfaction, implying that although the night market is attractive, the overall environment and facilities may need further improvement. Liede Village achieved higher satisfaction through its location and cultural preservation, while Tangxia Village, featuring night market activities, was still attracting tourists despite being affected by facility problems.

Liede Village, located in Tianhe District, Guangzhou City, Guangdong Province, is a typical representative of urban villages in the Guangdong-Hong Kong-Macao Greater Bay Area.69 The screened POIs in Liede Village show a dense concentration in the central part of the village and a relatively sparse distribution in the north and south. This distribution characteristic reflects the booming commercial development in the area. The density of commercial facilities usually signifies a strong attraction and forms a hotspot area for foot traffic, and Liede Village excels in this aspect. Combining the heat maps for each period, it is observed that foot traffic is clearly concentrated in the central part of the area and extends to the western business district. First, the aggregation of POI density in the central area reflects the commercial prosperity of the area, marking the central as the core area of the urban village. Second, the central part may double as a community center, gathering infrastructure such as schools and medical institutions, and becoming a core area for community residents to live, work and socialize. Finally, the trend of people flow spreading to the west, especially the heat map extending to the west, suggests the proliferation of commercial activities. This diffusion may be guided by commercial activity in the central part of the neighborhood, gradually extending into the adjacent western business district area. The intertwined trends of commercial prosperity in the central part of Liede Village, the community center function, and the diffusion of the western business district together constitute its unique use condition (Figure 5).

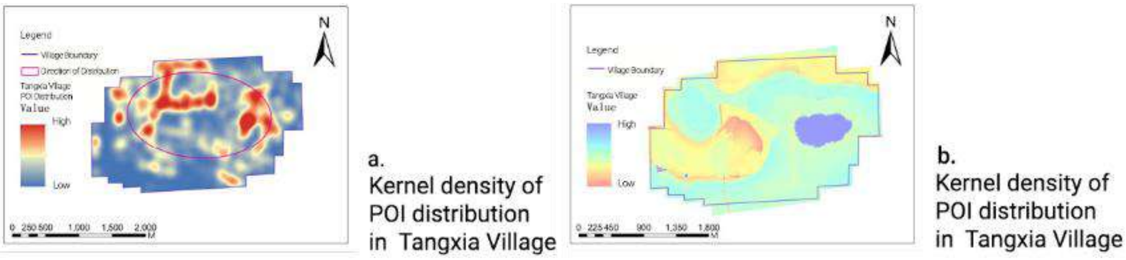


a. Kernel density of POI distribution in Liede Village

b. Heat Map of in Liede Village

Figure 5. Kernel density and heat map of POI distribution in Liede Village

Tangxia Village, located in Tianhe District, Guangzhou City, Guangdong Province. Regarding the distribution of POIs in Tangxia Village, the 5909 POIs screened were mainly concentrated in the north and east of Tangxia Village, showing a ring form. This distribution form reflects the layout of different functional areas in the area, with the north and east carrying more commercial and service facilities. Further observation in combination with the heat map of each period reveals that the pedestrian flow is mainly concentrated in the eastern part of Tangxia Village, which presents a clear fit with the distribution of POI. The observed trend indicates that the eastern sector of the village serves as a hub for significant human congregation, potentially owing to the proliferation of food services and the vibrant night market economy in the area. Furthermore, the eastern portion of Tangxia Village boasts a rich historical legacy, having been established as a settlement for over five centuries. This ancient heritage, with its distinct cultural and historical significance, exerts a notable influence on the current use and perception of the area. The region is characterized not only by its practical functionality but also by its distinctive fusion of historical and contemporary elements, as well as a blend of service offerings and cultural expressions. The dynamics of utilization within Tangxia Village are shaped by a multitude of influences, encompassing commercial activities, population flux, and the area's enduring historical and cultural context (Figure 6).



a. Kernel density of POI distribution in Tangxia Village

b. Kernel density of POI distribution in Tangxia Village

Figure 6. Kernel density and heat map of POI distribution in Tangxia Village

4. Conclusion

The research reveals a pronounced relationship linking the concentration of urban villages to the distribution of Points of Interest (POIs), suggesting an interdependent dynamic that contributes to the formation of the urban landscape. An in-depth analysis of Liede and Tangxia Village highlights their unique features; Liede Village stands out for its vibrant commercial scene and robust community facilities. In contrast, Tangxia Village, known for its lively night market, faces challenges due to insufficient infrastructure, which impacts its overall appeal. The study's findings underscore the multifaceted influences on the utilization of urban villages, including geographical positioning, cultural heritage, and economic activities. Collectively, the research elucidates the spatial patterns of urban villages and their dynamic interplay with the broader urban environment, offering insights for urban planners and policymakers aiming to foster sustainable urban development in the Greater Bay Area.

This paper has some deficiencies in data collection and research methodology, which need to be further improved. First, the insufficiency and inaccuracy of the data is mainly reflected in the collection of information on urban villages. Although Baidu map data was used, due to its limitations, the completeness and accuracy of the urban villages still have problems to be solved, and future work needs to seek for more comprehensive and accurate data sources. Second, a variety of big data sources such as Baidu heat map, POI data, as well as Dianping data were used in the study, but in further improvements, consideration could be given to increasing the dimensionality and depth of the data in order to get a more comprehensive picture of the distribution and utilization of urban villages. Possible improvements include the introduction of additional data sources, such as social media data, population flow data, etc., to capture richer urban information.

Despite the challenges associated with data management, the utilization of big data in urban planning and governance is considered extremely promising. Deeper analysis of data is anticipated to yield a more holistic view of urban village structures, their operational status, and the variables influencing their development. Subsequent studies are encouraged to broaden the scope of data inclusion, taking into account a spectrum of historical, cultural, socio-economic, and other relevant factors. Such an approach would enhance the scientific rigor supporting the sustainable evolution of urban villages across the Guangdong-Hong Kong-Macao Greater Bay Area. The anticipated outcome is to contribute significantly to urban planning strategies and foster social advancement, thereby catalyzing the holistic betterment and sustainability of urban villages within the region.

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Ecodesk: Digital Green Infrastructure Planning Tool for Jiangnan Water Villages

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Abstract

The Jiangnan water villages of southern China embody a unique harmony of agricultural traditions, cultural heritage, and natural ecosystems. However, rapid urbanization has disrupted this balance, fragmenting landscapes with urban and industrial developments while degrading natural and historical features. The traditional Rural Green Infrastructure (RGI) of these villages—comprising farmland, forests, and water networks—faces growing threats from expanding settlements, agricultural intensification, and industrial growth. To address these challenges, government initiatives have focused on restoring RGI through land consolidation, ecological projects, and community improvements, aiming to balance Ecosystem Services (ESs) at multiple scales. A key innovation in our study is the "Ecodesk" digital planning tool, which uses digital twin technology to enhance RGI planning. "Ecodesk" enables detailed mapping of ESs, supports decision-making, and provides value assessments for projects. Its toolkit evaluates greenhouse gas emissions, biodiversity, and economic value while ensuring transparent data monitoring and long-term evaluation. Applied in projects like Shanghai's Shuiku Village, "Ecodesk" has improved planning precision, reduced ecological damage, and better aligned development with human well-being. This digitized approach fosters interdisciplinary collaboration in landscape architecture and introduces innovative methods for sustainable RGI planning, offering a valuable framework for preserving the ecological and cultural heritage of Jiangnan water villages.

Keywords: Jiangnan water villages, rural green infrastructure, ecosystem services trade-off, ecodesk digital tool

1. Introduction

The Jiangnan water villages in southern China are renowned for their distinctive landscape, which harmoniously integrates agricultural practices, cultural heritage, and natural systems (Liu et al., 2022). These water villages, characterized by networks of rivers, farmlands, and forests, have sustained traditional rural life for centuries. However, rapid urbanization and industrialization in the Jiangnan region have significantly altered this landscape, leading to the fragmentation of natural ecosystems, the decline of historical and cultural sites, and the rise of modern urban and industrial elements. This transformation poses significant challenges to the preservation of the rural green infrastructure (RGI) that once defined the water villages (Hindersah et al., 2020).Traditionally, the RGI of these water villages comprised a complex system of farmlands, forests, and water networks, which provided essential ecosystem services (ESs) such as water regulation, food production, and cultural value (Dong et al., 2023). However, the introduction of new settlements, industrial developments, and modern agricultural practices, such as the expansion of ponds, orchards, and plantations, has disrupted the ecological balance. As a result, the local government has initiated various restoration and enhancement efforts aimed at reviving the traditional landscape while addressing the needs of modern development.

Rural Ecosystem Services (rES) are integral to sustainable development, offering unique and indispensable benefits to both urban and rural populations. These ecosystems provide a wide array of services, including agricultural products, biodiversity conservation, nutrient cycling, climate and gas regulation, water retention and purification, pollutant control, aesthetic value, and recreational opportunities (Pereira et al., 2024). Since 2015, there has been a notable increase in the number of countries, academic papers, and institutions dedicated to the study of rural ecosystem services. This research has progressed from examining the fundamental relationships between biodiversity and ecosystem services to investigating the complex interactions among stakeholders within broader social and cultural contexts (Ge et al., 2023). Rural communities, whose well-being is closely linked to these services, often possess a more comprehensive and direct understanding of them (Van Berkel & Verburg, 2014). Studies focusing on agricultural production have enhanced our understanding of how agricultural policies and development impact ecosystem services. For example, Jiao YM et al. explored the influence of rural landscapes in Japan on biodiversity and ecosystem service functions, highlighting connections between biodiversity loss, ecosystem services, and human well-being (Jiao et al., 2019). Additionally, other scholars have examined the agricultural production value of services provided by rural ecosystems from various perspectives, suggesting future directions for agricultural policy and research development (Awasthi et al., 2017; Maier et al., 2021; Nieto-Romero et al., 2014; Torralba et al., 2016).

These government-led initiatives focus on land consolidation, ecological restoration, watershed management, and community environmental improvements. A key challenge in these efforts lies in balancing ecosystem services across different scales—from regional to village-level planning—while integrating inputs from multiple fields, including ecology, water management, soil science, and environmental engineering (Turner et al., 2016). Additionally, the complexity of the ecological and human environments in the Jiangnan region requires precise mapping, efficient restoration strategies, and the ability to quantify both investments and the resulting ecosystem service outputs. To address these challenges, a new digital planning tool, "Ecodesk," has been developed to support the restoration and sustainable management of RGI in the Jiangnan water villages. This tool employs advanced digital technologies, such as digital twins, to enable precise identification, dynamic mapping, and the evaluation of ecosystem services. By providing a structured workflow for RGI planning, "Ecodesk" facilitates the assessment of greenhouse gas emissions, biodiversity, ecological health, and socio-economic values, aiding in the creation of sustainable and resilient landscape planning solutions.

2. Material and Method

a. Jiangnan water villages

The Jiangnan water villages in southern China exhibit a unique landscape pattern that integrates agricultural life, cultural production, and local natural system characteristics. The traditional RGI in the water villages is mainly composed of farmland, forests, and water networks. "Jiangnan Water Villages" is a geographical and cultural concept in the lower reaches of the Yangtze River in eastern China. The Yangtze River Delta has a long-standing tradition of land reclamation, polder construction, and intensive agricultural production, which has transformed the original swamps and peatlands into regions rich in rice, fish, and silk production.

Shuiku Village, located in Jinshan District, Shanghai, exemplifies the city's characteristic water villages. The village's unique island-like landscape originated from sediment deposits by the Yangtze River, which were subsequently reclaimed through human intervention. This reclamation has resulted in a network of 39 rivers with a total length of 28.91 km, contributing to a water area ratio of approximately 40%. Despite this extensive river network, the dense distribution primarily forms cutoff hills, which disrupt water circulation and result in inadequate hydrodynamic power. Before 2019, the village's economy was predominantly based on agriculture and farming. However, these activities led to environmental challenges, as surface source pollution from farmland and unregulated fish and shrimp farming introduced contaminants into the water. The direct discharge of untreated wastewater into the rivers further exacerbated water pollution and diminished biodiversity in the area.

b. Multi-scale and interdisciplinary assessment of RGI ecosystem services

The multi-scale and interdisciplinary assessment of RGI ecosystem services is critical for understanding and optimizing ecological, social, and economic outcomes. As shown in the Figure 1, RGI assessments are conducted at regional, village, and project scales, each involving distinct spatial and functional complexities. At the regional scale, broader ecological networks and landscape-level interactions are evaluated, while village-scale assessments focus on community-level impacts and land-use patterns. Project-scale evaluations zoom in further, addressing site-specific interventions and their immediate effects on the ecosystem. This multi-layered approach is facilitated by a collaborative digital base, which integrates data from various sources, ensuring precise analysis and decision-making across different scales.

Interdisciplinary collaboration is essential for comprehensive RGI assessments, drawing expertise from multiple professions such as water resources, soil science, environmental science, and ecology. These professionals contribute to evaluating ecosystem services through social, ecological, and economic lenses, providing a holistic view of RGI performance. For instance, water resource experts assess hydrological functions, while soil scientists focus on nutrient cycling and soil health. Ecologists evaluate biodiversity and habitat restoration, and environmental specialists monitor pollution control and climate regulation. This integrated, multi-professional approach ensures that RGI projects are designed and managed to maximize ecosystem services while minimizing ecological degradation, contributing to sustainable rural development.

Figure 1. Multi-scale and interdisciplinary framework for assessing RGI ecosystem services

3. Findings and Discussion

a. Precise identification based on ESs trade-offs

A comprehensive approach to spatial governance mapping and classification transcends traditional siloed data collection methods by integrating standards and insights from multiple disciplines. This holistic assessment framework acknowledges that effective spatial planning and management necessitate interdisciplinary considerations that extend beyond simplistic dimensional requirements. By incorporating the expertise of various professions, this mapping process facilitates a more nuanced evaluation of ecological protection areas, taking into account the local environment and its defining characteristics. This methodology is fundamentally centered on the application of advanced remote sensing technologies. Specifically, it employs low-altitude multispectral scanning conducted by unmanned aerial vehicles (UAVs) over key feature plots (Figure 2). This approach enables the system to capture detailed aerial data, which is crucial for interpreting the ecological quality of various waterfront areas. By analyzing indices such as the normalized difference vegetation index (NDVI) and the normalized difference red edge index (NDRE), the system can accurately identify natural river channels and other significant landscape features (Wei et al., 2023). This granular level of detail is indispensable for guiding precise spatial planning and effective environmental conservation efforts.

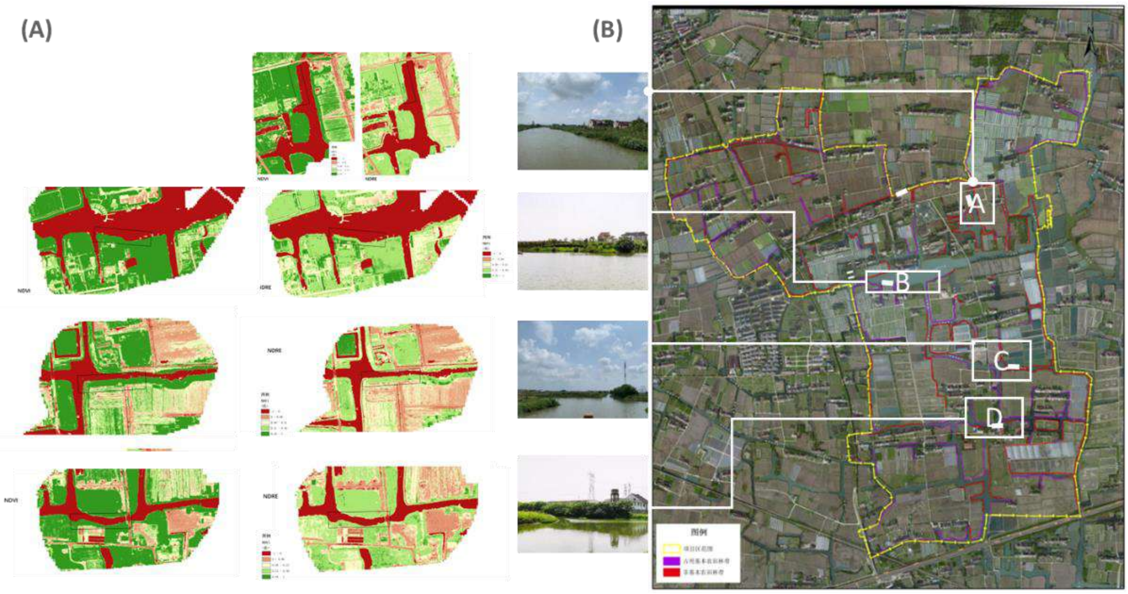

Figure 2. (A) Multispectral index identification (NDVI and NDRE) identification of natural river channels; (B) UAV flight location and route.

To assess the supply-demand characteristics of ecosystem services in rural riparian zones, we divided these areas into research units based on land use types. Utilizing value assessment methods, we evaluated the supply and demand of ecosystem services within these zones. Radar charts were employed to clearly illustrate the balance between supply and demand. This approach highlights the diverse landscapes and contexts in which these riparian zones exist, ranging from residential and industrial areas to agricultural fields and natural greenspaces (Figure 3). This underscores the regional differences in socio-economic development that can shape the demand for riparian ecosystem services. By acknowledging and accounting for these contextual factors, the research approach ensures that the proposed restoration and management strategies are tailored to the specific needs and constraints of each unique riparian zone, ultimately enhancing the effectiveness and long-term sustainability of ecosystem conservation efforts. This approach aids in understanding the ecological restoration needs of riparian zones across different land use units. Regional variations in socio-economic development can influence the demand for riparian zones and their ecosystem service capacity.

Figure 3. Radar charts of ecosystem service capacity for different riparian areas.

3.2 Data-driven workflow practices for RGI ecological restoration

In the realm of ecological restoration for rural ecosystems, employing data-driven workflow practices is crucial for fostering biodiversity and enhancing habitat quality. The classification of indicator species based on their specific habitat types allows for a detailed understanding of their ecological requirements and interactions within the environment (Figure 4). To evaluate the intensity of human-induced habitat disturbances, we analyze four dimensions: habitat suitability, the impact of production factors, the influence of living factors, and the effects of recreational activities. This multi-faceted approach culminates in the identification of habitat suitability zones tailored to each indicator species, ensuring that conservation efforts are both targeted and effective.

Additionally, by integrating spatial and temporal data on human agricultural practices with the survival habits of indicator species, we can pinpoint critical areas and times where human activities may conflict with wildlife needs. This analysis not only highlights the pressures faced by these species but also informs strategies to mitigate negative impacts, such as adjusting agricultural practices or altering recreational activities. The findings serve as a foundation for a planning framework that prioritizes biodiversity enhancement while accommodating human use of the land, leading to a balanced coexistence of ecological and economic interests.

To further refine habitat management, we categorize the overall habitat of Shuiku Village into two hierarchical levels. The first level consists of six primary habitat categories: fields, water, village, forest, green space, and wasteland. Each of these categories is then subdivided into second-level classifications based on specific characteristics such as habitat morphology, production functions, and vegetation types. This structured classification system enables a thorough understanding of the ecological landscape, guiding targeted restoration efforts and resource allocation to areas where interventions can yield the greatest ecological benefits. By employing this comprehensive approach, we aim to create resilient ecosystems that support both biodiversity and sustainable human activities.

Figure 4. Spatial distribution of potential threat of birds and frogs.

3.3 Multi-tool integrated for comprehensive RGI planning

Our digital planning toolkit incorporates Ecodesk's proprietary analysis software and collaboratively developed toolkits. Among these are various ESs-based tools, such as EnhancES (Stoycheva & Nedkov, 2024). This comprehensive suite of tools facilitates a more holistic assessment of RGI areas (Figure 5). Methods for ES assessment have significantly diversified, emphasizing analysis and mapping based on land use and land cover conditions (Martínez-Harms & Balvanera, 2012; Swetnam et al., 2011) . Notably, quantitative assessment tools such as the InVEST (Yang et al., 2019), SoLVES (Semmens et al., 2019), and ARIES (Bagstad et al., 2014) models have become prominent for their spatially explicit methods in ecosystem service assessment, serving as essential tools for both academic research and governmental decision-making (Koellner et al., 2019; Turner et al., 2016). By integrating multiple tools for RGI planning, planners and decision-makers can achieve a broader perspective on the ecological, economic, and social values of the regions under consideration. This integrated approach supports informed and sustainable planning decisions.

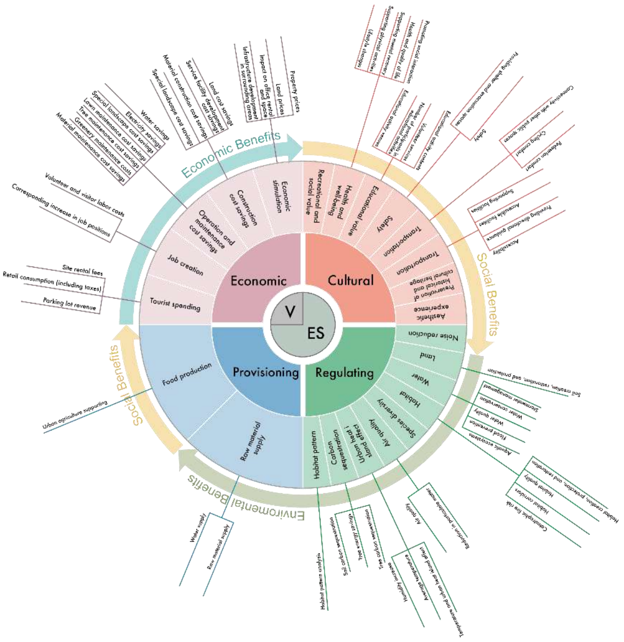

Figure 5. ESs and ESs values in rural green infrastructure planning.

4. Conclusion

As rapid urbanization continues to challenge the ecological integrity of these culturally rich landscapes, the adoption of data-driven methodologies and advanced technologies is crucial for effective restoration and management practices. Through its multi-scale assessment capabilities, "Ecodesk" enables planners to make informed decisions that balance ecological health with socio-economic needs, ultimately contributing to the resilience of these rural ecosystems. The integration of the "Ecodesk" digital planning tool into the management of RGI in the Jiangnan water villages represents a significant advancement in the pursuit of sustainable landscape planning. This innovative tool not only enhances the precision of ESs assessments but also facilitates interdisciplinary collaboration among various stakeholders, including ecologists, urban planners, and local communities. The findings from the application of "Ecodesk" in Shuiku Village underscore the importance of tailored strategies that consider local contexts and specific environmental conditions. By fostering an understanding of the intricate relationships between ecosystem services and human activities, this tool supports the development of sustainable practices.

The implementation of the "Ecodesk" digital planning tool presents several limitations that need to be addressed. Firstly, its application scenarios are primarily focused on the specific ecological and socio-economic contexts of Jiangnan water villages, which may restrict its adaptability to other regions with different environmental conditions. Additionally, the effectiveness of the tool is constrained by the diversity of ecological scenarios, as variations in land use, hydrology, and climate can affect the accuracy of ecosystem service evaluations. Furthermore, the universality and accessibility of the foundational ecological data that "Ecodesk" relies on can pose challenges, particularly in areas where comprehensive and updated data is lacking. This limitation highlights the necessity for improved data collection and standardization efforts to ensure that ecological information is robust and widely available, ultimately enhancing the tool's applicability across diverse landscapes.

In conclusion, the persistent dedication to incorporating digital tools of "Ecodesk" into RGI planning significantly enhances the ecological sustainability of Jiangnan water villages. This approach also provides a model for other rural areas experiencing the pressures of urbanization. Future research should focus on exploring the application of advanced technologies in ecological assessments and investigating the potential for scaling these practices to broader contexts. By fostering collaborative efforts and employing innovative strategies, we can establish a more sustainable coexistence between human development and natural ecosystems in rural areas.

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Quantifies Human Perception of Riverside Spaces from Network Text Data

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Abstract

Chongqing's special geographic and geomorphic conditions make the riverside public space very characteristic and gather high recreational vitality. Chongqing's discussion on social media has been high, and the emotions contained in a large number of social media comment texts can truly reflect the perceptions and feedbacks of the users on the environment. Therefore, the study selected fifteen public spaces with high recreational vitality along the "Two Rivers and Four Banks" in Chongqing, and use social media text data to explore riverside scene perception. Constructs the perception content framework of riverside scene, "landscape elements - service facilities - behavior - environment atmosphere". In the perception evaluation, natural landscape elements pay the most attention, and the perception evaluation of natural and human landscape elements is more distinct, as well as the three main environmental atmosphere of the riverside. And summed up the application of scene theory in the riverside green open space of the fit, transformation and difficulties in three aspects. The results are helpful to provide the research basis for future summarizing the perceptual law of the riverside scene. The research of riverside scene perception can provide effective theoretical basis and practical guidance for the sustainable construction of riverside public space.

Keywords: Network text data, perception evaluation, riverside space, social media data, scene theory

1. Introduction

The riverside space of Chongqing has its own characteristics, which is characterized by vertical spatial structure, dynamic hydrological change and unique urban culture. In terms of natural ecological environment, the complex vertical spatial structure is affected by topographic fluctuations. The seasonal variation of the landscape is due to the special fluctuation of water level in the Three Gorges Reservoir area. In terms of urban development, the rich elements of the riverside area constitute the new brand of the magic city, and with the construction process of the two rivers and four banks, the life atmosphere of the riverside space began to recover gradually. The riverside area of Chongqing is a combination of local characteristics and urban humanities. To understand how the public perceive the elements of public space along the riverside is a prerequisite for better utilization of these special resources, and an important issue for the construction of high-quality urban living space along the riverside in the inventory era.

In the process of urban transformation, Clark (2013) have summarized the theoretical framework of scene, which emphasizes the attention to local aesthetic characteristics and cultural styles (Kwon, 2004), and attaches importance to the spiritual and cultural value of space.It also puts forward the quantification of abstract urban culture by the combination of comforts, and refines and summarizes the analytical dimension of the scene.The reason why "scene" has received attention at present is that this theory has well integrated the concern of people in the discussion of urban space (Wu, 2014), and this concern is not only functional, but also includes more in-depth content such as group characteristics and subjective experience.In recent years, urban scene construction in China has also received more and more attention (Ying, 2022). On the one hand, the urban policy emphasizes scene construction, Chengdu first systematically combines the concept of scene with the development concept of park city (Wang et al., 2021), Shenzhen also has more exploration in the park scene, Jiangsu, Jinan and other cities issued the relevant guidelines for scene construction, Xiaoshan issued the guidelines for child-friendly scene construction. On the other hand, academic researchers mostly focus on city (Chen & Lin, 2020; Li et al., 2022; Wang et al., 2021; Zhou & Cheng, 2021), region(Huan et al., 2022), community (Huang et al., 2023; Zhao et al., 2021), street scale from the perspective of scene theory. The upper planning of scene system suitable for larger scale is put forward from the aspect of overall urban resource system and function positioning. The systematic scene system has the characteristics of high overview and direction guidance, but it can not reflect the diversity of scenes in each micro-scale space. At present, the research of specific scenes in the medium and micro spatial scale is relatively insufficient (Chen & Pang, 2022; Zhang, 2022). Moreover, There are few studies to explain how the ideal scene system is implemented in the physical space, including the relationship between the organizational relationship of spatial elements and the formation of scenes, the occurrence mechanism of urban spontaneous scenes, and the subjective perception of the public in scenes.

Social media data is often used to quantify public perception. In recent years, many comments published on social media have been used to evaluate urban landscape perception (Yu et al., 2020; Yuan et al., 2024), situational perception models and mechanisms of historical and cultural blocks (Nan et al., 2023). Benefiting from the huge amount of data, this research method is becoming more and more mature. With the popularity of social media, social media data will become more and more abundant, which is of great significance for learning the real experience of the public. Of course, such research methods must pay attention to the protection of personal information privacy issues.

This research focuses on Chongqing's riverside public space, extracts the types and perceptual rules of Chongqing's riverside scenes perceived by the public through social media data, and better understands the local aesthetic characteristics and cultural styles in Chongqing's riverside life. This paper will specifically discuss the corresponding relationship between social media data and riverside scenes, extraction of scene perception content, and quantitative perception evaluation.

2. Material and Method

In Chongqing, the scene along the riverside in the area of two rivers and four banks is varied. Public space, especially the green open space, is the main space to provide citizens with leisure activities and is also an important carrier to restore riverside life.The research scope is selected from the public space of the Two Rivers and Four Banks in Chongqing, and the horizontal scope is from the water level in dry season to the first row of buildings or construction land on the riverside.The research object is the green open space in the public space, including parks, squares, walkways, river beaches and active nodes in the subsidence zone. According to the review data of Dianping, 15 Spaces with a certain number of reviews within the research range were selected for the analysis samples (Figure 1). They are the Tashan Urban Park, Big Fish and Asiatic Apple Park, Coral Park, Binjiang Park, Tongbin Park, Xiangguo Temple Pier, Yaba Dong Washland Park, Yacht Square, Jiulong Square, Hugui Stone Terrace Park, Jiangbeizui Washland Park North, Jiangbeizui Washland Park South, Haitang Rain Park, Chaotianmen Square, Bell Tower Plaza.

Figure 1. Fifteen study samples

The study used Octopus crawler to collect a total of 3,655 review data from 15 samples, including review text content and satisfaction data on the five-point Likert scale. Data processing Use python to call jieba word segmentation for preliminary text analysis. The types of words are sorted out, corresponding to the conceptual connotation of scene theory, and the frequency of key words is calculated to obtain the public's subjective perception of spatial elements and scene characteristics. netdraw was used to draw a semantic network map to obtain the correlation between spatial elements and subjective feelings in public recreation perception.

3. Findings and Discussion

Figure 2. Four kinds of perceptual content

By summarizing high-frequency words and combining with the scene connotation of Riverside public space, this paper divides the overall scene perception content of Riverside into four categories: landscape elements, service facilities, crowd behavior and atmosphere experience (Figure 2).

Landscape elements and service facilities together constitute the material structure of the riverside scene. Landscape elements reflect the public's strong perception of spatial structure. Among these elements, the top five are riverside, night view, opposite bank, lawn and trail. Landscape elements include three subcategories: natural landscape, human landscape and temperature and climate. Service facilities show the public's perception of functional structure, the top five are:

transportation, Chongqing Grand Theatre, parking, parking, navigation. The whole can be divided into basic services, spiritual services, consumer services.

Behavior is the triggering condition of the scene, and the occurrence of activities is simultaneously affected by space, time and crowd. The behavior is divided into three sub-categories: activity type, target group and activity time. Activity type is one of the important indexes to define micro-scene. The target group is the main user of Riverside public space. Identifying the group helps to infer the "social group" easily formed in the space, and plan corresponding scenes to improve the spatial attractiveness of the target group. Not only does time have distinct seasonal variations, but each time of the day has different scenic features and behavioral preferences.

Material structure and behaviors belong to the entity characteristics that can be directly observed in the scene, and they have intuitive and explicit characteristics. The ambient atmosphere has no actual carrier, but as an "intangible element" that can be perceived objectively exists in three-dimensional space, it is also one of the important contents of the scene (Gandy, 2017; Griffero, 2014).

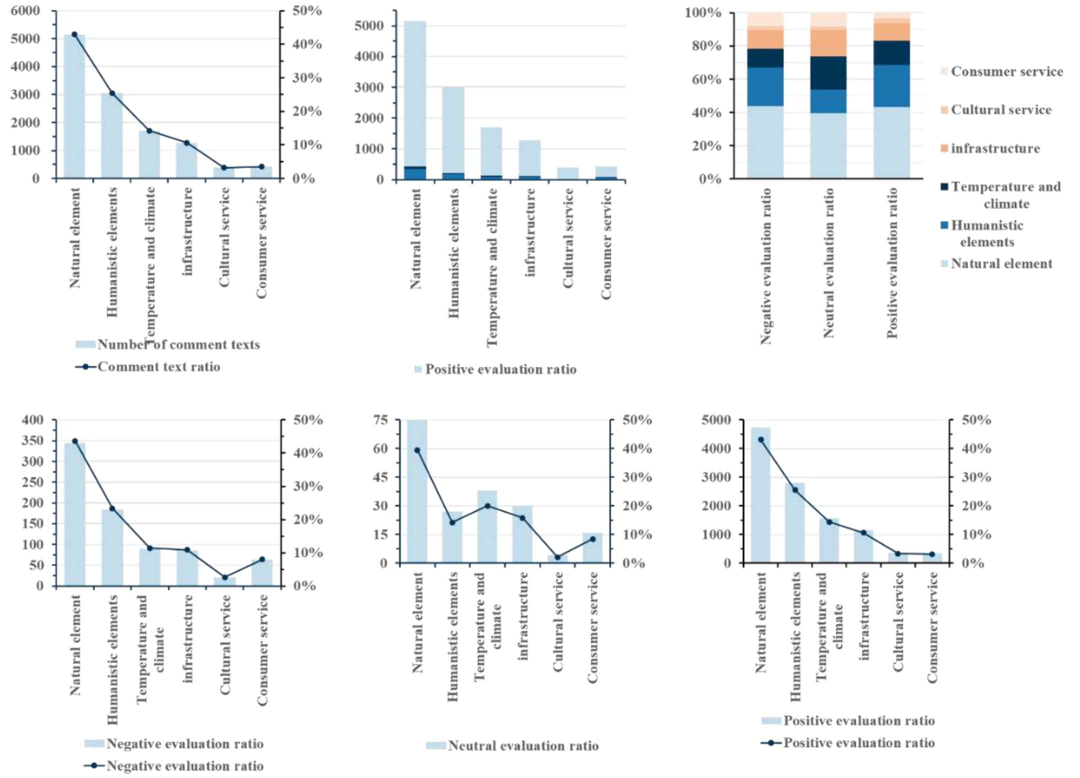

Figure 3. The perception of six elements of scene spatial structure

Keyword word frequency can represent the public's attention to this element, and attention is the expression of being attracted (Figure 3). From the perspective of overall factor concern, natural landscape 43%> cultural landscape 25%> temperature and climate 14%> basic services 11%> consumer services 4%> cultural services 3%. The attention of landscape elements (spatial structure) obviously exceeds that of facilities services (functional structure), while natural elements receive the most attention and cultural services the least.

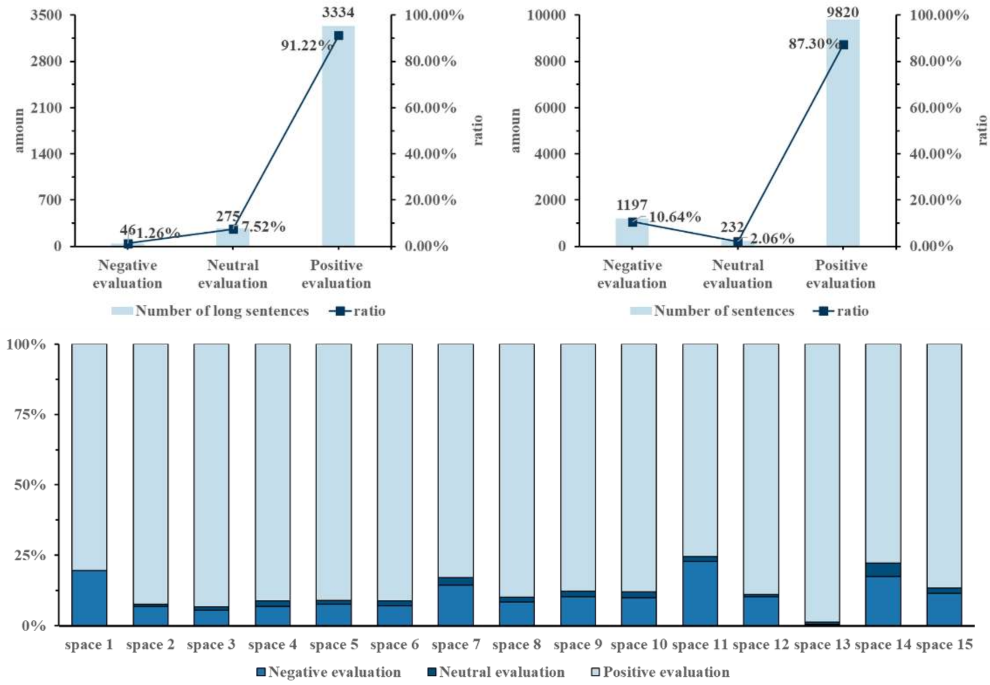

Figure 4. Emotion analysis of scene perception

From the perspective of the overall perception tendency(Figure 4), positive perception is the most prominent, and the perception of the six types of comfort objects presents the results of positive evaluation > negative evaluation > neutral evaluation, among which consumer service perception has the highest proportion of negative comments, followed by infrastructure. The proportion of factors in the perception evaluation of the three tendencies is slightly different. The negative and positive perceptions pay almost the same attention to the factors except consumption facilities, while the neutral evaluation pays less attention to the human landscape and pays less attention to the temperature climate and infrastructure. It can be inferred that compared with the temperature climate and urban infrastructure system which are more difficult to disturb. The public's perception and evaluation of natural landscape and human landscape elements that are easier for manual intervention are more distinct.

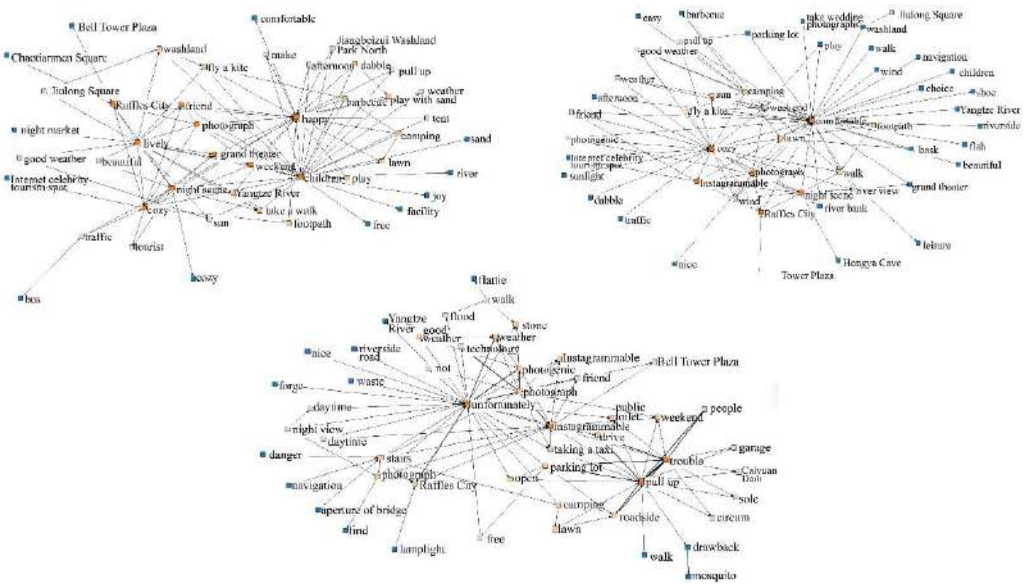

Figure 5. Three typical emotions in riverside scene perception

Extract the keywords describing the subjective experience emotion, happy - lively, comfortable - comfortable, regret - trouble three groups of emotions are the most significant(Figure 5). According to keyword search, the comments on emotion are put forward separately for social network analysis, and the perceptual content highly related to emotion is obtained. The socio-semantic network structure of the happy and lively emotion group involved landscape elements, crowd activities and service facilities, in which landscape elements accounted for the highest proportion and service facilities accounted for the lowest proportion. In the comfortable feeling group, landscape elements accounted for the highest proportion, and the perceived core degree of crowd activities was the highest. Unfortunately, in the trouble emotion group, it is mainly divided into hydroclimate-induced flooding and weather conditions, parking and traffic conditions of basic service facilities, as well as dangers and large numbers of people belonging to the atmosphere of space, in addition to the important factor of mosquitoes.

4. Conclusion

This paper studies the establishment of a framework for the association between riverside scene connotation and social media data, obtains a preliminary scene perception evaluation through data combing and induction corresponding to scene elements, and explores the possibility of quantifying riverside scene perception with social media data. The problems of sample type selection and the amount of comment data in this preliminary study will be adjusted in the subsequent continuous research, which will also deeply interpret the content of perception evaluation and further summarize the perception law of riverside scene.

The research shows that the application of scene theory in green open space needs to pay attention to three aspects: theory fit, transformation and difficulty.

The fit between scene theory and green space is mainly reflected in three aspects: First, the core of theoretical focus is highly matched with spatial characteristics, emphasizing the attraction of spatial culture and aesthetic characteristics. Second, the operability of the theoretical analysis framework provides the idea of quantifying the abstract spatial value of the comfort system. Third, the consumption orientation is consistent with the current spatial development trend. The spatial value is no longer just an emphasis on ecological value. The quality of green space also includes its role in promoting the happy life of urban residents and the urban economy and consumption.

There are still some contents that need to be transformed between scene theory and green space, mainly in three aspects: problem orientation needs to be discussed, that is, there is a contradiction between the consumption orientation of scene theory and the public nature of green space. The nature of green space is public open, enjoyed by the public, as a kind of social welfare is also one of its existence significance, these nature determines that the goal orientation of its scene construction can not only emphasize the consumption goal. The composition of elements needs to be discussed, especially the concrete form of existence of the two key factors, scene theme and comfort, in the green open space needs to be transformed. In terms of theme, the neighborhood atmosphere applies to the community, what should be the scene theme of the green open space, and what scene atmosphere needs to appear in the green space needs to be redefined. In terms of comfort items, there are two forms of consumption stimulus generated by green space. One is that consumption behavior occurs inside green space, such as shopping in park stores; One is that the consumption behavior takes place outside the green space, but the activity takes place inside the green space, such as camping. Therefore, how to calculate the spatial elements like lawns still needs to be transformed. The evaluation dimension needs to be discussed. The evaluation dimension constructed in scene theory is more effective for the evaluation dimension of city-scale public space, and the evaluation dimension of green space needs to refer to this framework and combine with the characteristics of green space.

The difficulty of using scene theory to discuss green space lies in the complexity of comfort system. Different from the rough division of nature, functional facilities and consumption facilities in the urban scale, the comfort system in the green space needs to re-sort the relevant elements inside and around the green space under the comfort discourse system. The comfort system of different types of green space is very different, and there are overlaps of comfort. The spatiotemporal variability of the scene. The method of expressing urban culture with comfort objects system has its own comfort objects carriers at different scales. At the macro and meso levels, the scene formed by objective functions as comfort objects is relatively fixed, which does not change with the coming and going of crowds and the passage of time, while the scene in the green space is mostly formed by crowd activities. When the crowd leaves, the scene disappears and only space remains. The same green space can have multiple scenes at different times, and how to define the scene needs further discussion. The extraction of scene value and the benefit representation of green space are research topics that need to be discussed. Social media data provide possibilities in providing the public with environmental experience, and how to define the benefits and values contained in these data from the perspective of scene theory needs to be explained.

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An Interconnected Conceptual Reading Between Practice & Theory in Search for A Lexicon

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Abstract

Although the fields of theory, design and practice of contemporary architecture share a common language, the perception of the meanings expressed by the terms of this language begins to diverge at different stages of the discipline. The increasing use of generative design tools and artificial intelligence applications in spatial design creates the need for a better understanding of the language and its meaning. Due to trace the changing discourses in landscape architecture and urban design, this study aims to analyze the current conceptual universe of landscape architecture by transforming it into numerical data through a textual reading based on the "corpus" technique.

This study seeks to answer these questions by analyzing the "speculations and performative contents" of landscape design projects produced in the last 10 years. Within the framework of the research, 45 competition specifications on urban design and landscape architecture published between 2014 and 2024 were scanned, and numerical and visual findings regarding the content of the conceptual world of landscape architecture were attempted to be revealed.

In order to analyze the content of current urban design competition projects extracted from the raw corpus, the method we will follow in this research will be "content analysis". The concepts to be obtained from the content analysis will be taxonomically separated from the specifications of the urban design project competitions and placed in a network map showing the periodic importance of each concept according to the result of frequency analysis.

Keywords: Data conceptualization, AI, knowledge taxonomy, landscape architecture, urban design

1. Introduction

Although the fields of theory, design and practice of contemporary architecture share a common language, the perception of the meanings expressed by the terms of this language begins to diverge at different stages of the discipline. While current design theories constitute a leading terminology both in higher education and in practice, the relationship between the meaning of this terminology and its manifestation in spatial design is gradually weakening. The increasing use of generative design tools and artificial intelligence applications in spatial design creates the need for a better understanding of the language and its meaning. Many popular generative AI programs and services manipulate images based on natural language commands. Although much research has been done and much theory has been produced in this field, there has been no common terminology focusing on the coordination of these tools in theory, design and practice.

The field of architecture offers us an ever-changing and evolving universe of concepts, in other words, a universe of concepts with a fluid character. As this multiple fields of knowledge evolves within itself, it is influenced by developments in both theory and practice. However, to see the interactions effectively, it is necessary to create a bridge/portal between practice and theory, especially in conceptualization. This study aims to analyze the speculations and performative contents of recent design projects in order to understand the level of interaction/fluctuation between the hypothetical background of the theoretical universe and the current debates in the universe of practices. By comparing the different universes of landscape architecture discipline, we hope to create a visual network map of the relationships between ideas.

2. Material and Method

This study aims to reveal the changes and interactions in the discourse of landscape architecture by analyzing the “speculations and performative contents” of landscape design projects produced in the last 10 years. In understanding the changes and interactions in the discourse of landscape architecture, the texts produced within the discipline are among the most important data sets. In this context, the specification texts produced for competitions constitute the sample of the research as a recorded source containing the most data in comparing the theoretical and practical fields of landscape architecture and monitoring periodic changes by years. Within the scope of the research, 45 competition specifications on urban design and landscape architecture published between 2014 and 2024 will be scanned and numerical and visual findings regarding the content of the conceptual world of landscape architecture will be revealed.

Within the scope of the study; in order to trace the changing discourses, breaking points and theoretical backbone in the city-landscape-architecture interface in the last 10 years, the current conceptual universe of landscape architecture will be analyzed by transforming it into numerical data with a textual reading based on the “corpus” technique with the help of artificial intelligence tools.

“In linguistics and natural language processing, a corpus (plural: corpora) or text corpus is a dataset of annotated or unannotated, naturally digital and older, digitized language resources. Annotated corpora have been used in corpus linguistics for statistical hypothesis testing, checking occurrences or verifying linguistic rules within a given language region. In search technology, a corpus is a collection of searchable documents (Gries, 2009).

Since there is no “corpus” that compiles the current discourse literature of landscape architecture, which is the focus of this research, a corpus was first created to cover the relevant topic. Different corpus types can be used depending on the study to be conducted. These are;

- Raw corpus: A corpus of texts without any labeling or annotation.

- Labeled corpus: A corpus in which words or phrases are tagged with information such as grammatical categories or semantic tags.

- Annotated corpus: A corpus that contains information explaining aspects of the texts such as grammar, style or pragmatics.

At the beginning of the study, in order to conduct content analysis, a corpus study based on the texts published in the field of landscape architecture to date was needed, but no corpus study was found in the literature for both landscape architecture and related professional disciplines. For this reason, the conceptual texts of the competition specifications were used as conceptual data, both in terms of their ability to provide chronological data and the opportunity to follow the views of various disciplines. By scanning the competitions held between 2014 and 2024 in the field of urban design and landscape architecture, the texts of 45 competition specifications (Table 1), which can be directly related to the large-scale urban design context of the last decade, were compiled, their contents were filtered and a "raw corpus" that can be used for analysis was created.

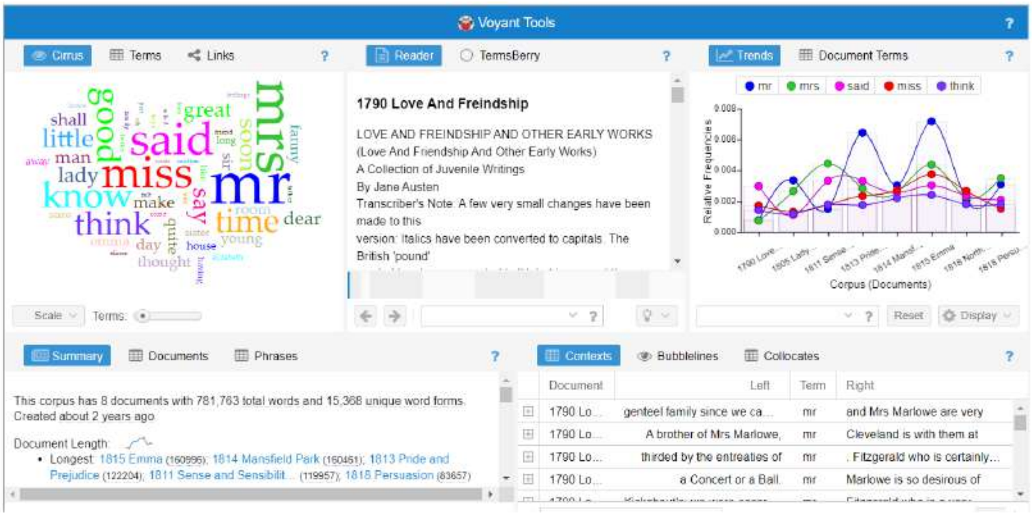
Table 1. The list of competitions chosen as case study

No	Name of the competition	City	Year	The Organization
1	ANAMUR ATATEPE SOCIAL CENTER AND ITS SURROUNDINGS NATIONAL ARCHITECTURAL PROJECT COMPETITION	Mersin	2014	Anamur Municipality
2	KONYAALTI WATERFRONT AREA ARCHITECTURE AND URBAN DESIGN PROJECT	Antalya	2014	Antalya Metropolitan Municipality
3	LAPSEKI GOVERNMENT MANSION AND ITS SURROUNDINGS ARCHITECTURAL PROJECT COMPETITION	Çanakkale	2014	Lapseki District Governorship
4	DÜZCE UNIVERSITY KONURALP CAMPUS DEVELOPMENT PLAN URBAN DESIGN COMPETITION	Düzce	2014	Düzce University Rectorate
5	ANTALYA KEPEZ MUNICIPALITY FOCAL BUILDING ARCHITECTURAL AND LANDSCAPING IDEA PROJECT COMPETITION	Antalya	2015	Kepez Municipality
6	BEYLİKDÜZÜ MUNICIPALITY VALLEY OF LIFE, BRIDGE AND CONNECTIONS COMPETITION	İstanbul	2015	Beylikdüzü Municipality
7	ARCHITECTURAL AND URBAN DESIGN PROJECT COMPETITION FOR TEKİRDAĞ METROPOLITAN MUNICIPALITY SERVICE BUILDING, SQUARE AND ITS SURROUNDINGS	Tekirdağ	2015	Tekirdağ Metropolitan Municipality
8	19 MAYIS TRACE URBAN DESIGN COMPETITION	Samsun	2016	Samsun Metropolitan Municipality
9	ADANA - SEYHAN SUCUZADE NEIGHBOURHOOD URBAN TRANSFORMATION AREA URBAN SQUARE AND ITS SURROUNDINGS URBAN DESIGN AND ARCHITECTURAL PROJECT COMPETITION	Adana	2016	Seyhan Municipality
10	SİVAS KIZILIRMAK AND ITS SURROUNDINGS IDEA PROJECT COMPETITION	Sivas	2016	Sivas Municipality
11	ANTALYA KEPEZ MUNICIPALITY WEAVING AREA IDEA PROJECT COMPETITION	Antalya	2017	Antalya Kepez Municipality
12	BANDIRMA ONYEDİ EYLÜL UNIVERSITY CENTRAL CAMPUS URBAN DESIGN COMPETITION	Balıkesir	2017	Bandırma Onyedi Eylül Üniversity
13	BURSA OSMANGAZİ MUNICIPALITY CEKIRGE SQUARE ARCHITECTURAL, URBAN DESIGN AND LANDSCAPE DESIGN PROJECT COMPETITION	Bursa	2017	Bursa Osmangazi Municipality
14	GELIBOLU HISTORICAL SITE - NEW MARTYRDOM DESIGNS IDEA PROJECT COMPETITION	Çanakkale	2017	Çanakkale Wars Gallipoli Historical Site Presidency
15	NEIGHBOURHOOD DESIGN IDEA COMPETITION	General	2017	İller Bankası Incorporated Company
16	IZMIR KARABAĞLAR MUNICIPALITY PUBLIC OPEN SPACE AND CITY SQUARE URBAN DESIGN PROJECT COMPETITION	İzmir	2017	İzmir Karabağlar Municipality
17	LÜLEBURGAZ MUNICIPALITY TOSBAGA CREEK RECREATION AREA IDEA PROJECT COMPETITION	Kırklareli	2017	Lüleburgaz Municipality
18	NEMRUT CALDERA VIEWPOINTS ARCHITECTURAL PROJECT COMPETITION	Bitlis	2017	Bitlis Valiliği Special Provincial Administration
19	7 CLIMATES 7 REGIONS - NEIGHBOURHOODS NATIONAL ARCHITECTURAL AND URBAN DESIGN IDEA COMPETITION	General	2017	TOKİ - Emlak Konut REIT Inc.
20	ODAKULE PASSAGE NATIONAL DESIGN COMPETITION	İstanbul	2018	İstanbul Chamber of Industry
21	IDEA PROJECT COMPETITION FOR COASTAL AND RECREATION ARRANGEMENT BETWEEN TEVFİK SİRRİ GÜR STADIUM AND ÇAMLIBEL PORT	Mersin	2018	Mersin Metropolitan Municipality
22	OLİVELO IZMIR ECOLOGICAL COMMUNAL LIVING SPACE IDEA PROJECT COMPETITION ON THE CITY PERIPHERY	İzmir	2019	İzmir Metropolitan Municipality
23	BURSA HAN REGION ÇARŞİBAŞİ URBAN DESIGN PROJECT COMPETITION	Bursa	2020	Bursa Metropolitan Municipality
24	HALIC COAST DESIGN COMPETITION	İstanbul	2020	İstanbul Metropolitan Municipality
25	BAKİRKÖY SQUARE URBAN DESIGN COMPETITION	İstanbul	2020	İstanbul Metropolitan Municipality
26	KADİKÖY SQUARE URBAN DESIGN COMPETITION	İstanbul	2020	İstanbul Metropolitan Municipality
27	SALACAK URBAN DESIGN COMPETITION	İstanbul	2020	İstanbul Metropolitan Municipality
28	TAKSİM URBAN DESIGN COMPETITION	İstanbul	2020	İstanbul Metropolitan Municipality
29	COMMEMORATING MASTER SINAN IN ÜSKÜDAR	İstanbul	2020	İstanbul Metropolitan Municipality
30	10 OCTOBER MONUMENT AND MEMORIAL PROJECT COMPETITION	İzmir	2020	İzmir Metropolitan Municipality
31	KAYSERI TALAS MEVLÂNA NEIGHBOURHOOD SQUARE NATIONAL IDEA COMPETITION	Kayseri	2020	Kayseri Talas Municipality
32	MELES CREEK AS AN URBAN AND ECOLOGICAL BACKBONE NATIONAL URBAN DESIGN IDEA PROJECT COMPETITION	İzmir	2020	İzmir Metropolitan Municipality

33	UŞAK MUNICIPALITY PEDESTRIANISED STREETS ARCHITECTURE - URBAN DESIGN IDEA PROJECT COMPETITION	Uşak	2020	Uşak Municipality
34	5 JANUARY PARK AND ITS IMMEDIATE SURROUNDINGS URBAN DESIGN COMPETITION	Adana	2021	Adana Metropolitan Municipality
35	100TH YEAR BAZAAR AND ITS IMMEDIATE SURROUNDINGS IDEA PROJECT COMPETITION	Ankara	2021	Ankara Metropolitan Municipality
36	ANTAKYA BRIDGEHEAD CITY SQUARE AND ITS NEIGHBOURHOOD URBAN DESIGN COMPETITION	Hatay	2021	Hatay Metropolitan Municipality
37	BÜYÜKADA PHAETON SQUARE URBAN DESIGN COMPETITION	İstanbul	2021	İstanbul Metropolitan Municipality
38	DESIGN COMPETITION TO COMMEMORATE PANDEMICS AND HEALTH WORKERS	İstanbul	2021	İstanbul Metropolitan Municipality
39	KARADUVAR NEIGHBOURHOOD URBAN DESIGN PROJECT COMPETITION	Mersin	2021	Mersin Metropolitan Municipality
40	ŞANLIURFA SARAYÖNÜ KİZİLAY SQUARE AND URBAN DESIGN IDEA COMPETITION	Şanlıurfa	2021	Şanlıurfa Metropolitan Municipality
41	TALAS PUBLIC GARDEN AND CULTURAL CENTRE URBAN DESIGN COMPETITION	Kayseri	2021	Kayseri Talas Municipality
42	KÜÇÜKÇEKMECE LAGOON BASIN IDEA PROJECT COMPETITION	İstanbul	2022	İstanbul Metropolitan Municipality
43	ALAEDDIN HILL, KILIÇARSLAN II. KILIÇARSLAN II PAVILION AND EXCAVATION AREA ARCHITECTURAL IDEA PROJECT COMPETITION	Konya	2022	Konya Metropolitan Municipality
44	ISTANBUL LAND WALLS TOPKAPI CASTLE SQUARE URBAN DESIGN COMPETITION	İstanbul	2022	Fatih Municipality
45	BALAVCA STREAM AND ITS IMMEDIATE SURROUNDINGS AS A MULTI-LAYERED NATURAL AND CULTURAL LIFE CORRIDOR IDEA PROJECT COMPETITION	Muğla	2024	Milâs Municipality

Competitions organized in the field of urban design and landscape architecture are environments that are expected to address multi-layered urban problems and are formed by the gathering of a wide range of stakeholders. They are usually organized by local governments and the public, and specifications are created by juries consisting mainly of academics and professionals. Therefore, the texts prepared for competitions are the texts of cities, public spaces and the projects expected to be realized in these areas, which are formed by passing through the current public, academic and professional filters. At the same time, since cities and public spaces are political and social spaces, they are pragmatic and visionary texts that put forward projections that try to define the present. In the pilot study to be conducted within the scope of this paper, the texts of the competition specifications will be converted into raw corpus and used as the basic data.

Many open source or commercial programs such as AnrGram, AntMover, CorpusExplorer, QDA Miner were examined for the analysis of the raw corpus, but considering the nature and sustainability of the study, studies were continued with “Voyant Tools” (Rockwell, G.2003).



1790 Love And Freindship

LOVE AND FREINDSHIP AND OTHER EARLY WORKS
(Love And Friendship And Other Early Works)
A Collection of Juvenile Writings
By Jane Austen
Transcriber's Note: A few very small changes have been made to this
version: Italics have been converted to capitals. The British 'pound'

This corpus has 8 documents with 781,763 total words and 15,368 unique word forms. Created about 2 years ago.

Document Length:
- Longest: 1815 Emma (160996); 1814 Mansfield Park (160461); 1813 Pride and Prejudice (122204); 1811 Sense and Sensibilit... (119957); 1818 Persuasion (83657)

Document	Left	Term	Right
1790 Lo...	genteel family since we ca...	mr	and Mrs Marlowe are very
1790 Lo...	A brother of Mrs Marlowe,	mr	Cleveland is with them at
1790 Lo...	thirded by the entreaties of	mr	. Fitzgerald who is certainly...
1790 Lo...	a Concert or a Ball.	mr	Marlowe is so desirous of

Figure 1. The working environment of Voyant Tools.

We focused on "word frequency" and "word combination" through the raw corpus text created in the relevant interface, both in terms of years and keywords. With word frequency, periodic trend analysis can be performed depending on how often each word is used in the text. In this way, it can be understood which concepts are more prominent and set the agenda according to the years. With the "word combination" analysis, word pairs or word groups that occur together in the specifications were identified, and the relationships between concepts in different categories and the change in this network of relationships were analyzed. It is predicted that certain breaks will occur in different years in terms of agenda and theoretical aspects; accordingly, the main context of this study is to develop a taxonomic approach to the theory of the future by trying to perceive the logic of the theory and analyzing the fluid metadata universe of landscape architecture with diagrams on a perceptible axis through a continuing study process.

3. Findings and Discussion

3.1 A reading on theoretical content of landscape architecture

Architecture operates in an inherently dynamic and fluid universe of concepts. Theoretical advances and practical innovations constantly redefine this conceptual world. However, bridging the gap between theory and practice remains a challenge, especially at the critical stage of conceptualization. Architecture uses theory as a tool to understand what exists, to rethink what has been thought and done, and to update itself. Theoretical knowledge is reproduced knowledge (Tanyeli, 1999). Just like in architecture, it is clear that there is an intellectual expansion in the field of landscape architecture that is gradually expanding and fringing but is closer to spontaneity since it does not have a systematic pattern. Since this spontaneity, or "drift", does not have a backbone with defined "boundaries", it is in dire need of being analyzed and reproduced to take on a theoretical quality. Tanyeli, 1999 defines this as the intellectual construction of architecture. Although landscape architecture has not yet established its intellectual construction, it is just now realizing the strengthening effect of its relationship with natural processes on the theoretical discourse.

Nonaka and Takeuchi (1995) identified four knowledge domains in applied research situations: "tacit knowledge", tacit, taken-for-granted knowledge of practice; 'conceptual knowledge', which makes tacit knowledge explicit and codifies it as principles and protocols; 'systematic knowledge', which is also explicit and formally articulated, validated and integrated at the core of the discipline; and 'operational knowledge', in which systematic and conceptual knowledge is translated into different fields of practice (Deming and Swaffield, 2011). It would not be wrong to say that the knowledge universe of landscape architecture has been shaped over time according to the cyclical evolution between these four. However, it is also clear that these forms of knowledge need to be reread from time to time in order to correctly construct the relationships between research, practice and academia in landscape architecture.

The study draws on Nonaka and Takeuchi's (1995) model of knowledge creation, which defines four different knowledge domains:

Tacit knowledge: Implicit, tacit, experiential knowledge embedded in practice, raw knowledge expressed through architectural action.

Conceptual knowledge: The explicit expression of tacit knowledge through principles and protocols, terms, know-how and standards.

Systematic knowledge: Formally validated and integrated knowledge that is central to the discipline, academic knowledge.

Operational knowledge: The transformation of systematic and conceptual knowledge into practical applications, evolved practical knowledge such as project report, project concept.

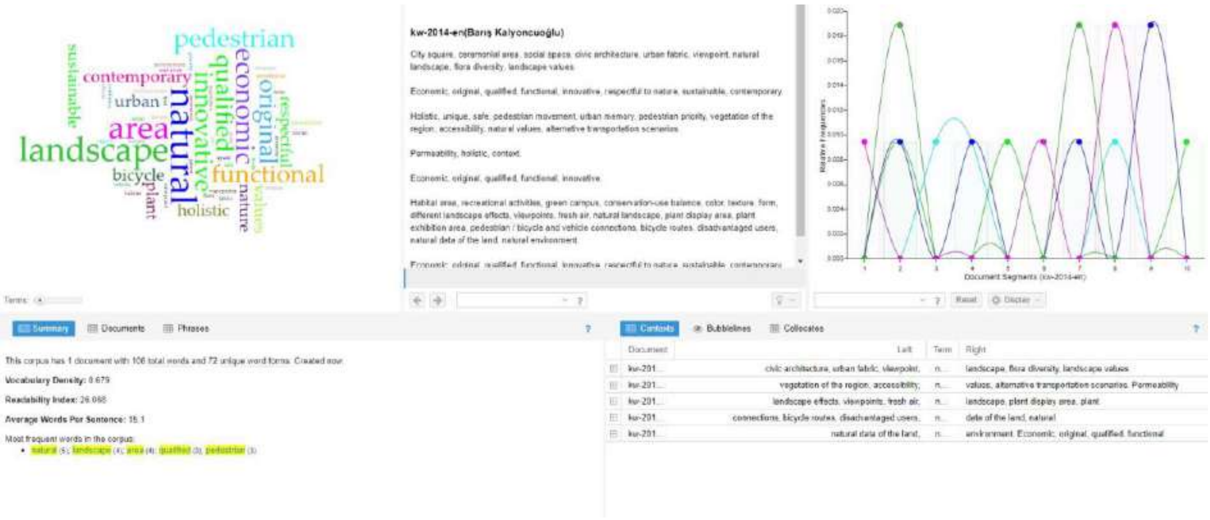
The above classification draws a roadmap that allows for a conceptual taxonomy to understand the cyclical evolution of architectural knowledge in these four areas. However, the research emphasizes the need for continuous re-examination of these forms of knowledge to strengthen the links between research, practice and academia in landscape architecture. The terms contained in the above four different forms of knowledge that landscape architecture constantly uses constitute the content pool of the research.

The “corpus” texts to be used with the content analysis tool 'Voyant Tools' to be used within the scope of this study were created with terms and concepts that meet the fields of “practical knowledge”, “tacit knowledge”, “conceptual knowledge” and “systematic knowledge” of landscape architecture. Figure 2 shows the word cloud visualized according to the frequency analysis of the conceptual keywords obtained.

Figure 2. Word cloud of conceptual expressions extracted from the raw corpus texts between 2014 and 2024.

3.2 The process of change and breaking points of the theoretical agenda of landscape architecture over the years

As a result of the content analysis, it is observed that the conceptual universe, which places people at the center with more technical and abstract expressions such as “urban”, “public”, “functional”, “economic”, “sustainable”, “flexible”, “innovative”, “contemporary” in the texts produced in a certain period, started to use a language closer to the ecological side of the business in terms of producing sustainable urban space after 2020. The indicator words that confirm our hypothesis, “ecological”, “ecosystem”, “climate”, “water”, “natural”, “flora”, “fauna”, “resilient” are repeated in the text more frequently than in the periods before 2020, and even constitute the focus of the subject in some competitions. In Figure 3 the word frequency map of 2014 and in Figure 4 the word frequency map of 2024 can be seen.



kw-2014-en(Barış Kalyoncuoğlu)

City square, ceremonial area, social space, civic architecture, urban fabric, viewpoint, natural landscape, flora diversity, landscape values

Economic, original, qualified, functional, innovative, respectful to nature, sustainable, contemporary

Holistic, unique, safe, pedestrian movement, urban memory, pedestrian priority, vegetation of the region, accessibility, natural values, alternative transportation scenarios

Permeability, holistic, context

Economic, original, qualified, functional, innovative

Habitat area, recreational activities, green campus, conservation-use balance, color, texture, form, different landscape effects, viewpoints, fresh air, natural landscape, plant display area, plant exhibition area, pedestrian / bicycle and vehicle connections, bicycle routes, disadvantaged users, natural data of the land, natural environment

This corpus has 1 document with 106 total words and 72 unique word forms. Created now.

Vocabulary Density: 0.679

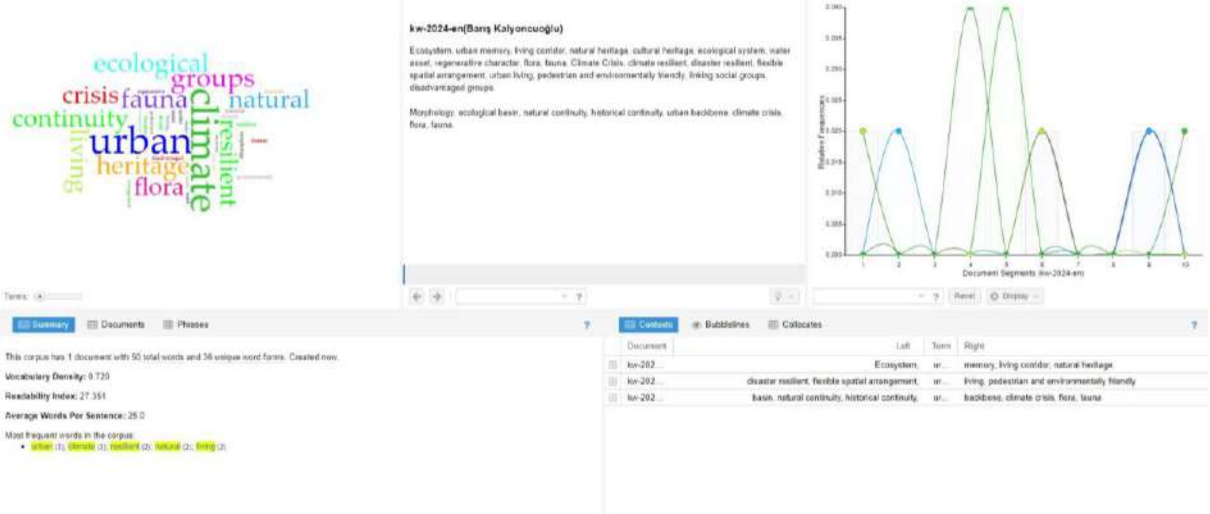
Readability Index: 26.068

Average Words Per Sentence: 15.1

Most frequent words in the corpus:
- natural (5); landscape (4); area (4); qualified (3); pedestrian (3)

	Document	Left	Term	Right
▤	kw-201...	civic architecture, urban fabric, viewpoint,	n...	landscape, flora diversity, landscape values
▤	kw-201...	vegetation of the region, accessibility,	n...	values, alternative transportation scenarios. Permeability
▤	kw-201...	landscape effects, viewpoints, fresh air,	n...	landscape, plant display area, plant
▤	kw-201...	connections, bicycle routes, disadvantaged users,	n...	data of the land, natural
▤	kw-201...	natural data of the land,	n...	environment. Economic, original, qualified, functional

Figure 3. The word frequency map of 2014



kw-2024-en(Barış Kalyoncuoğlu)

Ecosystem, urban memory, living corridor, natural heritage, cultural heritage, ecological system, water asset, regenerative character, flora, fauna. Climate Crisis, climate resilient, disaster resilient, flexible spatial arrangement, urban living, pedestrian and environmentally friendly, linking social groups, disadvantaged groups

Morphology, ecological basin, natural continuity, historical continuity, urban backbone, climate crisis, flora, fauna.

This corpus has 1 document with 50 total words and 36 unique word forms. Created now.

Vocabulary Density: 0.720

Readability Index: 27.351

Average Words Per Sentence: 25.0

Most frequent words in the corpus:
- urban (3); climate (3); resilient (2); natural (2); living (2)

	Document	Left	Term	Right
▤	kw-202...	Ecosystem,	ur...	memory, living corridor, natural heritage
▤	kw-202...	disaster resilient, flexible spatial arrangement,	ur...	living, pedestrian and environmentally friendly
▤	kw-202...	basin, natural continuity, historical continuity,	ur...	backbone, climate crisis, flora, fauna

Figure 4. The word frequency map of 2024.

The findings of these analyses show that the theoretical and conceptual contents of landscape architecture competitions have changed from a human-centered discourse to an ecology and nature-centered paradigm. Landscape architecture, which is defined as the act of creating more useful and comfortable environments for people, has started to develop a narrative that puts nature conservation at the center of design and prefers naturalism even in urban spaces.

4. Conclusion

The topic of this research is to analyze the content of the changes in the universe of theories and practices of landscape architecture over the last decade. While current design theories dominate both education and professional discourse, they are increasingly failing to conceptualize terminologies and bridge the gap between the field of practice. Furthermore, the field of landscape architecture is undergoing a discourse shift, directly affected by the climate crisis and global scale changes, and there is a need for a common language framework that can coordinate theory, design and practice. This is particularly evident in the rise of generative AI for spatial visualization, where design processes are heavily influenced by digital tools and natural language prompts (Rockwell and Sinclair, 2016).

Language is a multi-layered, dynamic and transformative medium of communication, thought and creative expression. Professional language, which can be considered one of the lower layers of everyday language, has been undergoing a rapid transformation in landscape architecture and related professional disciplines in recent years. Especially the theoretical theory and philosophy, which are constantly developing and dealing with current problems, are largely of western origin, and despite the important potential they carry, they are often lost in translation and cannot create their counterparts. Although the work we have begun focuses on the theoretical transformation of landscape architecture in recent years, it will continue to explore the boundaries of related professions, thought practices and current debates. The main concepts of the competition specifications that form the basis of our study, which is currently a basic exploration practice, offer a blurred picture of the transformation in the current literature. This is because the relevant competition specifications were analyzed on a year-by-year basis, and the texts of the specifications, which were obtained in large numbers in some years and in small numbers in others, did not provide a reliable and stable basis for analysis. At the same time, the effort spent in the creation of the relevant specifications, the breadth of participation and the vision of the future have been binding on the basic definitions.

In this journey of discovery, which we started with the awareness of the limits of our current work, finding important breaking points that excite us and enable us to continue even in this blurred picture we have created has been recorded as an important achievement in this study. In the ongoing stages of the research, the related corpus texts will continue to be analyzed on theoretical texts by creating labeled corpuses by compiling academic, professional and critical texts obtained from open sources.

Note

This study is based on the discussions and information gathered by the design team on discourse and theory in the field of landscape architecture and urban design within the scope of R&D studies at “Caps Office” @Istanbul/Türkiye.

As Caps Office, we are in search of an alternative world in urban design, landscape architecture and architecture. We intend to influence this world not only in spatial design but also in the philosophy and theory of landscape architecture. This research you read above is one of the traces of our design philosophy.

The text above is open for discussion with all interested parties who think that it will improve the content of our ongoing research. You can contact us for contribution and communication from https://caps.com.tr

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Redefining Smart City Implementation: A New Model From Türkiye's Experience

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Abstract

In the midst of rapid urbanization and the urgent need for sustainable urban development, this study critiques traditional techno-centric models and advocates for a holistic integration that harmonizes the efforts of government, industry, and citizens. The objective is to not only redefine smart city implementation but also to propose a universal model that facilitates global urban innovation and sustainability. The research critically evaluates Türkiye's smart city landscape, revealing a significant disconnect between ambitious plans and their tangible impacts. This disconnect is largely attributed to the absence of a unified strategy that effectively combines governmental actions, technological advancements, and citizen participation. The proposed triple helix model emerges as a foundational framework for future smart city initiatives, emphasizing the need for collaborative governance, strategic technology deployment, and active citizen engagement. Analysis of 115 municipal websites and a survey of 1141 citizens across four major Turkish cities underscore the model's necessity, demonstrating that without informed and involved citizens and a responsive government, smart city projects fail to achieve their full potential. Results from this study highlight the significant gaps in current implementations, where technological solutions are often prioritized without sufficient consideration for governance and citizen involvement. By advocating for a participatory approach to urban development, the model ensures that the benefits of smart cities are equitably distributed, calling on policymakers, urban planners, and technology providers to adopt this integrated model for more inclusive and sustainable urban futures.

Keywords: Sustainable smart city, smart people, smart governance, smart mobility

1. Introduction

Smart cities change urban livability, efficiency, and sustainability via technology innovation (Castells, 1997; Herrschel, 2013; Martin, 2018). Cities worldwide implement smart transportation, energy, safety, and governance solutions using ICT to enhance services, cut costs, and involve residents (Hollands, 2008; Dameri, 2013; Cocciha, 2014; Angelidou, 2014). However, implementations are challenging. Turkish early adoption and ambitious goals typically fail, underscoring the necessity for a new and comprehensive model. Existing approaches prioritize technology above government and community involvement (Leydesdorff, 2011; Arnkil, 2010). On the contrary, this research integrates technology innovation, governance, and active citizenship with a new triple helix model (Figure 1).

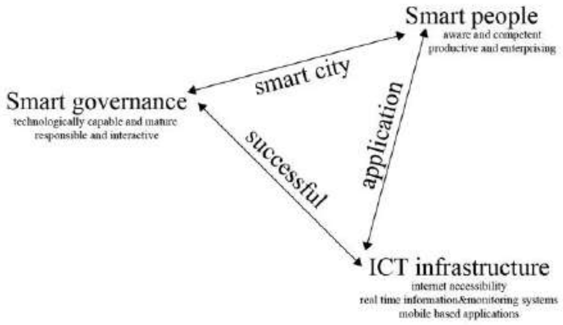

Figure 1. Proposed triple helix model for successful implementation of the smart to the city

Smart cities need smart transportation, smart people, and smart administration, according to research. Smart Mobility employs ICT to gather, analyze, and send data via the Internet, mobile phones, and wireless networks (Orlowski, 2019), lowering pollution, congestion, and transfer costs while enhancing safety and transfer speeds (Benevolo, 2016; Kalogirou, 2018). Smart mobility apps engage individuals, making them critical to studying "smart people." Active public engagement and comprehensive ITS and urban initiatives are needed for successful smart city implementation.

Above and beyond government engagement, citizen involvement is essential to smart city development (Berntzen, 2016). Active participation influences urban development, governance, and servicing (Cardullo, 2019; Mora, 2019). ICT, especially mobile technologies, empowers individuals to make decisions and usage. According to Dameri's Amsterdam-Genoa research smart city Amsterdam succeeds due to technology innovation and community involvement. On the other hand, Genoa failed because of a lack of citizen knowledge and participation (Dameri, 2014). Low public awareness doomed London's smart parking service (Peng, 2017). South Korean u-cities promote socially relevant digital technology (Shin, 2009). Helsinki encourages public involvement via accessible data and contests (Hielkema, 2012). Barcelona's collaborative approach is criticized for low citizen involvement (Capdevila, 2015; Gasco-Hernandez, 2015). What we learn all those examples is that technological advances are inadequate without public participation.

The literature defines smart people as lifelong learners, social and ethnic diversity, creative, open-minded, and public-spirited (Giffinger, 2007; Benamrou, 2016; Gupta, 2017). These measures emphasize education, foreign language abilities, and public involvement to promote social rights and democracy. However, smart cities must encourage citizen involvement and stakeholder collaborations (Paskaleva, 2011). Citizenship includes reporting urban concerns as well as political activity. throughout opposition to Smart Growth America's 'Complete Street Design' Project, Seattle resident Cuquis Robledo highlighted 'crappy curbs' throughout the city. She filmed the crappy curbs on social media. Many individuals from other places post this video on social media to alert authorities and report crappy curbs. ICT-enabled acts show the value of citizen involvement. Thus, this research suggests that smart cities' success depends on residents' understanding and usage of smart apps rather than social qualities.

In conclusion, smart city implementation requires aware, active citizens willing to use smart apps to improve their city and authorities with smart technology infrastructure who are responsive and interactive on citizen actions to reduce environmental problems, increase energy efficiency, and improve quality of life.

2. Material and Method

The main Research question is: "How can smart city concepts be successfully implemented?" The goal of this research is to connect smart city discussion, identify critical factors, and develop new terminology for optimal implementation. Smart city literature spans multiple disciplines and approaches. Thus, the research examines smart city concept, the process of emergence the theory of evolution, components, governance, and implementation. The paper offers a new triple helix model (Figure 2) that promotes active citizens and responsive collaborative government.

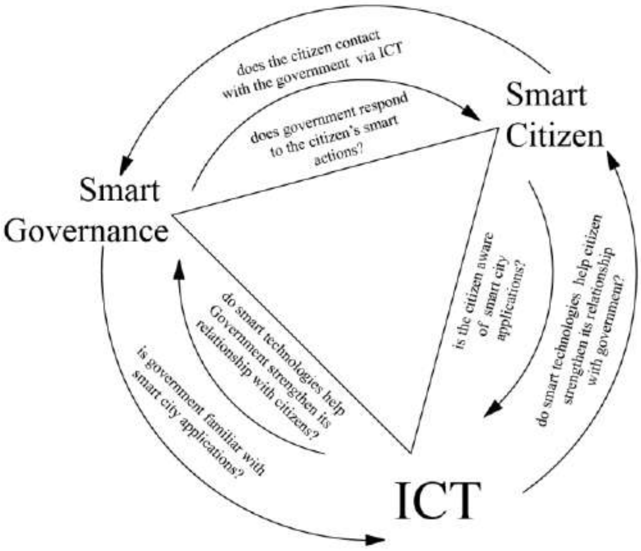

Figure 2. Bilateral relationship between the components of the proposed new triple helix model for the successful application of the smart to the city

The study examined smart government, smart people, and smart technology in Türkiye to answer the research questions. This included evaluating national technological ability and awareness and smart government and smart people in four cities.

Smart technologies ability and awareness research (Figure 3) assessed Türkiye's smart city laws, policies, and implementations through 2019. It examined Türkiye's Smart Mobility capacity and if it possesses the literature-listed intelligent transportation technologies. Sustainable transportation methods including commute sharing and green car use were examined too.

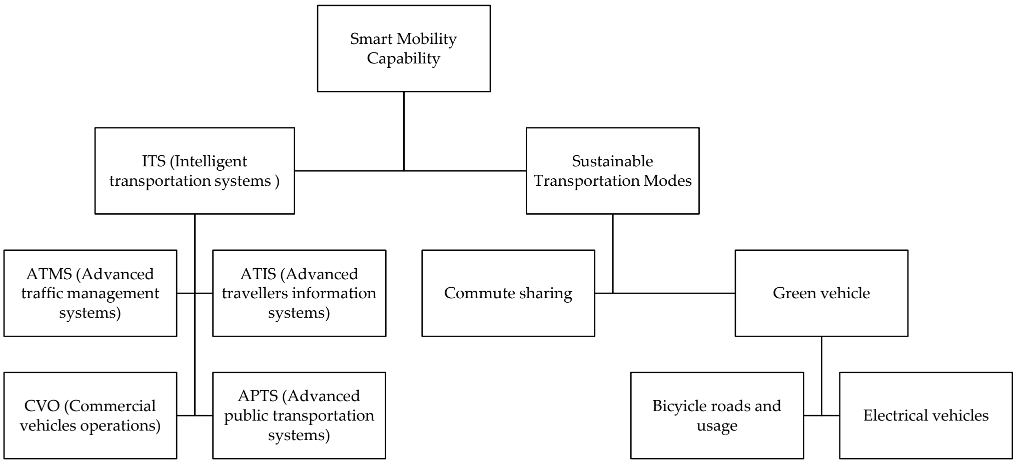

Figure 3. Smart mobility indicators within the thesis context to evaluate

Smart Governance Capability and Maturity Analysis examines smart governance using e-government activities like government-provided ICT services. The research assessed 115 municipality websites in four locations to assess municipal operations based on McMillan model of interaction. Through interaction tools, it assessed the websites' information and interaction capabilities and authorities' response to citizen activities.

Smart People Analysis assesses residents' knowledge and use of municipally generated smart mobility mobile apps, which are essential for smart city operations. Citizens' usage of interactive technologies to communicate with authorities was also examined. In 2019, 1141 residents in four cities completed an online survey on smart mobility apps and municipal services.

The research examined the variables influencing the knowledge and use of smart mobility apps and interaction tools via the use of SPSS. The research analyzed 13 parameters affecting the use and awareness of 19 mobile apps developed by metropolitan governments across four case study locations.

Based on smart mobility applications, Istanbul, Ankara, Izmir, and Bursa were chosen as case studies (Table 1). These cities have more smart mobility applications than others, making them ideal for smart government and smart people tests. Istanbul, the most populated city, features 20 smart city apps, including seven for smart mobility. Capital of Ankara, with roughly 6 million residents, has 10 smart city apps, two of which concentrate on smart mobility. At 4 million, Izmir is the third most populated city and has eight smart city apps, including two for smart mobility. Bursa, a 2 million-person automotive hub, has three smart city applications, two of which are smart mobility. The research studied smart city activities and applications in these cities to understand smart city implementation and emphasize the importance of public involvement and responsive government.

Table 1. Selected smart mobility mobile applications in selected four cities

	Public transportation information mobile applications	**Driver information mobile applications**	**Digital municipality**
İstanbul	Mobiett	IBB Yol Gösteren, IBB Cep Trafik, Şehir Hatları, İSPARK, iTaksi, İSBİKE Smart Bike	IBB İstanbul, IBB Beyaz Masa
Ankara	EGO Cep'te	ABB Trafik	ABB Ankara, Başkent Mobil, Mavi Masa
İzmir	ESHOT Mobil	IZUM	IBB Mobile
Bursa	Burulas Ulaşım	Burulas Trafik	Bursa Cepte

3. Findings

According to three analyses mentioned above, main findings of the study can be listed as follows:

3.1 Smart technologies capability and awareness

Since the early 2000s, the Turkish government has promoted smart city efforts, notably in transport, to improve traffic management, safety, and energy efficiency. The 2014-2023 National Intelligent Transportation Systems Strategy Document stresses these targets. Detailed evaluations show that many action plans are declarative and lack execution. Since Istanbul launched the first complete smart city master plan in 2016, various metropolitan municipalities have cooperated with Vodafone, Turkcell, and Huawei to purchase smart technology. The 2019 National Smart Cities Strategies and Action Plan 2020-2023 paved the way for organized smart city development. Türkiye is capable of producing Intelligent transportation Systems (ITS) such passenger information, traffic management, public transit, electronic payment, driver assistance, security, and fleet management. The adoption of these technologies is patchy. In 2014, 23% of 30 metropolitan Turkish cities did not use ITS, according to the KENTGES Municipalities Survey Report held on 2014 and 2016 (Figure 4). Many big cities limit smart mobility apps to bus monitoring and route planning.

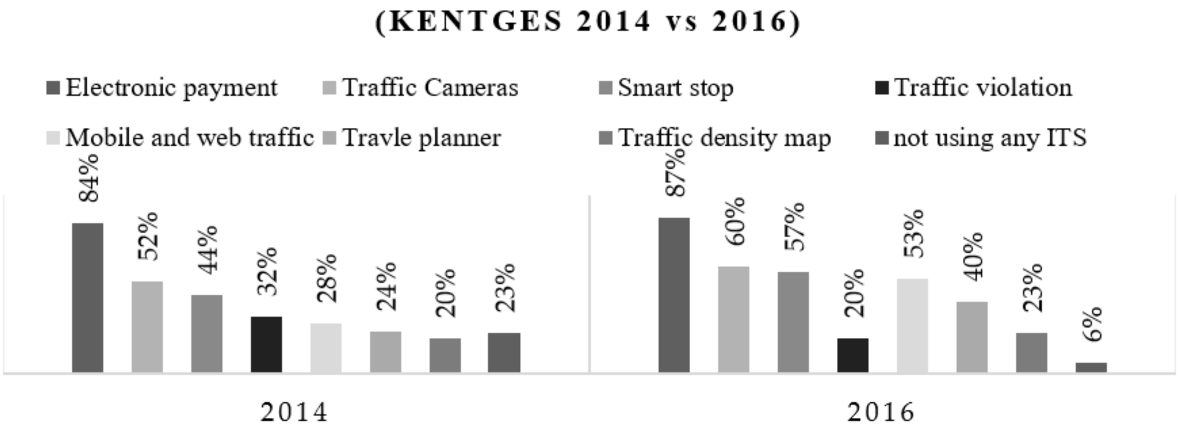

Figure 4. Intelligent Transportation Systems Usage Rate in Metropolitan Municipalities

3.2 Smart governance capability and maturity

Smart Governance refers to which is technologically capable and mature enough to respond to citizen actions and willing to collaborate with them in city matters.

Türkiye has shown strong performance in e-government, with an effective e-government portal and extensive municipal websites that provide information and allow interaction. An investigation of municipal web pages across four metropolitan municipalities, using the McMillan model of interaction, demonstrated significant efficacy in delivering informational resources (Table 2), including news and announcements. Nonetheless, these websites are inadequate in providing comprehensive plans, rules, budgetary information, strategic initiatives, activity reports, council resolutions, and performance programs.

Table 2. Information tools in percentages, all municipalities

	GIS maps and plans	**Online documents (pdf)**	**News and announcements**	**Multimedia (video/images)**	**Multilanguage**
İstanbul, N=40	90	87,5	97,5	97,5	30
Ankara, N=26	26,9	57,7	100	100	7,7
İzmir, N=31	6,5	90,3	96,8	96,8	16,1
Bursa, N=18	16,7	66,7	94,4	94,4	22,5

Municipal interaction tools (Table 3) are generally effective, with a high usage of corporate email, online transactions, and call centers. However, there is a lack of private staff emails and interactive tools like live chat rooms. Social media activity is high, but responsiveness through these channels is inconsistent.

Table 3. Interaction tools in percentages, all municipalities

	Feedback		**Responsive dialogue**		**Mutual discourse**		
	Corporate e-mail	Staff e-mail	Request complaint suggestions	Online transactions	Social media accounts	Live support	Call center
İstanbul, N=40	72,5	62,5	92,5	95	100	0	97,5
Ankara, N=26	69,2	11,5	65,4	73,1	100	0	100
İzmir, N=31	87,1	6,5	51,6	90,3	100	0	100
Bursa, N=18	88,9	27,8	66,7	66,7	100	0	100

Smart governance involves technical expertise and technological maturity. The survey found that 79% of participants don't use government communication platforms. Only 34% of participants utilize these tools and find responses. These figures indicate that the government has technological skills but struggles to use them to communicate with people and solve issues (Figure 5).

Figure 5. Municipalities' response to interaction tools

3.3 Smart people

Smart people refer to citizens who are aware, willing to use smart applications and active citizens. This section studies people's awareness, interaction, and intentions toward governmental smart city applications. Surveys were conducted in Istanbul, Ankara, Izmir, and Bursa for the study.

3.3.1 Demographic overview

Out of the participants, 53% have obtained a bachelor's degree, 29% have completed a postgraduate degree, and 18% possess only primary education. The age distribution indicates that 52% of the population is be-tween the age range of 26-45, 37% are aged 18-25, 10% are between the ages of 46-65, and 1% are 65 years or more. Regarding transportation options, 33% of individuals use public transit on a near-daily basis, while 22% use it a few times each week or year. Additionally, 20% use public transportation a few times per month, and 3% report never using it. Approximately 50% of the participants express a preference for using private vehicles. However, the subway remains the most popular means of public transit, with 81% of respondents. Following the subway, buses are the second most often used mode of transportation, with 77% of respondents. Minibuses, known as 'dolmuş' in Türkiye, are the third most desired mode of transportation, chosen by 38% of respondents. Sea transportation is available in İzmir and İstanbul, although only about 30% of the respondents choose to use it.

3.3.2 Smart mobility awareness and usage

The study disclosed unexpected findings on the awareness and use of smart mobility applications (Table 4). Half of respondents were not aware of the existence of public transportation information apps in their city.

Table 4. Application awareness and usage ratios

Public transportation information applications	**Aware**	**All respondence**	%51
		Among the frequent users	%59
	Using	**All respondence**	%47
		Among the frequent users	%25-all the time %68-sometimes
Driver information applications	**Aware**	**All respondence**	%20
		Among the frequent users	%45
	Using	**All respondence**	%18
		Among the frequent users	%7-all the time %85-sometimes

3.3.3 Citizen participation and interaction with government via ICT

Although municipalities have various digital platforms for interaction, including websites, email ser-vices, call centers, mobile applications, and social media links, citizens show low engagement. The survey revealed that most respondents do not visit municipal websites or use the provided interaction tools to share complaints and suggestions. Only 8% of the respondents were aware of the fact that the municipalities have the mobile application for all the services they provide, and only 13% of the respondents were using those applications.

The literature demonstrates the crucial role of application usage in smart city applications. However, there is a direct correlation between application awareness and its usage. The crosstabulation of the application awareness and usage relationship revealed that the majority of the respondents do not use the smart application as they do not know the application, especially in driver information applications and digital municipalities.

Through smart government analysis, it has been seen that every municipality has its own websites, all of which do well in transmitting information and offering efficient communication mechanisms. In order to request information or to voice concerns or opinions, residents can get in touch with any metropolitan municipality through one of these services, such as email services, phone centers, mobile apps, and social media linkages. Nevertheless, the citizen awareness survey reveals that most respondents are unlikely to visit municipal websites (Table 5), despite the fact that these websites are generally seen as user-friendly and clear (the complexity of the websites does not seem to be a deterrent for non-visitors).

Table 5. Digital municipality awareness and usage

Digital Municipality (applications)	**Aware**	%8
	Using	%13
Visiting municipality web site	**Visiting**	%32

Additionally, there are citizen lines such as Mavi Masa in Ankara, Beyaz Masa in Bursa and Istanbul, and HİM in Izmir. These lines have their own email services, contact centers, and social media profiles to facilitate the submission of various claims and viewpoints. Nevertheless, the majority of respondents in the citizen survey indicated a lack of preference for using the available contact mechanisms to express their complaints and suggestions (Figure 6). Put simply, they are failing to engage in civic affairs by neglecting to voice their complaints or recommendations.

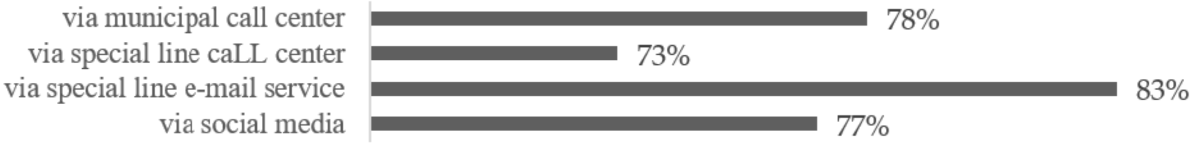

Figure 6. Non-use of municipal interaction tools in percentages

The Digital 2023 Global Statshot Report reveals that in January 2023, 83.4% of Türkiye's population are connected to the internet, while 73.1% of the entire population engage with social media platforms. In early 2023, the active cellular mobile connections in Türkiye account for 95.4% of the total. In early 2023, the number of Twitter users in Türkiye amounted to 18.55 million. However, when examining the level of engagement by municipalities on social media platforms, particularly Twitter, which is the primary means of connection, the percentages are very low (Figure 7).

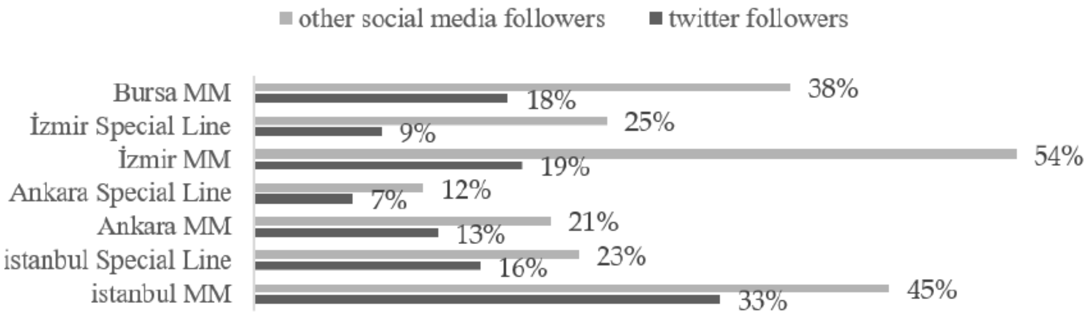

Figure 7. Social media followers for the municipalities city-by -city

In summary, the findings indicate that there is little interest among individuals in digital municipal ser-vices, as seen by the low level of awareness and use of municipal mobile applications. Furthermore, they lack interest in accessing the municipality's online sites or using interaction tools when necessary.

3.3.4 Citizen awareness of the smart city concept

The survey also evaluated residents' understanding of the smart city idea. The findings indicated that 69% of participants had a deficiency in understanding or carried inaccurate information on smart cities. Significantly, 75% of individuals with inaccurate information have a high level of education, whereas 91% belonged to younger age groups (18-45 years). Notwithstanding this limited comprehension, 90% of participants hold the belief that investment in smart cities is essential, indicating that the idea is largely viewed positively.

The results suggest that while there is a widespread desire to adopt smart city efforts, there are notable deficiencies in knowledge and participation that must be resolved. The primary objective should be to prioritize improved communication and education on smart city apps in order to boost their use and engagement. Furthermore, it is essential to cultivate a culture of engaged citizenry and promote environmentally conscious mobility practices in order to effectively execute smart city initiatives in Türkiye.

3.4 In-Depth analysis of the factors effecting the awareness and usage

This part delves into the factors influencing citizen awareness and usage of smart city applications, utilizing survey results analyzed through SPSS. The study examined 13 relations based on 19 mobile applications produced by the metropolitan municipalities in four cities selected as case study to find out the factors affecting awareness and usage based on smart mobility mobile applications and interaction tools usage to communicate the metropolitan municipalities. Two types of statistical analyses have been applied to the survey result in order to understand the relationships between factors that affect the citizen awareness. The Chi Square of Independence and Binary Logistic Regression methods have been used for the analysis.

3.4.1 Factors affecting smart mobility mobile applications awareness and usage

Based on the study findings, there is a positive correlation between the degree of education and awareness of application. Public transportation information applications are more likely to be known by bachelor's and postgraduate degree holders than elementary education graduates. Still, postgraduates are less informed than bachelor's degree holders. Driver information mobile applications awareness, on the other hand, increases according to the education level.

It is not clear why those with a postgraduate degree are less likely to be aware of the public transportation application than the driver information applications compared to those with a bachelor’s degree. It may be argued that those with a postgraduate degree correspond to relatively older and possibly wealthier citizens, who do not use public transportation, but use private vehicles. Hence have no interest in public transportation information applications but have more interest in driver information applications.

The study findings also revealed that application usage seems to be related to education level too. Public transportation information applications are more likely to be used by bachelor's degree holders than elementary education graduates. Postgraduate degree holders are not significant in using those applications. Driver information mobile applications are more likely to be used by the elementary education graduates than both postgraduates and bachelor’s degree holders. Those applications used in the study produced by the municipalities. However, there is lots of driver information application produced by private companies such as Google map, Maps by Apple, Moovit, Trafi and such. As a scope of the study, citizens were asked to write the driver information application they use. 99% of the respondents who named the private applications mentioned above, are either bachelor’s degree or post graduate degree holders. It can be concluded that individuals with higher levels of education are more willing to use private applications, while those with lower levels of education may either be unaware of these applications and therefore not use them, or they may prefer government ap-plications.

Based on the study findings, application awareness seems vary from age to age. Public transportation information applications are more likely to be known by age groups 18-25 years than the age groups 26-45 and 46-65. Driver information mobile applications are more likely to be known by age groups 26-45 and 46-65 than age groups 18-25. Also, age groups 46-65 are more likely to be aware of those applications than age groups 26-45.

According to the driver information applications awareness relationship, it is reasonable to infer that those aged 18–25 is likely to be students and are more likely to use public transportation compared to those aged 26–45 and 46–65. The 26–45-year age group is comparatively younger and has a higher preference for using public transportation compared to the 46–65-year age group.

The study findings also revealed that application usage seems to be related to age. Public transportation information applications are more likely to be used by age group 18-25 years old than age groups 26-45 and 46-65. Driver information mobile applications: there is no real evidence that the driver information mobile application usage is different for people who have different age.

Furthermore, public transportation information mobile application awareness and usage seems to be affected from people's public transportation usage frequency. We can say that those who are using public transportation 5 to 7 days a week and few times a week are much more likely to know about and use the public transportation information mobile application.

3.4.2 Factors affecting active citizenship attitude

Although there is no real evidence that digital municipality awareness is related with the education level, but age seems has an effect. Individuals in the age range of 46-65 are more likely have knowledge about digital municipality compared to those in the age range of 18-25. Nevertheless, those with a basic education degree are more likely to use digital municipality services compared to those with a bachelor's or postgraduate degree. This time age has no effect on using digital municipality service. On the other hand, municipality web site visiting preference seems to be related to age and it seems that people who are between 46-65 years old are more likely to visit municipality web site than those who are between 18-25 years old. When it comes to act in urban affairs, individuals who have bachelor's degree and elementary education degree are more likely to use citizen lines than those who have postgraduate degree. Also people who are between 46-65 years old are more likely to use citizen line services than those who are between 18-25 years old. There is no real evidence that use-friendliness have a relation with the digital municipality usage. Therefore, it can be concluded that older citizens are more likely to show interest in urban affairs and municipal operations due to their increased use of municipal websites and interaction tools. However, there is a negative correlation between being an active citizen and education, as the degree of education increases, interest in urban affairs drops.

4. Conclusion

In order to effectively implement a smart city, it is crucial to emphasize the role of individuals as informed and active citizens who are willing to use smart city applications, take responsibility of urban problems and collaborate with a technologically advanced government that is responsive to the needs of its citizens.

Based on the extensive field study undertaken, it is clear that the production of smart city technologies is not sufficient. According to the survey results, there is a lack of understanding of the smart city idea and smart city applications, even in urban environments where these applications are commonly seen. Furthermore, it is determined that there is little motivation towards using smart city applications. Also, there is a notable lack of enthusiasm in assuming responsibility for the city as an active citizen.

Based on the extensive research and analysis, this research has uncovered an urban challenge within the framework of smart cities. In order to achieve a successful smart city application, it is crucial to enhance both the awareness and use of smart city applications, as shown in numerous examples found in the literature. An in-depth investigation was conducted to uncover how it may be boosted. The analysis examined 13 distinct interactions among 19 smart applications. The survey findings indicate a tenuous correlation between users and the smart city applications. The analysis of citizen survey findings revealed several aspects regarding the awareness and use of smart city applications. In light of all these findings, the study can propose the following solutions to the problem of user disconnections.

1. The implementation of smart practices relies on smart technology, which should not be restricted to a few cities. Nationwide implementation of smart city techniques is necessary.

2. In a smart city, citizens are expected to be active and autonomous, taking responsibility and participating as creative individuals in urban affairs via non-political involvement. The survey's findings indicate a significant lack of interest in active citizenship. Therefore, it is essential to promote and motivate citizens to actively engage, contribute, and provide innovative ideas for the improvement of their community.

3. Furthermore, it is essential for authorities to show responsiveness and interactivity in order to foster citizen encouragement. The smart city expects that the government will collaborate alongside with the active citizens. Both metropolitan and local governments must take responsibility for implementing smart city principles and actively engage with citizens.

4. The awareness of the application has a direct impact on its use, as shown by the findings of the citizen survey. Individuals that have knowledge about the program are more likely to use it. Therefore, it is essential for local officials, namely the municipalities responsible for developing smart apps, to focus on promoting these applications in order to enhance public awareness.

5. Furthermore, the findings indicated a significant correlation between the amount of education and the level of awareness about smart city applications. Individuals with a higher level of education are likely to have knowledge about urban applications. Therefore, to increase public knowledge, municipal authorities should guarantee that the release of the product is adequate and accessible to all individuals. They must actively participate in propagating and marketing the apps.

6. The study findings revealed a negative correlation between the degree of education and the use rate of applications. Despite holding a high level of education, individuals are less likely to choose to use an application. The usage of smart city tools is essential for ensuring the sustainability of smart cities. Therefore, municipalities must ensure that the smart city tools they develop adequately address the demands and specific requirements of all users.

7. User-friendliness has a positive impact on usage. If an application is simple to use and understood, it is more likely to be selected for use. Therefore, it is essential to prioritize user preferences and ensure that smart apps and tools are universally available and easily accessible.

8. Furthermore, those who often use a certain mode of transportation are more likely to use the corresponding transportation application. Therefore, people only use the application when they have a need for it. Therefore, product releases must prioritize the needs and preferences of the target audience.

9. The findings indicate a lack of enthusiasm among younger individuals, namely those aged 18-25, about urban affairs. Nevertheless, those age groups are characterized by high levels of creativity and productivity, making them very valuable for addressing urban affairs. In this scenario, municipal authorities ought to try to attract the interest of the younger generation and actively request their cooperation.

10. Furthermore, the findings indicated that there is a negative correlation between education level and interest in urban affairs. However, the situation should be reversed when considering smart people. As the level of education in a smart city rises, there should be an anticipated growth in both the understanding of smart city applications and the sense of duty for the city. On the other hand, municipal officials should actively engage with the more educated populace and collaborate with them to create and enhance ap-plications.

Based on the data analysis, it is evident that application producers, particularly those affiliated with local authorities (as private enterprises do their own research), should prioritize user preferences. An investigation should be conducted to see if consumers of their products are using or satisfied with those applications. Otherwise, the city would be filled with unused smart apps, thereby becoming a metropolis filled with abandoned smart application waste.

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Analyzing Public Sentiment In Residential Green Spaces Using Multi-Source Data

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Abstract

As urbanization intensifies, green spaces in residential areas are vital for alleviating the mental stress associated with high-density environments. The functions, aesthetics, and ecological qualities of these spaces significantly impact public sentiment, especially in high-density urban centers like Chongqing. This study examines the relationship between green space characteristics and public sentiment by analyzing residential data and local comments. Ten representative sites, with an average plot ratio of 4.96, were selected for field investigation. A multidimensional evaluation of functionality, ecology, aesthetics, culture, and social factors revealed a correlation with emotional well-being. Analysis of 6,355 comments and 202 questionnaires from 783 residential areas shows that at the urban scale, Yuzhong, Jiangbei, and Yubei districts exhibit a "large group, small cluster" pattern, with 74.9% of responses positive, 24.7% negative, and 0.4% neutral. At the community scale, commercial and tourist-oriented residential areas offer diverse opportunities for emotional expression. At the residential area scale, key factors influencing sentiment include green space pavement color (r=0.961, p<0.01), accessibility (r=0.881, p<0.01), and olfactory satisfaction (r=0.869, p<0.01).This study highlights the importance of optimizing green space design to improve emotional well-being, reduce stress, and enhance quality of life in high-density urban areas.

Keywords: High-density; big data; Chongqing

1. Introduction

The rapid urbanization process has introduced significant challenges to public health, driven by environmental pollution, lifestyle changes, and social pressures. As a result, there is an increasing demand for healthier and safer built environments in urban areas. Numerous studies highlight the environmental and health benefits of urban green spaces, which help mitigate issues such as air pollution and climate change caused by urbanization (Matos et al., 2019).. Green spaces also enhance human comfort (Gal et al., 2021) and alleviate stress, underscoring the importance of understanding public preferences, particularly in high-density urban areas. Residential green spaces, being the most commonly encountered green areas, are especially relevant for studies of urban public needs.

Research has shown a significant correlation between residential greening and various health outcomes, including respiratory diseases, low birth weight, and cardiovascular diseases (Gal et al., 2021). Additionally, factors such as landscape visibility, plant morphology, building density, and housing prices influence residents' preferences for green spaces (Nutsford et al., 2016; Regnier et al., 2024; Wen et al., 2023). Understanding the relationship between green space characteristics and public preferences is crucial for enhancing urban sustainability.

The impact of residential green spaces on public health has typically been studied through offline methods, such as structured observations, surveys, and site measurements(Chang et al., n.d.). However, these methods are limited by short timeframes and narrow geographical coverage. Given the complex interactions of environmental factors, a more comprehensive approach is needed. Multi-Criteria Decision-Making (MCDM) methods, which integrate multiple evaluation criteria, are increasingly used to provide more objective assessments (Zavadskas et al., 2017). Since 2019, public data has become more widely used, providing long-term, large-scale datasets. Additionally, advancements in artificial intelligence enable the analysis of diverse materials like text, images, and audio in urban studies (Gu et al., 2019; C. Li et al., 2024; Pak et al., 2021).

Public perception data has become a valuable tool for assessing the role of urban planning in promoting well-being. However, big data research often lacks granularity, and findings based on public feedback typically do not offer the same depth of analysis as traditional methods. There are also challenges related to data localization and limited applicability for small- to medium-scale studies. Few studies have combined big data with public sentiment regarding residential green spaces, despite its increasing use in disaster early warning and environmental monitoring(S. Li et al., 2024; Tan & Schultz, 2021).

This highlights the need for a framework combining large-scale public data with precise small-scale data to analyze residential green spaces. Chongqing, a high-density city, faces challenges in building renewal and green space optimization. While air pollution in southern China poses minimal health risks, urban green spaces provide significant health benefits. Using data from Fang.com and real estate sources, this study aims to: 1) map the spatial distribution of residents' emotions in high-density areas; 2) identify factors influencing emotional states; and 3) examine how plant landscape features affect emotions.

2. Material and Method

2.1 Material

2.1.1 Study area

Located in the southwest of China, Chongqing is renowned for its abundant natural resources and densely populated areas (Fig.1).

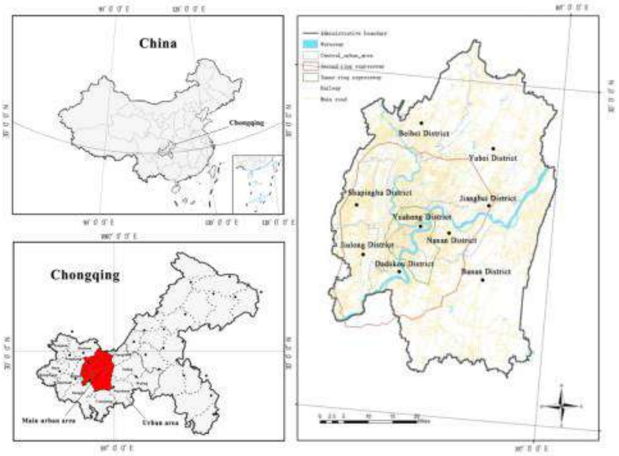


Figure 1. Location of the study area

2.1.2 “Public Sentiment - Landscape Preferences” framework

As it showed in the Fig.2, the housing data were crawled by python in large scale, and the comments of each residential area were emotion-analyzed using emotion lexicon and natural language processing techniques. Secondly, 10 residential areas were screened through data analysis and field survey, and online questionnaires were distributed to obtain residents' preferences for green. Finally, a measurement index system of green space characteristics in high-density residential areas was established.

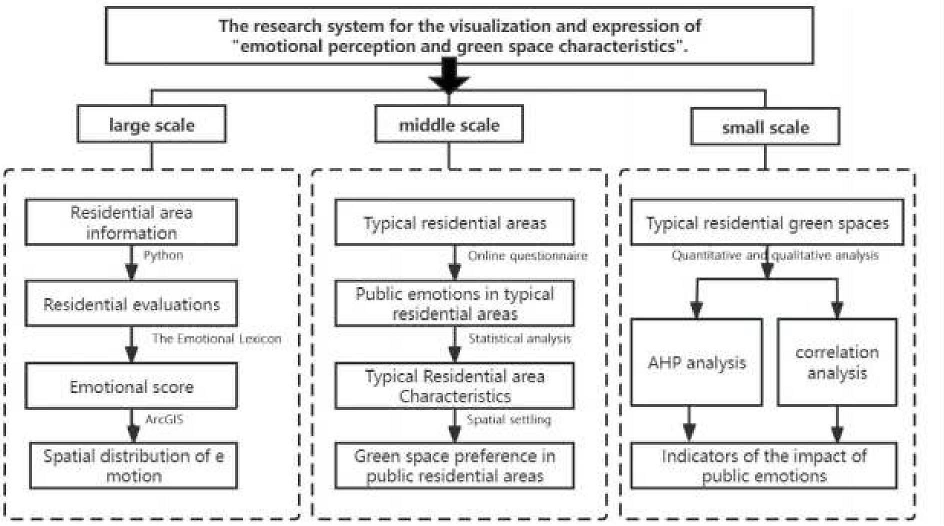


Figure 2. "Sentimental perception- Green space characteristic" visualization research program

2.1.3 Data source

The definition of urban residential areas has been defined as places with a relative concentration of residential density in cities. This research defines a high density residential area as one with a FAR of more than 2.0. Because the population of second-hand houses is relatively stable, the data on the housing website was searched and specific information about the houses as well as user evaluations can be found on the website. Crawling items Included the name, construction date, building type, developer, coordinate, and reviews.

The field survey was conducted from 14 March to 20 March 2022. The survey locations were a total of 10 neighbourhoods in Yubei District, Yuzhong District and Jiangbei District in Chongqing. During the field survey, data were collected by DJIMAVIC 3 drone photography and SONY A6000 photo collection. In this study, 40 green spaces were selected in 10 residential areas. Used different tools to get specific contents respectively.

The online questionnaire survey was conducted from 1st April to 1st May 2024 (Table.1).

Table 1. Description of the data sources in this study.

Types	Description	Data sources	Content
Housing data	Fang Holdings Limited	https://cq.esf.fang.com/	Coordinates in the WGS-84 coordinate system, FAR, building type, number of households, residential type, floor area
Water and road data	Open Street Map	https://www.openstreetmap.ie/	Area features, line features
Questionnaire data	Residents' satisfaction scores for residential plant landscaping	online marking	(1) the gender and age of the population; (2) the reasons why residents come to live in the green space of the residential area, the frequency and length of stay; (3) the satisfaction of residents with the perceived experience of the street.
Top view of planted landscape	30m resolution	field research	Four landscape top views were taken per plot, for a total of 40 views
Planted Landscape Elevation	1.5m viewing height	field research	Four landscape elevations were taken for each plot, for a total of 40 landscapes

2.2 Method

2.2.1 Text sentiment analysis

Used the Gooseeker website to tokenize the comments to get public sentiments of each residential area. Then, imported How-Net sentimental lexicon that was appropriate for the Chinese context to assess the text of the comments. Finally, obtained the sentimental score for each POI in ArcGIS.

$$N_0 = \frac{N_1}{N_2} (N_0 > 1 \text{ is positive}, N_0 \ < 1 \text{ is negative}, N_0 = 1 \text{ is neutral}) \tag{1}$$

N_0 is total sentimental score, N_1 is positive emotion, N_2 is negative emotion.

2.2.2 Per-person green space ratio

The land area, green space ratio, and number of residents in the community are all based on data published on the website. The per capita green space area is the ratio of green space area to the residential population.

$$A_{gm} = (A_{g1} \times R_{gs})/N_{p3} \tag{2}$$

A_{gm} is per-person green space ratio, A_{g1} is land area (m^2), R_{gs} is green space ratio, N_p is number of residents (m^2).

2.2.3 Green coverage ratio

Using the current aerial images of green spaces as a reference.

$$R_{gc} = \frac{A_{g2}}{A_{g1}} \times 100\% \tag{3}$$

Rgc is green coverage ratio, Ag2 is the vertical projection building area of the plant (m^2), Ag1 is land area (m^2).

2.2.4 Canopy density

The principles for calculating canopy density include:

(1) Newly planted street trees have small canopies that are difficult to outline, so they are disregarded.
(2) To ensure data comparability, the boundaries of the greening coverage map are used as the boundaries for the vertical projection of green spaces.

$$R_{cd} = \frac{A_{g3}}{A_{g2}} \times 100\% \tag{4}$$

Rcd is canopy density, Ag3 is the vertical projection building area of the tree (m^2), Ag2 is the vertical projection building area of the plant (m^2).

2.2.5 Green view index and sky view index

Calculate the areas of the green and blue zones within the green space separately.

$$R_{gv} = \frac{A_{g4}}{A_{P1}} \times 100\% \tag{5}$$

Rgv is Green view index, Ag4 is green area within the field of vision (m^2), Ap1 is total area of the photo (m^2)

$$R_{sv} = \frac{A_{g5}}{A_{p1}} \times 100\% \tag{6}$$

Rsv is Sky view index, Ag5 is blue area within the field of vision (m^2), Ap1 is total area of the photo (m^2)

2.2.6 Residential area green space evaluation system

A total of 23 indicators were screened based on five different criteria: Functionality, ecology, aesthetics, culture, and society (Table 2). The results of the weighting calculations were shown in annex B.

Table 2. Residential Area Green Space Evaluation System.

Goal Level A	**Criteria Level B**	**Indicator Level C**	**Data Collection Method**
		Indicators	
Landscape characteristics of plant in residential green spaces(A)	Functional indicators(B1)	Traffic Flow (C1)	Questionnaire Scoring
		Space Prosperity(C2)	Questionnaire Scoring
		Accessibility Integrity(C3)	Questionnaire Scoring
		Nocturnal lights(C4)	Questionnaire Scoring
		Environmental and maintenance facilities(C5)	Questionnaire Scoring
	Ecological indicators(B2)	Green Space Ratio(C6)	Data Processing
		Per-person Green Space Ratio(C7)	Data Processing
		Green Coverage Ratio(C8)	Data Processing
		Green View Index（C9)	Data Processing
		Canopy Density(C10)	Data Processing
		Woody Plant Diversity(C11)	Data Processing
	Aesthetic Indicators(B3)	Seasonal Plant Diversity(C12)	Questionnaire Scoring
		Plant Color Diversity(C13)	Questionnaire Scoring
		Sky View index(C14)	Data Processing
		Pavement Color(C15)	Questionnaire Scoring
		Pedestrian Space Width(C16)	Questionnaire Scoring
		Olfactory Perception Satisfaction(C17)	Questionnaire Scoring
		Auditory Perception Satisfaction(C18)	Questionnaire Scoring
	Cultural indicators(B4)	Regional Characteristics of Plant Landscape(C19)	Questionnaire Scoring
		Temporal Characteristics of Plant Landscape(C20)	Questionnaire Scoring
	Social indicators(B5)	Safety or Security(C21)	Questionnaire Scoring
		Satisfaction(C22)	Questionnaire Scoring
		Sense of Belonging(C23)	Questionnaire Scoring

2.2.7 Correlation analysis

The Pearson coefficient, which has values ranging from 1 to 1, is a tool used to quantify the degree of linear correlation between two successive variables. A relationship is considered to be unrelated if its value is 0, totally positive if its value is 1, and completely negative if its value is 1. The calculation formula is as follows ：

$$\rho_{x_{i,}x_j} = \frac{E[(x_i - \mu x_i)(x_j - \mu x_j)]}{\delta_{x_i}\delta_{x_j}} \tag{7}$$

$x_{i,}$is the i-th indicator variable, $\rho_{x_{i,}x_j}$ is the Pearson correlation coefficient between the i-th indicator variables, δ_{x_i} is the population standard deviation of the i-th indicator variable, and μx_i is the population mean of the i-th indicator variable.

3. Findings and Discussion

This study obtained a total of 1,253 housing data entries. After cleaning up blank and erroneous data, 783 housing data entries remained. After processing, there were still 6,355 housing reviews left, including 4,760 positive reviews (74.9%), 1,573 negative reviews (24.7%), and 22 neutral reviews (0.4%).

3.1 Findings

3.1.1 Spatial density distribution of residential areas and high-density residential areas in Chongqing

The residential complex of Chongqing central urban area was distinguished by a high FAR and dense distribution, particularly inside the inner circle, showing cluster distribution (Fig.3).

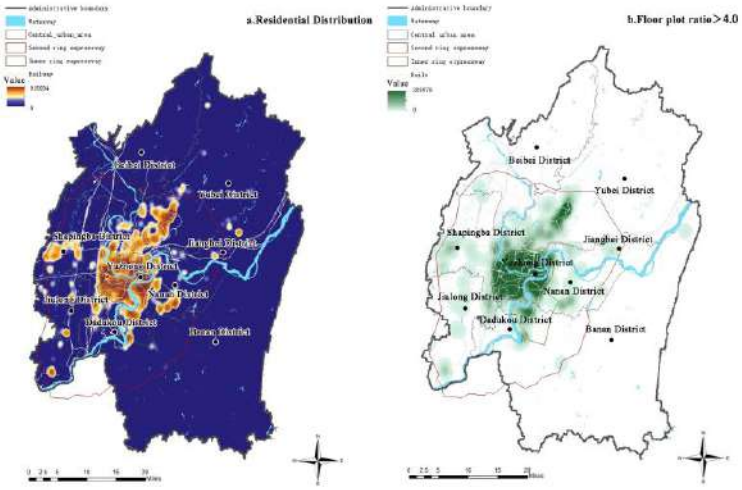
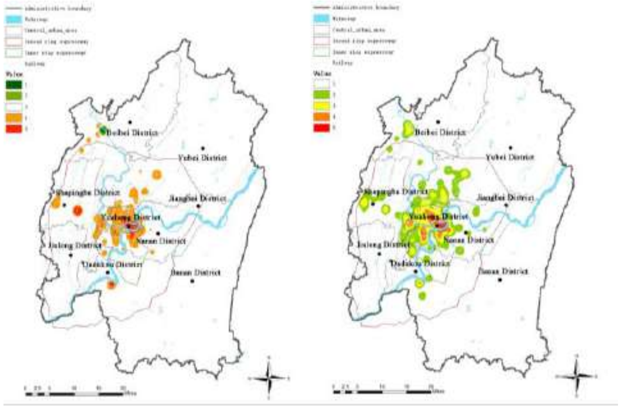


Figure 3. Density distribution of residential areas(a) and high-density residential areas(b) of the study area.

3.1.2 Spatial density distribution of residential sentimental scores in Chongqing

The distribution of positive emotions among the public of the residential complex was more concentrated in the central urban area, compared with the negative (Fig.4). The public sentimental data were mainly concentrated in Yuzhong District, Yubei District and Jiangbei District. The mix of positive and negative emotions was highly integrated in Jiefangbei Street in Yuzhong District, and in the proximity of Guanyinqiao Business Circle in Jiangbei District (Fig.5).



（a）Positive （b）Negative

Figure 4. Positive and negative sentiment density distribution in residential areas of the study area.

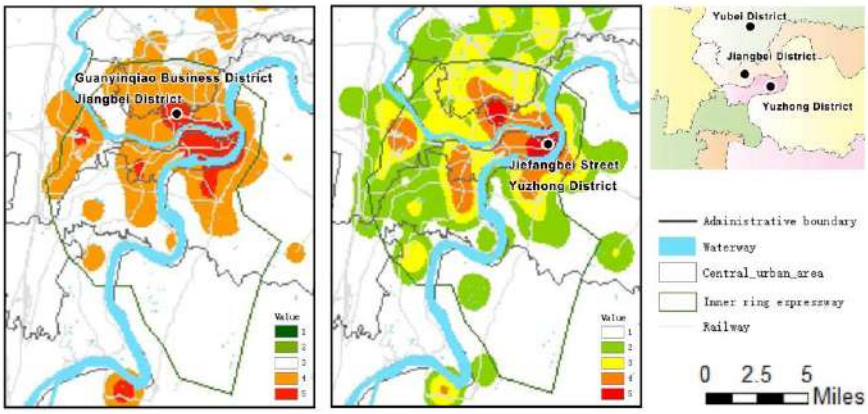


Figure 5. Local amplification in areas of sentimental concentration in the study area.

3.1.3 Green space preferences in typical residential areas of the study area

After field surveys, 10 typical residential areas within the inner ring of sentimental concentration including four positive, four negative, and two neutral, were finally selected for analysis (Table 3).

Table 3. 10 typical residential areas

Residential number	Construction time	Residential name	Floor area ratio	District	Emotion Score Ratio	Sentimental tendency
1	2006	Yuzhong Mingjun	4.05	Yubei district	3	positive
.2	2009	Luneng Star City 8 blocks	4.62	Jiangbei district	3	positive
3	2012	Longhu River and City-Thousands of Trees	2.8	Yubei district	4	positive
.4	2017	Longhu River and City - Original Mountain Time	5.57	Yubei district	2	positive
5	2006	Huayu Yuzhou Xindu	4	Yuzhong district	1	neutral
6	2018	Longhu River and City-Qinghui Time	2.3	Yubei district	1	neutral
7	1980	Shuanggang Road District	10	Yuzhong district	0.33	negative
.8	2007	Jiahua Xincheng	7.13	Yuzhong district	0.33	negative
.9	2012	Longhu River and City-View Uptime	3.5	Yubei district	0.30	negative
10	2016	Luneng Star City 13 blocks	5.58	Jiangbei district	0.44	negative

3.1.4 Evaluation of green space characteristics in typical residential areas

The result of Visual Perception of 10 residential areas are as follows (Table 4). AREA1 had the highest score of Olfactory and Auditory Perception. Overall, AREA1 dominated in five indicators, including traffic flow and Accessibility Integrity ect.

Table 4. Multi-dimensional evaluation of green space characteristics in residential areas.

Standardized layer	**Indicator layer**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
functionality	C1	3.15	3.29	3.5	3.05	3.35	3.36	2.75	3.05	2.55	3.00
	C2	3.00	3.62	3.55	3.55	3.35	3.14	2.80	3.00	3.30	2.95
	C3	2.65	3.33	3.65	3.30	2.55	3.55	2.65	3.20	3.65	2.80
	C4	2.80	3.24	3.55	3.8	3.15	3.45	2.55	3.15	2.95	2.75
	C5	3.1	3	3.15	3.4	2.55	3.73	2.35	2.55	3.45	2.25
ecology	C6	90	90	90	76	90	76	76	90	76	92
	C7	80	100	90	68	91	99	30	55	65	75
	C8	81	95	91	91	90	93	82	90	98	90
	C9	71	75	96	91	75	86	85	96	98	93
	C10	81	100	88	92	96	89	89	91	97	98
	C11	72	88	66	67	76	67	20	65	70	62
aesthetics	C12	2	4	5	4	3	5	2	2	4	4
	C13	3.4	4	4.6	4.2	2.8	4.8	2.4	2	4	3.8
	C14	62	6	77	78	55	85	27	20	85	51
	C15	2.75	4.5	4.25	4	2.75	4	2.5	2.25	4.25	3
	C16	3.50	4.50	5.00	3.50	3.00	4.50	2.50	3.00	3.00	3.50
	C17	3.25	4.00	5.00	4.00	3.50	4.50	2.75	2.50	4.00	2.75
	C18	3.25	4.25	4.75	3.00	3.00	4.00	3.50	3.00	4.50	2.25
culture	C19	3.00	4.00	3.25	3.00	3.50	3.00	4.00	3.50	3.00	3.00
	C20	2.75	3.75	4.25	3.75	3.75	4.25	3.25	3.50	3.75	3.25
sociability	C21	3.10	3.62	3.10	3.10	2.90	3.55	2.40	2.55	3.05	2.55
	C22	3.10	3.71	3.75	3.45	3.30	3.45	2.50	2.45	2.40	2.60
	C23	2.80	3.05	3.40	3.35	3.45	3.45	2.80	3.00	3.55	2.40

3.1.5 The correlation between green spaces in typical residential areas and public sentiment

Based on the defined types, selected the most or least popular green space in each of the ten residential areas respectively. The results of the correlation analysis showed that six indicators had strong correlation with public sentiment and eight indicators had significant correlation (Table 5). Built on the hillside with a staggered hierarchical structure(37%) was the style that best reflected the regional characteristics of chongqing. Featured buildings(66%), featured symbols(57%) was the place that best represented the spiritual culture of chongqing. Motor vehicles(54.78%) have become the sound source that most affects people‘s mood. Floral and fruity scent of plants(54.78%) have become the most predominantly odour that affects residents' mood. Light lime green (28.29%), followed by light blue-grey(20.76%) and light yellow-beige（20.34%）were residents‘ favourite colours of green space pavement.

Table 5. Relevance data analysis of the 23 indicators.

	C1	C2	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**C12**	**C13**	**C14**	**C15**	**C16**	**C17**	**C18**	**C19**	**C20**	**C21**	**C22**	**C23**
Relevance evaluation	0.162	0.751*	0.881**	0.702*	0.820**	-0.426	0.440	0.707*	0.277	0.202	0.379	0.805**	0.813**	0.430	0.961**	0.651*	0.869**	0.727*	-0.193	0.744*	0.756*	0.552	0.658*

* p<0.05 ** p<0.01

3.2 Discussion

3.2.1 The stock update of the distribution of high-density building clusters.

The big data analysis revealed that residential areas in Chongqing exhibit a “large groups, small gatherings” pattern, with high-density clusters concentrated in Yuzhong, Jiangbei, and Yubei districts. Due to Chongqing’s mountainous terrain, high-density residential areas are organized into clusters. According to Shen et al. (2022), the city's main urban area has been expanding outward, particularly to the north. In the context of urban renewal, building density in central Chongqing should be rationalized through zoning optimization and dynamic adjustments. Density standards should be tailored to regional functions, resident needs, and the overall urban plan, ensuring balanced development and avoiding overdevelopment.

3.2.1 Commercial and tourist residential areas provide rich sentimental expression scenarios.

Residents generally expressed higher satisfaction with highly urbanized areas than with peri-urban zones, with mixed emotions most common near business and tourist districts. Sohn (2016) suggested that commercial land-use diversity impacts residential burglary differently depending on the type of facilities; integrating grocery stores, restaurants, and offices can enhance safety. Kim and Park(2016) found residents satisfied with infrastructure but dissatisfied with tourism development, property value increases, and overall residential satisfaction. The fast pace and competition of city centers can create stress but also a sense of achievement. In core urban areas, contrasts between wealth and poverty may trigger dissatisfaction. Frequent social interactions in commercial areas evoke diverse emotional responses, from tension and excitement to joy and satisfaction. Tourist areas, filled with novelty and cultural landmarks, elicit awe and joy. However, emotional data may be influenced by social media, leading to biases like overlooking the city’s foundational strength (Xiao et al., 2023) or errors in sentiment recognition. Future studies should integrate multi-source data, such as WeChat and mobile signaling, and apply machine learning to improve sentiment analysis accuracy.

3.2.3 Optimization strategies for residential area environments based on residents' landscape preferences

Pavement color ($r = 0.961$, $p < 0.01$) was the most significant factor affecting public sentiment in residential green spaces, followed by accessible facilities ($r = 0.881$, $p < 0.01$) and olfactory satisfaction ($r = 0.869$, $p < 0.01$). Zhang et al. (2021) recommended that residential building exteriors feature high brightness and low saturation. Floor color in residential areas influences emotions through visual, spatial, and cultural factors. Well-chosen colors promote comfort and security, while poor choices can cause anxiety or fatigue. Thus, color design should consider functional needs, community culture, and residents' psychological expectations. To improve public services, it is vital to: (1) optimize space by utilizing underground parking and commercial areas, freeing up ground space for public use and green areas; (2) ensure that schools, hospitals, and cultural facilities match population size in high-density areas. Additionally, attention to ventilation and lighting is necessary: (1) optimize building layouts for airflow and natural light; (2) use a mix of building heights to create a more human-centered environment.

4. Conclusion

This study established the relationship between high-density urban residential areas and public sentiments, exploring the diverse impacts of residential green space features on public sentiments. These sentimental expressions not only reflect individuals' reactions to their surroundings but also, to some extent, embody a microcosm of urban culture and social dynamics. The findings offer valuable insights that optimizing the functional and aesthetic design of green spaces in high-density residential areas will have a positive effect on improving quality of life, alleviating stress, mitigating depressive emotions, and promoting physical and mental health.

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Analyzing Human-Physical, Player-Virtual Landscape Interaction in Disaster Simulations Context

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Abstract

Urban theorists like Jacobs, Lynch, and Gehl highlight the importance of accessible layouts and community engagement in designing livable cities. Lynch's five elements—paths, nodes, edges, districts, and landmarks—are foundational for understanding spatial legibility in urban environments. With advancements in digital technology, virtual worlds and gaming landscapes have introduced new dimensions to spatial interactions, particularly in disaster-themed simulations that enhance disaster preparedness and awareness. This study explores the adaptation of Lynch's urban design principles within digital contexts, focusing on player-virtual landscape interactions and responder-affected individual dynamics in disaster simulations. Drawing from this theoretical platform, this research contrasts urban, virtual, and simulated environments in order to show both opportunities and challenges of translating physical design elements to the digital realm. The findings show potential for integration of urban design theories with games development and propose new insights into creating more immersive and functional digital environments. This new approach results in interdisciplinary enrichment for academic discourse and gives practical strategies to enhance spatial legibility and interaction across the physical and digital landscape.

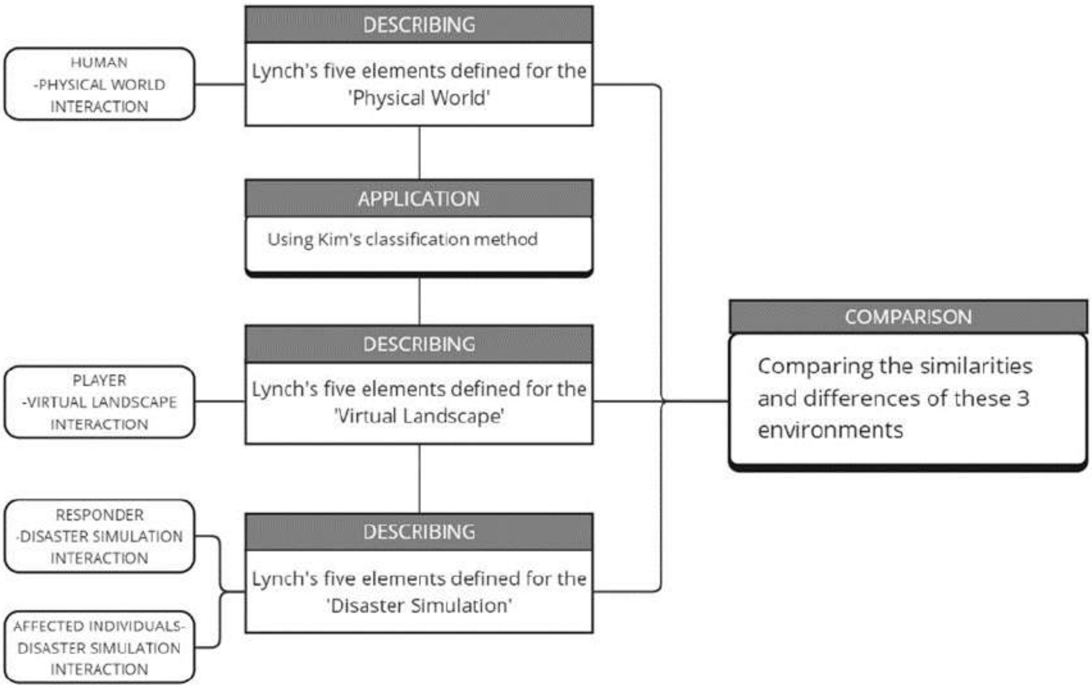
Keywords: Virtual landscape, disaster simulations, human-environment interaction, gamer-virtual landscape interaction

1. Introduction

Long key topics in debates on the livability and sustainability of cities have been urban design and the background of spatial legibility. Pioneering urban theorists such as Jacobs (1961), Lynch (1960), and Gehl (2010) emphasize the significance of community engagement, diverse activities, and accessible urban layouts in crafting well-designed cities. Lynch's framework, particularly his five elements of urban design -paths, nodes, edges, districts, and landmarks- has been instrumental in understanding how individuals interact with and perceive their physical environment. In parallel with these urban design principles, advancements in digital technology have introduced new dimensions to spatial interaction, especially within virtual environments such as video games. As digital games evolve, their role in shaping immersive and engaging experiences has become increasingly significant (Nitsche, 2008). This evolution prompts a critical examination of how spatial legibility and human-environment interactions are represented not only in physical urban spaces but also in virtual game landscapes. Adapting classic urban design frameworks, like Lynch's components, to virtual environments raises problems concerning their transferability. Kim’s classification approach (2016) provides insights into recontextualizing fundamental ideas in digital contexts. Furthermore, with the rise of disaster simulations, there is a growing interest in learning how these virtual worlds might help with disaster preparedness and response. This research examines spatial legibility and human-environment interaction through Lynchian elements in the context of digital disaster simulations. At the same time, this study aims to uncover the challenges and opportunities inherent in designing both physical and digital spaces by investigating how Lynch's five elements operate within simulations. Through a comparative analysis of Lynch's urban design principles and their virtual counterparts, we aim to advance our understanding of how spatial design principles are adapted and applied across environments, affecting how individuals perceive, navigate, and interact with their environments.

2. Material and Method

Table 1. Methodology for analyzing the three environment



Analyzing human-physical environment ınteraction

Human interaction with the environment is a cornerstone of urban design, shaping how people perceive and navigate their surroundings. Jacobs (1961) emphasizes the importance of fostering community engagement, diverse activities, and ease of travel in urban areas. Lynch (1960) builds on this by proposing five elements—landmarks, pathways, nodes, edges, and districts—that enhance mobility, environmental understanding, and social interaction. These principles not only aid navigation but also create spaces for connection and belonging, which strengthen safety and cohesion (Totten, 2014).

Gehl (2010) underscores the need for walkable, people-centered cities for a sustainable future, while Lynch (1960) highlights spatial legibility as essential to cohesive urban planning. Köseoğlu (2010) links legibility to wayfinding, suggesting that cultural, mental, and physical traits of a place affect navigation. Ingold (2000) explores how perception evolves through experience, culture, and environment. Ocakçı (2013) further examines human-environment interaction through four stages: evaluation, interpretability, interaction, and cognition, all of which enhance spatial understanding.

By integrating design principles, spatial legibility, and individual perception, urban areas achieve higher functionality and enrich human experiences.

Methodological Approach

To analyze human-physical environment interaction effectively, the following methodological steps are proposed:

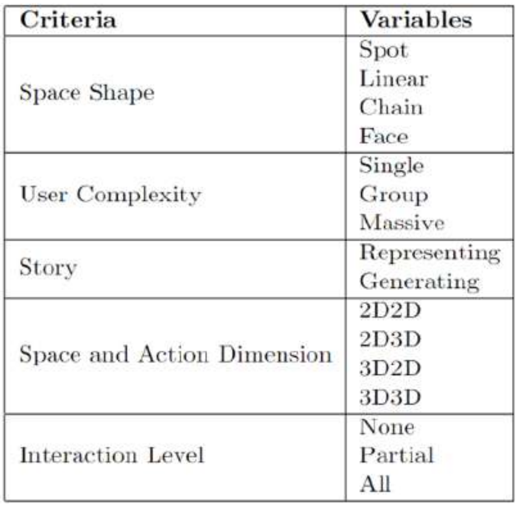
- *Mapping Urban Elements:* Identify and categorize the five key elements (landmarks, paths, nodes, edges, and districts) within the urban or virtual environment under study.
- *Assessing Spatial Legibility:* Evaluate how these elements contribute to spatial legibility and ease of navigation, considering both physical and cognitive aspects of interaction.
- *Examining Human Interaction:* Investigate how individuals interact with these elements, focusing on how landmarks facilitate social gatherings, paths serve as conduits for movement, and districts support various activities.

Analyzing Player-Virtual Environment Interactions Using Kim's Classification

The rapid change and development of gaming universes and the emergence of different types of digital games have made virtual environment design even more crucial. Especially in game genres like Massively Multiplayer Online Role-Playing Game (MMORPG), virtual environment design requires critical adjustments for spatial readability and player-virtual landscape interactions (Nitsche, 2008).

Game genres can often be complex. Numerous types and classes of games exist. To better understand players' interaction with virtual landscapes and reach solutions more efficiently, it is necessary first to understand how virtual environments are classified. In 2016, KIM proposed a classification methodology for virtual landscapes in digital games. This classification allows us to grasp the class of the game we want to change and improve game interactions, enabling us to reach results more efficiently and systematically.

Table 2. Virtual landscape classification methodology by KIM (2016)



Criteria	**Variables**
Space Shape	Spot Linear Chain Face
User Complexity	Single Group Massive
Story	Representing Generating
Space and Action Dimension	2D2D 2D3D 3D2D 3D3D
Interaction Level	None Partial All

In game design, Space Shape classifies the plan according to the options for mobility. Chain combines both for solving mysteries and moving between locations, whereas Spot permits unrestricted mobility and Linear limits it to predetermined routes. Although the face appears to be boundless, designers must take space constraints into account when building layers.

One factor that describes the quantity of players is User Complexity. Group-player scale games are ones in which two or more players participate at the same time, whereas single-variation games only have one player. Lastly, game styles that include two or more groups playing together are included on the huge scale.

The game's story layer is determined by the variable "story." The game is categorized as Representing if it contains a certain story that players follow to finish it. The game is categorized as Generating if players create and consume the narrative within the game.

Action and Space Dimension involves considering how players control the character and how many axes game creators must create. There are two numbers in it. The first figure indicates how many axes the designer must take into account. The game will be categorized as 2D if creators must take into account both axes (XY) when creating it.

Similarly, if developers need to consider three axes (XYZ) to create and manipulate the game, the game will be classified as 3D. (Kim, 2016) Information about how players and the environment interact is contained in the Interaction Level. It is categorized as None if players are unable to interact with the surroundings. It is categorized as partial if players are limited to interacting with certain resources. The game is categorized as All if players are able to interact with every resource.

Kevin Lynch's five aspects are influenced by virtual settings, which are distinct from actual surroundings. Parallels appear when Kim's taxonomy is applied to Lynch's framework: Edges and Landmarks, which direct player movement, line up with Space Shape. Similar to Lynch's Nodes and Districts, User Complexity and Story represent social dynamics and narratives. Furthermore, Lynch's focus on pathways—which highlights how players travel and interact in the game environment—corresponds with the Space and Action Dimension. The intricate relationship between digital and real-world spatial experiences is emphasized by this adaption.

Methodological Approach

To analyze player-virtual environment interactions using Kim’s classification, the following steps are proposed:

- *Categorize Virtual Environments:* Apply Kim's categorization to virtual environments based on Shape of Space, User Complexity, Story, Space and Action Dimension, and Level of Interaction. Clearly indicate both the game type and the specific features of the space that will influence player movement and interaction.
- *Analyze the spatial Dynamics:* Examine the way classified elements influence navigation and spatial cognition of players, in particular, how the space structures movement and interaction.
- *Player Interactions:* Determine the level of interaction that may take place while interacting with players in an environment using Kim's definition in his taxonomy. For instance, what are the player interactions that can potentially be done with another player or an object within a virtual environment?
- *Comparison with Physical Environments:* Compare the findings with the human interaction in physical environments using Lynch's framework, and find if there are similarities or differences in spatial behavior and design strategies.

Analyzing Responder-Disaster Simulation Interaction And Affected Individuals - Disaster Simulation Interaction

During an evacuation, people’s navigation behavior is usually influenced by the clarity of evacuation signs and the surrounding environment. Lynch has pointed out that a chaotic space image lacking personality will always cause difficulties to people’s spatial orientation, resulting in environmental fear and psychological uneasiness, whereas a desirable environmental image with “legibility” can reduce the possibility of labyrinth or wilderment, give space users a psychological sense of safety, and help them to establish psychological harmonious relationship with the outside world (Lynch, 1960). People tend to follow previously-used and known routes (to retrace) rather than follow evacuation signage (Snopková,2021). This has proven undesirable, even fatal, in emergencies and such behavior calls for a better understanding of the influencing factors (Snopková,2021). Urban design, when oriented towards enhancing people's safety, must consider several factors. Cai and Wang (2009) identified four critical aspects:

Psychological Safety: The sense of psychological safety in an environment is closely tied to spatial factors, particularly how well individuals can maintain privacy and control over their surroundings. Lynch (1960) argued that an individual's ability to navigate and orient themselves within a space, known as legibility, enhances this sense of control by allowing for better recognition and organization of urban elements into a coherent pattern.

Behavioral Safety: The physical configuration of urban elements can directly impact human behavior and activities. According to Cai and Wang (2009), ensuring behavioral safety involves designing environments that minimize physical risks. This includes improving the walking environment by optimizing the form, structure, and function of the surrounding landscape to prevent accidents and enhance usability.

Defense for Safety: The spatial layout of urban environments plays a crucial role in preventing inappropriate and disruptive behavior. Clear distinctions between public and private spaces, coupled with community surveillance, can deter crime and enhance safety (Jacobs, 1992).

Safety Against Disasters: Finally, the resilience of urban environments to disasters is significantly influenced by site selection and spatial form. Proper planning and design can mitigate the impacts of natural and man-made disasters by enhancing the structural resistance of the environment (Cai and Wang, 2009).

Methodological Approach

After a disaster, two types of people can be identified: affected individuals and responders. These two groups interact differently with the post-disaster city environment. Therefore, it is essential to analyze these two groups separately to understand their unique needs and behaviors. To analyze the interactions within disaster simulations, this section focuses on two primary groups: responders (emergency personnel and first responders) and affected individuals (civilians experiencing the disaster). The methodology aims to understand how these groups interact with the simulated environment, respond to dynamic scenarios, and utilize spatial elements in the context of a disaster.

- Key Elements Identification in Disaster Simulations: Map out the critical spatial components that the simulation will contain: evacuation routes, hazard zones, resource locations, and shelter areas. These elements allow response workers and impacted citizens to effectively move through the environment.
- Response Interaction: The way in which responses interact with the simulation environment is to be evaluated. Focus is primarily placed on the movement, decision-making, and resource management strategies of these responders—that is, through the process of the analysis of how spatial components, such as routes and nodes (emergency access points), enables their efforts toward controlling the disaster and assisting the affected individuals.
- Analyzing Behaviors of Affected Individuals: Observe behavior among the affected population as modeled in the simulation in terms of risk perception, search for safety, or interaction with the environment. Special attention is paid to the use of landmarks, paths, and shelters and their responses to dynamic changes of the surrounding, for instance, blocked paths and spreading hazard.
- Interaction Dynamics Evaluation: Explore the dynamics of interaction occurring between the responders and those affected—communication, coordination, and assistance. From

this perspective, it is also investigated how such interactions are influenced by the simulation design: clarity of spatial elements and availability of resources.

- Comparative Analysis with Physical and Virtual Environments: A comparison should be made between the interactions of the disaster simulation and physical and virtual environments to determine similarities and differences in spatial behavior and use between the two. The comparison will clarify how spatial design and its legibility will affect human response and coordination in dynamic, highly stressful situations.By examining these interactions, the analysis aims to provide insights into effective disaster simulation design, emphasizing the importance of spatial legibility and strategic placement of critical elements to enhance training, preparedness, and emergency response.

Comparing the Similarities and Differences of These 3 Environments

The final phase of the methodology will then engage a comparative approach between the three kinds of environments: urban, virtual, and disaster simulations. Here the commonalities and differences within designs, perceptions, and uses of the spatial elements and human interactions are to be outlined.

- Identification of Common Spatial Elements: Describe and compare the representation and function across the three environments of spatial elements, such as landmarks, paths, nodes, edges, and districts. Identify how these elements support navigation, orientation, and interaction.
- Compare Interaction Dynamics: Discuss how the interaction occurs in the different settings. As an example, compare how people interact with their physical surroundings in an urban area, how a player will be able to interact with any of the digital representations present inside a virtual landscape, and how both responders and those affected interact with the disaster simulation.
- Perception and Legibility Assessment: Environmental contexts—elucidate how spatial legibility and cognitive mapping are influenced by them. Further, consider clearly distinguishable elements and their effects on moving around and feeling safe in urban and virtual settings; consider also that these factors play a critical role in emergency response during disasters.
- Design Strategies: Design principles and strategies to be used in the design of each environment. This shall include a comparison of how urban design principles such as community engagement, safety, and accessibility compare with design for the virtual environment in engaging players and bringing about immersion, and both with the design of simulations for effective emergency response.
- Understanding Behavioral Influences: Analyze how human behavior is influenced by spatial configuration and environmental context in each setting. Consider social interactions in cities, gameplay in virtual environments, and emergency responses in disaster simulations.
- Summarize Insights: At this point, the findings are brought together to provide a holistic insight into how each environment shapes and is shaped by its users. This brings to light key similarities, such as the reliance on clear spatial elements for navigation, and differences, for example, in purpose of design—community building in urban design versus immersion in virtual games versus safety in disaster simulations. As such, the work actually shares deeper insight into the general and specific elements of spatial design and human interaction within urban, virtual, and disaster simulation environments. This is critical in the understanding of how principles from one environment will either be adapted or applied in another to ensure usability, safety, and engagement are achieved.

3. Results

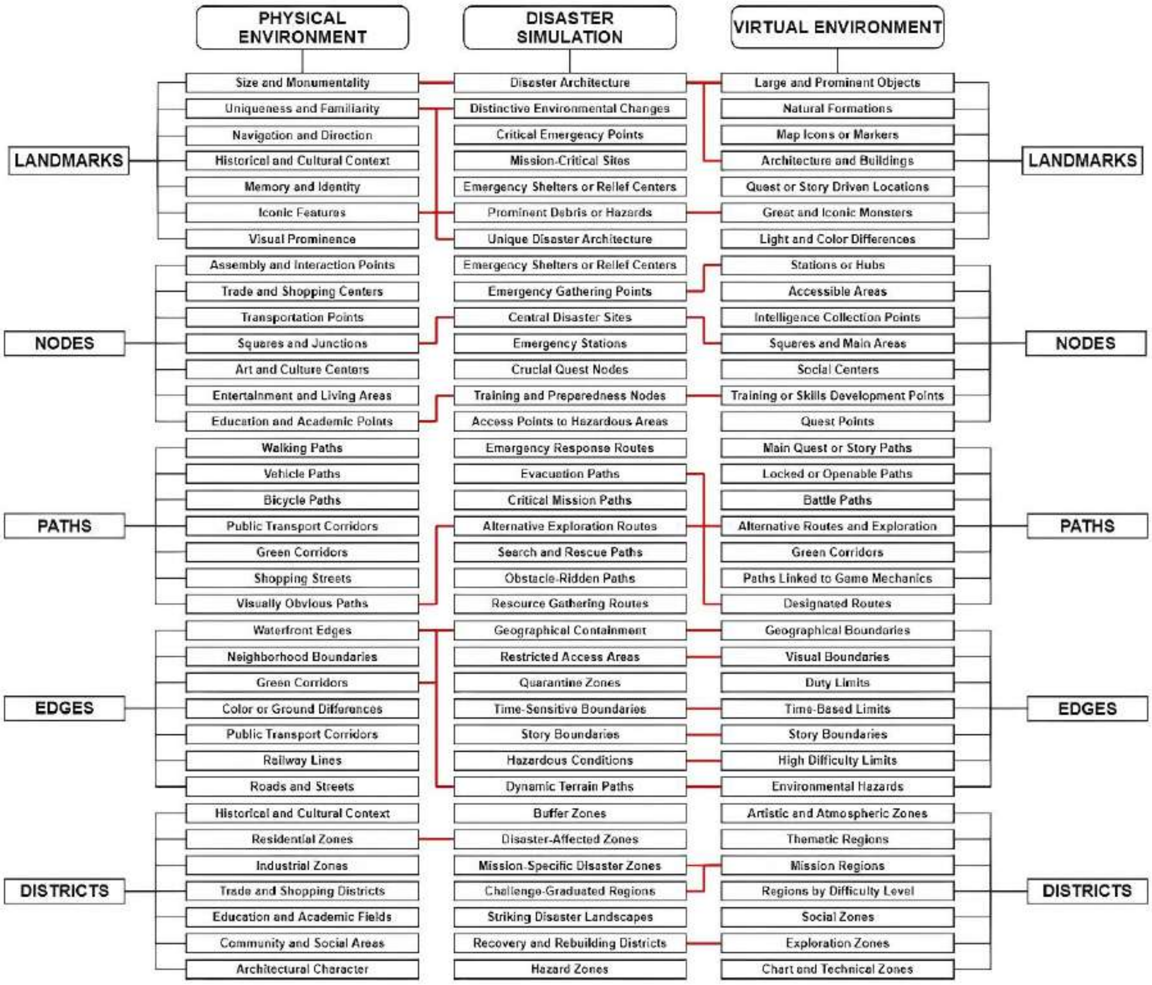
Overview application of Kevin Lynch's five elements— landmarks, nodes, paths, edges, and districts— between physical, disaster simulation, and virtual environments. While each environment has differences in how the elements are implemented, at the heart of it, each design objective is similar to the following: increase spatial legibility, orientate the user in terms of space, and the experience of the end user. For instance, physical environmental landmarks, like a monument or an iconic building, have the same function in disaster simulations as emergency shelters or debris landmarks. In the virtual world, these landmarks become marked prominent in-game objects or quest markers that guide the player in the same way as pedestrians in an urban environment.

Spatial legibility is a main theme across all environments. Put another way, it is shown in the table that in the physical environment, nodes such as transportation hubs or cultural centers are mirrored in disaster simulations by critical emergency points and in virtual environments by key quest nodes or social centers. This shows that whatever the context, nodes are foci of activity and decision points important for navigation and orientation.

However, while the dynamics of interaction between humans and environments may be very different across these three contexts, the requirement for facilitating similar spatial configurations binds them. In an urban context, paths may take the form of public transport corridors or shopping streets in order to facilitate flow and connectivity. Paths in disaster simulations would include evacuation routes or search and rescue paths that provide for least risk and fastest egress. In virtual environments, the structure of paths must balance exploration with guided progression—thereby implicitly guiding player behavior and modulating engagement.

This adaptation in disaster and virtual context creates a plethora of both problems and potentials. Edges in the urban environment can be elements that define a boundary, say between neighborhoods or water fronts, which again would have to be re-interpreted for its use as quarantine zones or hazards for disaster simulations. In the virtual, edges may bound stories or environmental hazards and direct interaction and exploration through player action. The challenge is in maintaining coherence and functionality across these adaptations. As shown in the table, comparative analysis sheds light on how urban design principles can be effectively exemplified in virtual and disaster environments. This cross-pollination of ideas would open new vistas for both urban planners and game designers. For urban planners, it points to the possibility of understanding better how virtual environments work with navigation and engagement and, in the process, creates more resilient and interactive urban designs. For game designers, such use of urban planning concepts can increase the depth and realism of game environments.

Table 3. Comparison of three environments



	PHYSICAL ENVIRONMENT	DISASTER SIMULATION	VIRTUAL ENVIRONMENT
LANDMARKS	Size and Monumentality	Disaster Architecture	Large and Prominent Objects
	Uniqueness and Familiarity	Distinctive Environmental Changes	Natural Formations
	Navigation and Direction	Critical Emergency Points	Map Icons or Markers
	Historical and Cultural Context	Mission-Critical Sites	Architecture and Buildings
	Memory and Identity	Emergency Shelters or Relief Centers	Quest or Story Driven Locations
	Iconic Features	Prominent Debris or Hazards	Great and Iconic Monsters
	Visual Prominence	Unique Disaster Architecture	Light and Color Differences
NODES	Assembly and Interaction Points	Emergency Shelters or Relief Centers	Stations or Hubs
	Trade and Shopping Centers	Emergency Gathering Points	Accessible Areas
	Transportation Points	Central Disaster Sites	Intelligence Collection Points
	Squares and Junctions	Emergency Stations	Squares and Main Areas
	Art and Culture Centers	Crucial Quest Nodes	Social Centers
	Entertainment and Living Areas	Training and Preparedness Nodes	Training or Skills Development Points
	Education and Academic Points	Access Points to Hazardous Areas	Quest Points
PATHS	Walking Paths	Emergency Response Routes	Main Quest or Story Paths
	Vehicle Paths	Evacuation Paths	Locked or Openable Paths
	Bicycle Paths	Critical Mission Paths	Battle Paths
	Public Transport Corridors	Alternative Exploration Routes	Alternative Routes and Exploration
	Green Corridors	Search and Rescue Paths	Green Corridors
	Shopping Streets	Obstacle-Ridden Paths	Paths Linked to Game Mechanics
	Visually Obvious Paths	Resource Gathering Routes	Designated Routes
EDGES	Waterfront Edges	Geographical Containment	Geographical Boundaries
	Neighborhood Boundaries	Restricted Access Areas	Visual Boundaries
	Green Corridors	Quarantine Zones	Duty Limits
	Color or Ground Differences	Time-Sensitive Boundaries	Time-Based Limits
	Public Transport Corridors	Story Boundaries	Story Boundaries
	Railway Lines	Hazardous Conditions	High Difficulty Limits
	Roads and Streets	Dynamic Terrain Paths	Environmental Hazards
DISTRICTS	Historical and Cultural Context	Buffer Zones	Artistic and Atmospheric Zones
	Residential Zones	Disaster-Affected Zones	Thematic Regions
	Industrial Zones	Mission-Specific Disaster Zones	Mission Regions
	Trade and Shopping Districts	Challenge-Graduated Regions	Regions by Difficulty Level
	Education and Academic Fields	Striking Disaster Landscapes	Social Zones
	Community and Social Areas	Recovery and Rebuilding Districts	Exploration Zones
	Architectural Character	Hazard Zones	Chart and Technical Zones

4. Conclusion

The readability analysis of physical and virtual environments provides a comprehensive analysis opportunity thanks to Kevin Lynch's 5 elements. Since disaster simulations are a combination of physical and virtual environments, they have provided the opportunity for comparison and analysis. When examining the physical environment and human interactions, settlements are designed to facilitate all kinds of human activities and navigation. While historical structures serve as landmarks, they are described as reference points that help orientation in space. While squares provide an environment for activities such as gathering points and economic activities, streets and roads provide movement and connection. Districts characterized by their architectural or cultural identities develop a sense of belonging and identity among residents.

In the virtual environment, Lynchian elements have been reinterpreted in the design of the virtual environment with immersive, engaging experiences for players. While Landmarks can be a monster in the game, nodes can change as leveling and item collection areas. The concept of the road can serve as either building roofs or even the top of the clouds with game mechanics. When it comes to boundaries, invisible level boundaries and impassable virtual boundaries show us the biggest difference of virtual environments. Zones are designed to reflect thematic regions or difficulty levels, offering a variety of experiences that appeal to different player skills and preferences.

In contrast, disaster simulations use elements of Lynch by focusing on emergency response and safety. Here, landmarks can become emergency shelters or aid centers, becoming critical reference points in a crisis. Nodes are redefined as central disaster zones or emergency stations that are crucial for coordinating rescue operations and providing assistance. Roads in disaster simulations emphasize efficiency and safety in movement, prioritizing evacuation routes, critical mission paths, and resource collection routes. Edges can represent restricted access areas or geofences that separate safe zones from dangerous ones. Zones are adapted to disaster-specific areas, such as hazard zones or rescue areas, reflecting the dynamic and often unpredictable nature of disaster scenarios. These adaptations underscore the need for flexibility and rapid response in emergency situations, where traditional urban planning principles must be rapidly reconfigured to protect lives and resources.

This comparative analysis shows that while the application of Lynch's five elements may differ across physical, disaster simulation, and virtual environments, the core principles remain relevant and adaptable. Physical environments leverage these elements to support human needs and activities, disaster simulations prioritize safety and emergency response, and virtual environments focus on creating dynamic and engaging user experiences. Understanding these adaptations provides valuable insights for urban planners, emergency responders, and game designers. It suggests that effective spatial design, regardless of context, is based on a nuanced understanding of how people interact with their environments. By applying Lynch's principles in innovative ways, we can create more functional, engaging, and flexible spaces, whether in the real world or in virtual environments. Making disaster simulations more realistic and educational requires designing these elements with the interactions of rescuers and people affected by the disaster in mind. This cross-contextual understanding opens new avenues for collaboration and innovation, fostering environments that are not only practical but also enriching and transformative for their users.

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VR Mirror Integration: Reducing Carbon Emissions Through Enhanced Communication Design

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Abstract

Online platforms reduce carbon emissions, which many researchers have proven. Decreasing emissions due to transportation and electricity consumption is enough to calculate the positive impact of online platforms on carbon emissions (Yin et al., 2022). As Kameoka and Kaneko (2022) indicate, developing technology such as virtual reality social network service (VRSNS) platforms enables the attraction of individuals to convene online. However, it is important to consider the lack of design in VRSNS platforms (Kim et al., 2017). Pang et al. (2022) highlighted the design limitations of Virtual Reality (VR).

This research examines the functions of mirrors in VR to enhance user communication by observing and interviewing users of the VRSNS platforms VRChat (VRChat Inc., 2015), Oasis VR (Oasis VR, 2019), and Horizon Worlds (Meta Inc., 2021). As a result of our research, we discovered that mirrors play an important role in VR communication.

We discovered significant details about using mirrors for design in VR. Along with the requirement of mirrors in any world for communication, we discovered design approaches for their amounts, sizes, and styles. The result of this study will attract more users by improving social interaction in VR, and it will lower carbon emissions (Halonen et al., 2023).

Keywords: VR, design methodology, communication, mirror, carbon emissions

1. Introduction

Online platforms reduce carbon emissions, which many researchers have proven. As Yin et al. (2022) presented, decreasing emissions due to transportation and electricity consumption is enough to calculate the positive impact of online platforms on carbon emissions. With the developing technology, as Kameoka and Kaneko (2022) define, VRSNS (virtual reality social network service) platforms enable the attraction of individuals to convene online. However, it is important to consider the lack of design in VRSNS platforms. Pang et al. (2022) highlighted the graphics and environment design limitations of Virtual Reality (VR).

Within VRSNS, VR design has become a critical element, opening up a new design domain for landscape architects (Kim et al., 2017). Öksüz et al. (2024) and Kim et al. (2025) investigated multiple design theories to help landscape architects understand the different characteristics of VR as a design domain and become a significant role in the rising industry. According to Kim (2017), virtual reality needs a design approach for users and virtual reality to engage in an interactive activity. To enhance user communication in these platforms, further research is required on users, assets, and the environment to understand the relationship between design, user experience, and communication.

As the deficiency in design aimed at attracting individuals to VRSNS platforms increases, Kameoka and Kaneko (2022) were among the first to examine user behaviors on VRSNS platforms. They observed the player's attraction towards mirrors and conducted experiments about it. Despite the research and experiments thus far indicating that mirrors affect users, a definitive conclusion about how to use mirrors as a design asset in VR has yet to be reached. If we can discover how to use mirrors in VR to enhance user interaction, VR performance will increase and reduce carbon emissions. Therefore, this paper examines the functions of mirrors in VR to enhance user communication.

2. Method

Mirrors are one of the first assets researchers focused on the VRSNS platforms. The research on the VRSNS platform VRChat (VRChat Inc, 2015) mentions the wide usage of mirrors in user communication, which led us to study this asset further (Kameoka and Kaneko, 2022).

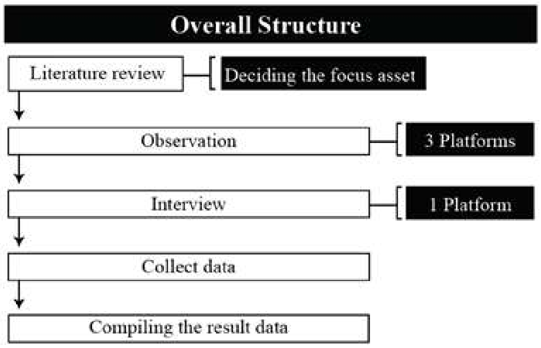


Figure 1. Overall Methodology Structure

We used observation and interviewing to understand the functions of mirrors and their connection with user communication. We chose the most popular VRSNS platform to observe (Steam Charts, 2024). We observe users from VRSNS platforms VRChat (VRChat Inc, 2015), Oasis VR (Oasis VR, 2019), and Horizon Worlds (Meta Inc, 2021). To interview users, we chose VRChat (VRChat Inc, 2015), the VRSNS platform with the most active user base according to Steam (Steam Charts, 2024). The observation and interviews were conducted using a laptop and a head-mounted display (HMD) device to access VRSNS platforms. We proceeded with the first observation and then the interview steps, as seen in Figure 1.

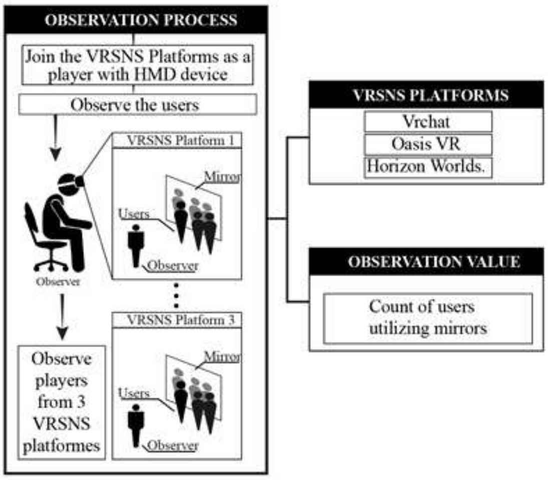


Figure 2. Observation Process

2.1 Observation

The observation process included observing users without interacting with them. We joined the platform as users and observed its highly populated environments. The players who gathered around the mirrors and those who used the mirrors were observed from a distance, as seen in Figure 2.

2.2 Interview

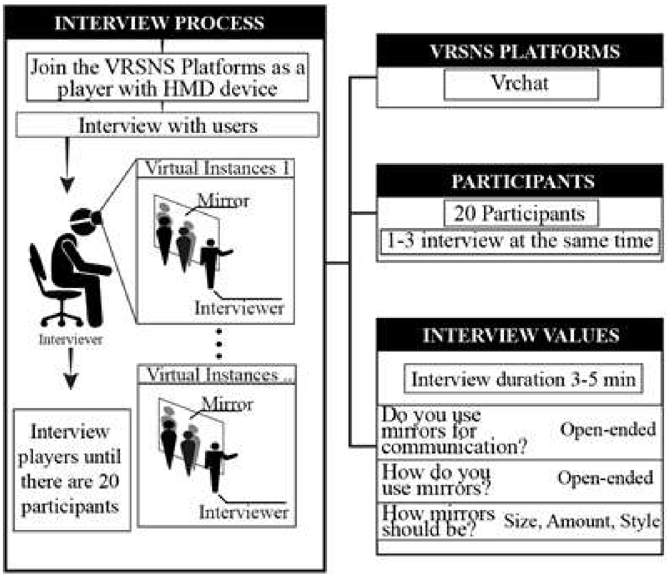


Figure 3. Interview Process

The interview process included communicating verbally with users worldwide on the VRSNS platform (Figure 3). All interviews took place in the virtual reality environments by approaching individuals actively using mirrors. Using an HMD to access the platform, researchers used body gestures during the interview to maintain high levels of interaction. The data was collected in real-time on Google Sheets (Google LLC, 1998). We interviewed 20 users on the VRSNS platform VRChat to understand how they use the mirrors (Kameoka and Kaneko, 2022). Since users were positioned in groups in front of mirrors, the interviews were conducted simultaneously with 1 to 3 users. In interviews, we first asked participants about communication with mirrors, then how they use mirrors and how mirrors should be used. Open-ended answers were expected for the first two questions. To classify the answers to the question about the appearance of the mirrors more accurately, interviewers gave categories such as size, amount, and style. The interview for one participant is set to last 3 to 5 minutes.

3. Result

During the research, ten social virtual reality environments were observed on three different VRSNS platforms. We observed that mirrors are used in most environments, and users communicate by positioning themselves in front of them. As we observed the usage density of mirrors, we interviewed 20 users to understand how they utilize them.

3.1 Observation results

We observed users frequently utilize mirrors on VRSNS platforms. On the platform VRChat (VRChat Inc, 2015), most players are positioned in front of and utilizing mirrors while communicating, as seen in Figure 4.

Figure 4. Observation Process on VRChat (VRChat, 2015)

3.2. Interview results

After observing that mirrors are widely used on platforms, we interviewed 20 users to determine their role (Figure 5).

Figure 5. Interview on VRChat (VRChat, 2015)

As a result of the interviews, we discovered that mirrors play an important role in VR communication. While almost all participants supported using mirrors as a tool for communication, some added that they used mirrors because they liked looking at their avatars. 95% of users indicate that they utilize mirrors on VRSNS platforms to communicate (Figure 6).

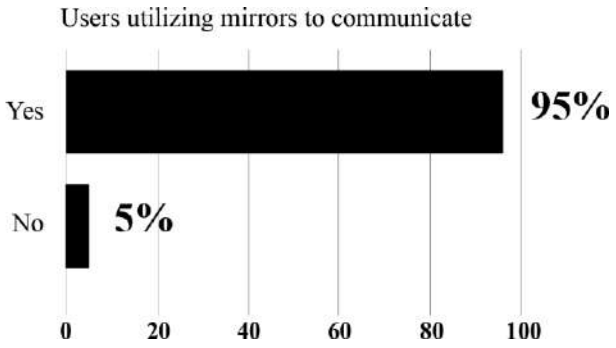
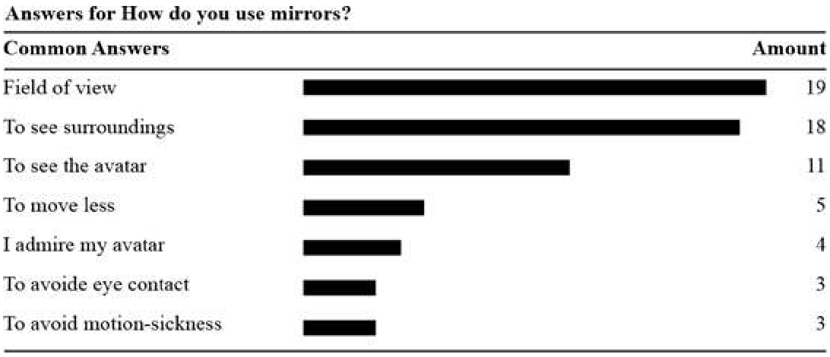


Figure 6. Percentage of users using mirrors for communication

In interviews, we asked participants how they use mirrors and how they should be used. As shown in Table 1, most users utilize mirrors for communication purposes.

In the interviews, when asked, “What did they use the mirrors for?” users stated, “Field of view is better with mirrors.”, ”Mirror causes you to fill the gap of the other senses”, ”It is easier to understand what your avatar is doing.”, and ”Some people struggle with eye contact, mirror makes it less intimate” (Table 1).

Table 1. Common Answers on the Interview



Answers for How do you use mirrors?

Common Answers	Amount
Field of view	19
To see surroundings	18
To see the avatar	11
To move less	5
I admire my avatar	4
To avoide eye contact	3
To avoid motion-sickness	3

3.3. Appearance of the Mirrors

Through our observations and interviews, we gained valuable insights into the importance and specific details of using mirrors in social VR design. In addition to understanding the necessity of mirrors in virtual environments for enhancing communication, we identified key design approaches related to their amount, size, and style (Kameoka and Kaneko, 2022).

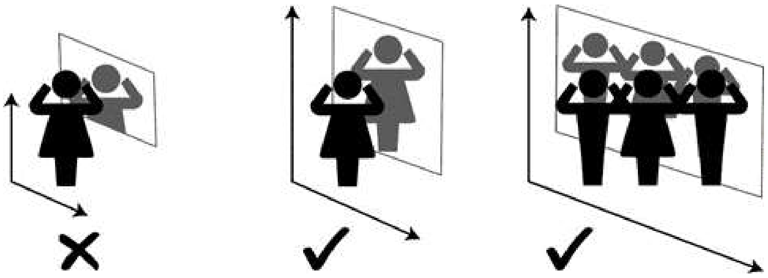


Figure 7. Size of mirrors

Size: Since users utilize mirrors in VR to observe their avatars and surroundings better, the mirrors should be at least larger than the size of the avatars (Figure 7).

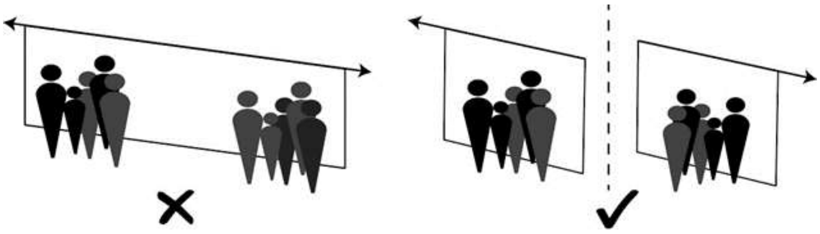


Figure 8. Amount of mirrors

Amount: If more than one group needs the mirror to communicate, positioning separate mirrors so that the sounds will not interfere with giving a positive response (Kameoka and Kaneko, 2022), but the number of mirrors should not be increased more than necessary to stabilize the optimization of the virtual environment (Figure 8).

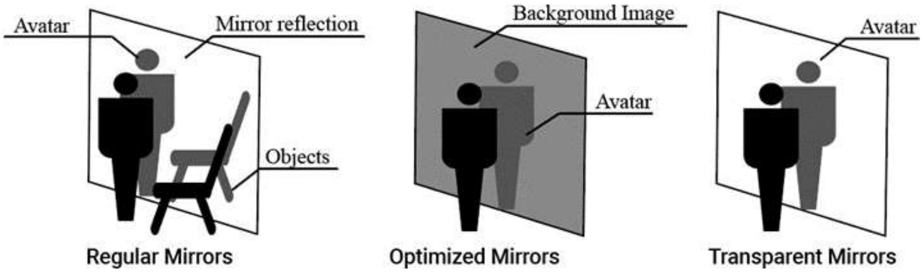


Figure 9. Style of mirrors

Style: On the VRSNS platforms, there are different types of mirrors, including semi-transparent and regular or the ones that only show the avatars. The style of mirrors in virtual reality environments contributes to their optimization, providing users with more comfortable usage options in different settings (Figure 9).

4. Conclusion

Through observations and interviews with 20 users, this study aimed to explore the role and impact of mirrors in VRSNS platforms to learn how to enhance user communication in VR by design. Results reveal that mirror assets are widely used for communication on VRSNS platforms and have a significant role in designing better interactive places. Furthermore, creating more immersive and efficient virtual environments can reduce the need for physical travel and gatherings, contributing to lower carbon emissions (Orngreen et al., 2019). As landscape architects are more involved in the design of VR, this study will assist them by providing detailed information on mirror assets for designing interactive environments within VR. However, future studies should be made to deliver practical design methodology based on this study's findings.

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Quantifying Beauty: Global Sentiment on Public Aesthetic-Views of Chinese Gardens

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Abstract

This study aims to explore the complex relationship between perceptual and cognitive interactions in multimodal data analysis, with a specific emphasis on spatial experience design in overseas Chinese gardens. It is found that evaluation content and images on social media can reflect individuals' concerns and sentiment responses, providing a rich data base for cognitive research that contains both sentimental and image-based cognitive information. Leveraging deep learning techniques, we analyze textual and visual data from social media, thereby unveiling the relationship between people's perceptions and sentiment cognition within the context of overseas Chinese gardens. In addition, our study introduces a multi-agent system (MAS) alongside AI agents. Each agent explores the laws of aesthetic cognition through chat scene simulation combined with web search. This study goes beyond the traditional approach of translating perceptions into sentiment scores, allowing for an extension of the research methodology in terms of directly analyzing texts and digging deeper into opinion data. This study provides new perspectives for understanding aesthetic experience and its impact on architecture and landscape design across diverse cultural contexts, which is an essential contribution to the field of cultural communication and aesthetic understanding.

Keywords: Landscape architecture; aesthetic cognition; landscape cognition; overseas Chinese gardens; cultural communication; machine learning; multimodal deep learning

1. Introduction

The practice of spreading Chinese gardens overseas along the countries of the "Belt and Road" has a long history, with 114 gardens established to date. However, for a long time, whether it was the government, designers, or operators, there has not been an objective and scientific measurement of the needs and cognition of different audiences. Phenomena such as cultural misunderstandings and lack of identity occur frequently, severely affecting the overseas dissemination effect of Chinese gardens. Currently, half of these gardens struggle to maintain operations, let alone achieve their original construction intentions. Therefore, the practice of spreading Chinese gardens overseas urgently requires effective guidance.

The study of audience cognitive differences and dissemination optimization pathways of overseas Chinese gardens under the "Belt and Road" initiative has significant theoretical and practical application value in the current context. The cognitive differences of audiences of overseas Chinese gardens also reflect, to some extent, the background cognition and needs differences of overseas groups, providing references for the formulation of other similar Chinese cultural overseas dissemination strategies. This project lays an academic foundation for cultural output in major country diplomacy, boosting the international dissemination of excellent traditional Chinese culture. More importantly, introducing large model technology into cross-cultural research captures cultural perceptual differences more deeply and vividly demonstrates cultural perception patterns, creating a deeper research paradigm for the perceptual patterns of overseas audiences and opening new pathways for shaping the international image of Chinese culture.

2. Material and Method

2.1 Frameworks

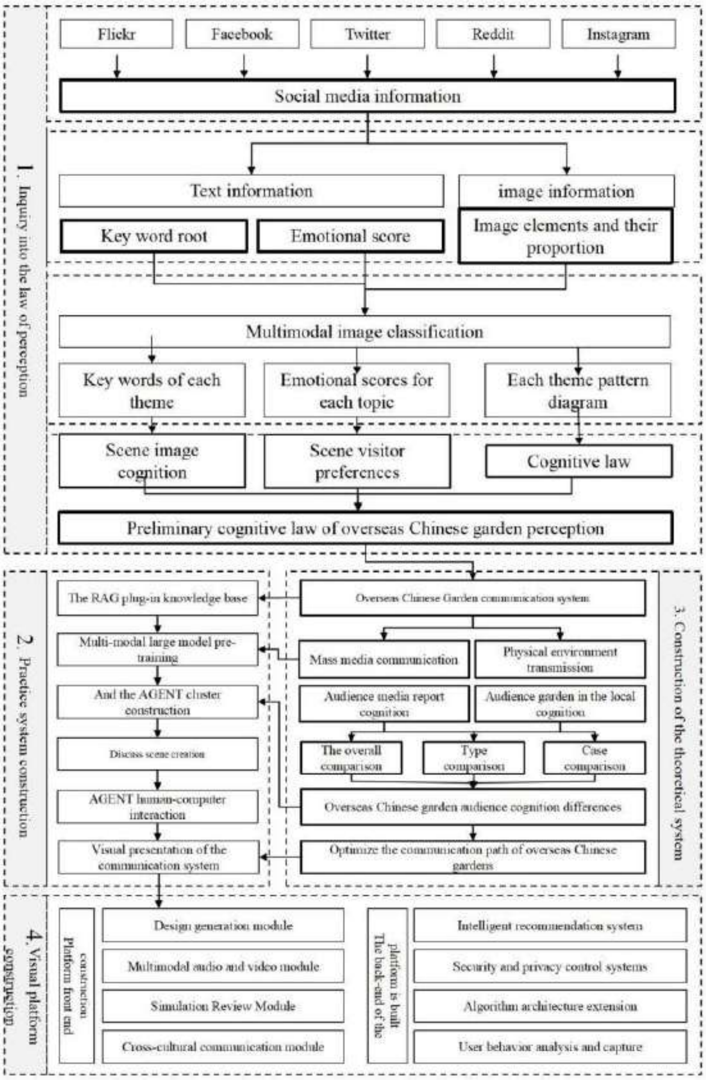


Figure 1. Analytical framework

2.2 Data collection

In this study, we searched for comment threads with images from five foreign social media sites: Flickr, Twitter, Instagram, Tripadviser, and Reddit, using "Chinese Garden" as the keyword, and taking 2016-2023 as the time period. The time period from 2016 to 2023 was searched for comment threads with images.

Each piece of data includes a paragraph of text and a number of images, and each piece of data is linked by a unique ID to facilitate subsequent correlation analysis, as well as a number of other information types, as shown in Table 1.

Table 1. Types of raw data information

Categories	Information	Purpose
Raw Data Information	IDs	as digital credentials for all information linked to each piece of data
	Images	for post-excavation analysis of scene elements, Element proportion , and topic mode pattern
	Texts	for later mining of text keywords, text sentiment, etc.
	Additional comments	as supplementary data for text analysis
	Evaluation scores	to train models that predict the sentiment of text

2.3 Data preparation

The data processing stage is mainly divided into the following stages: 1. Image segmentation 2. Image preclassification 3. Image secondary classification 4. Sentiment score processing

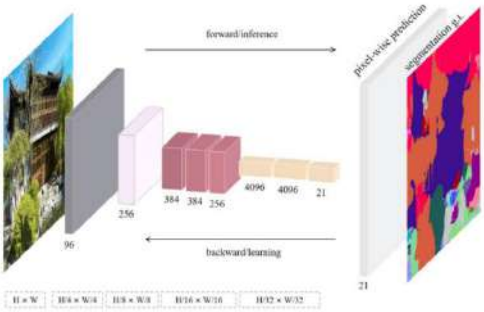


Figure 2. FCN schematic diagram

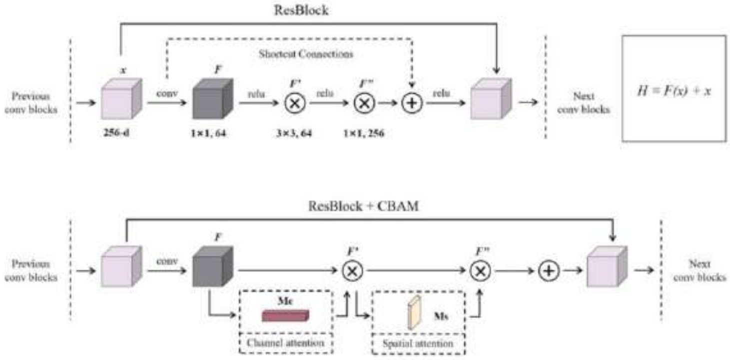


Figure 3. Diagram of resnet and resnet+ attention mechanism after schematic diagram (CBAM)

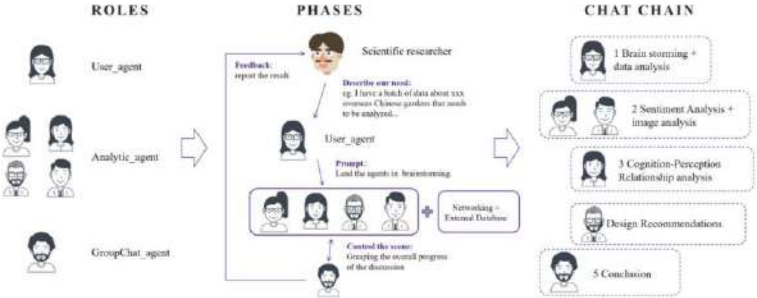


Figure 4. Division of labor process in the aesthetic cognition discussion community

3. Findings and Discussion

3.1 Image segmentation results

According to the image segmentation results, we can get the scene elements, the proportion of each data, and the scene mode pattern. The final combing results show that all the images contain 150 in the scenes.

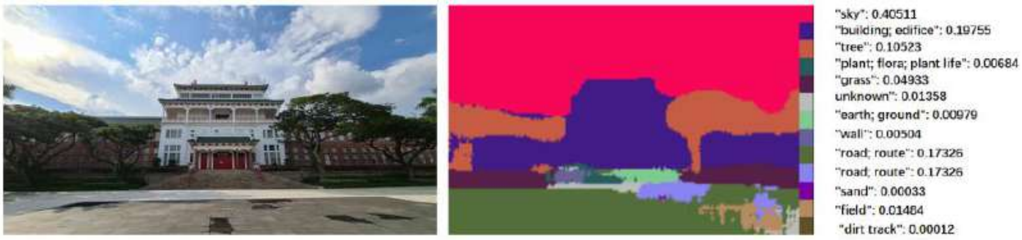


Figure 5. Segmentation result

3.2 Image classification results

In the pre-training stage, the ResNet deep learning model initially classified images of overseas Chinese gardens into 365 categories. Combining the elements of garden design, style, materials used, vegetation types, architectural features and other dimensions, we organize and classify these images into 17 large categories, 102 medium categories and 139 small categories.

In organizing the 17 major categories, we further divided them into aesthetic and functional spaces, presented in Figure 8 and 9 respectively. Functional space is mainly used for site infrastructure, so this study focuses on aesthetic space to investigate the relationship between perception and cognition.

```
"cat_0": {"chalet": 0.164},

"key_words_vision_0":
["man-made", "natural light",
 "open area",  "no horizon",
"foliage", "sunny",  "trees",
 "vegetation", "leaves"]}
```

Figure 6. Resnet+ attention mechanism classification results

Commercial space																	Entertainment space											Urban scene	
stall keeper	Formal dining room				Specialty Chinese restaurant			Pub		utdoor b	Tearoom	Coffee House		Chinese Souvenir Shop			item Festaformanipatory aarts perfctdoor pic Chinesceme SpStage PerWater parot on three tempi											City scene with	
	31:bakery_shop	72:butchers_shop	257:pizzeria	284:restaurant	114:delicatessen	120:dining_hall	121:dining_room	39:bar	54:beer_hall	53:beer_garden	322:sushi_bar	99:coffee_shop	185:ice_cream_parlor	160:general_store, indoor	162:gift_shop	146:flea_market_indoor	7:amusement_park	16:arena_performance	20:art_school	225:martial_arts_gym	265:picnic_area	286:restaurant_patio	291:rope_bridge	315:stage_indoor	353:water_park	277:raft	335:toyshop	47:bazaar_outdoor	318:street

Figure 7. Table Functional Scenario Classification Results

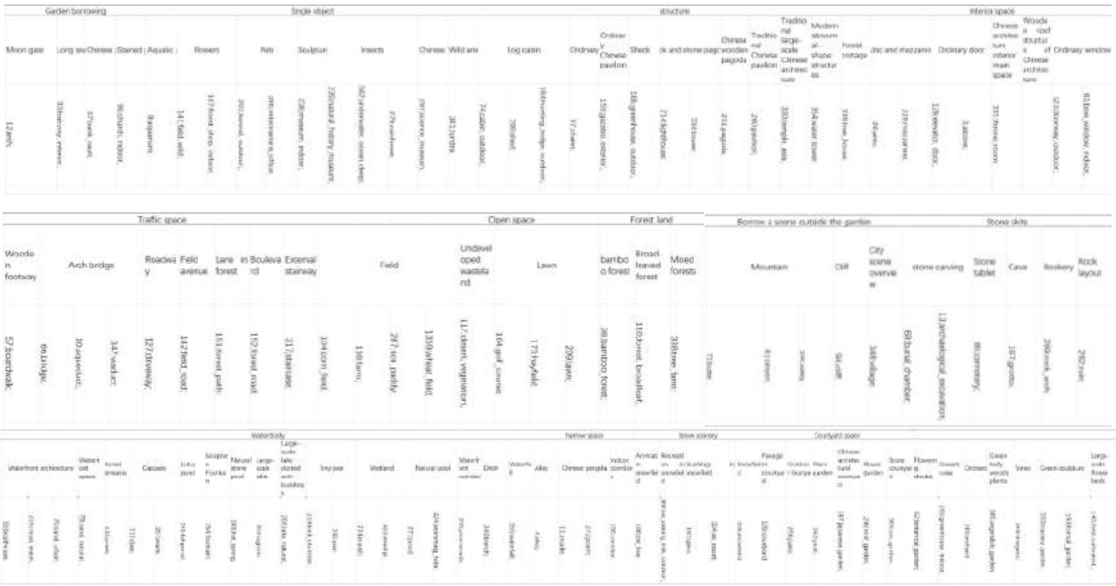


Figure 8. Table Classification results of aesthetic scenes

3.3 Typical Case - Water Feature Focus Analysis

In categorizing water features in overseas Chinese gardens, we subdivided them into four main categories: regular water features, natural water features-lakes, natural water features-streams, and waterfront buildings. According to Figure 9, for regular water features, the statistical analysis of emotional probability distribution revealed that the emotional responses were relatively uniform and low, which indicated that regular water features did not elicit strong emotional responses. Regular water features appeared more subdued regarding emotional arousal than the other categories.

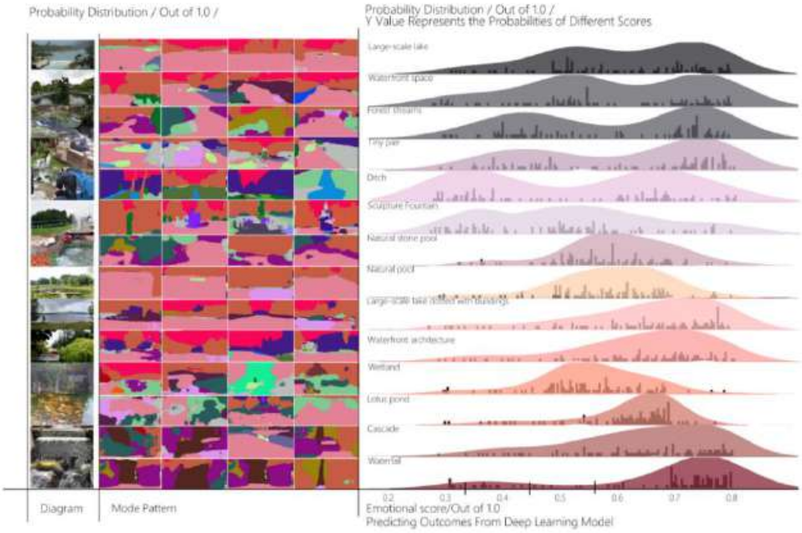


Figure 9. Analysis of the water feature

3.4 Three-level classification analysis

3.4.1 Effect of the ratio of perceptual elements on cognitive emotions

From the distribution of emotions, it can be seen that when the proportion of plants to buildings is close to 2:1, the distribution of emotions is concentrated in the positive range (greater than 0.6), which to some extent reflects the theory of "three parts of water, two parts of bamboo, and one part of the house" described by Li Gefei. It also confirms that although foreign tourists have a low cognition of Chinese garden culture, their aesthetics can conform to the general design laws.

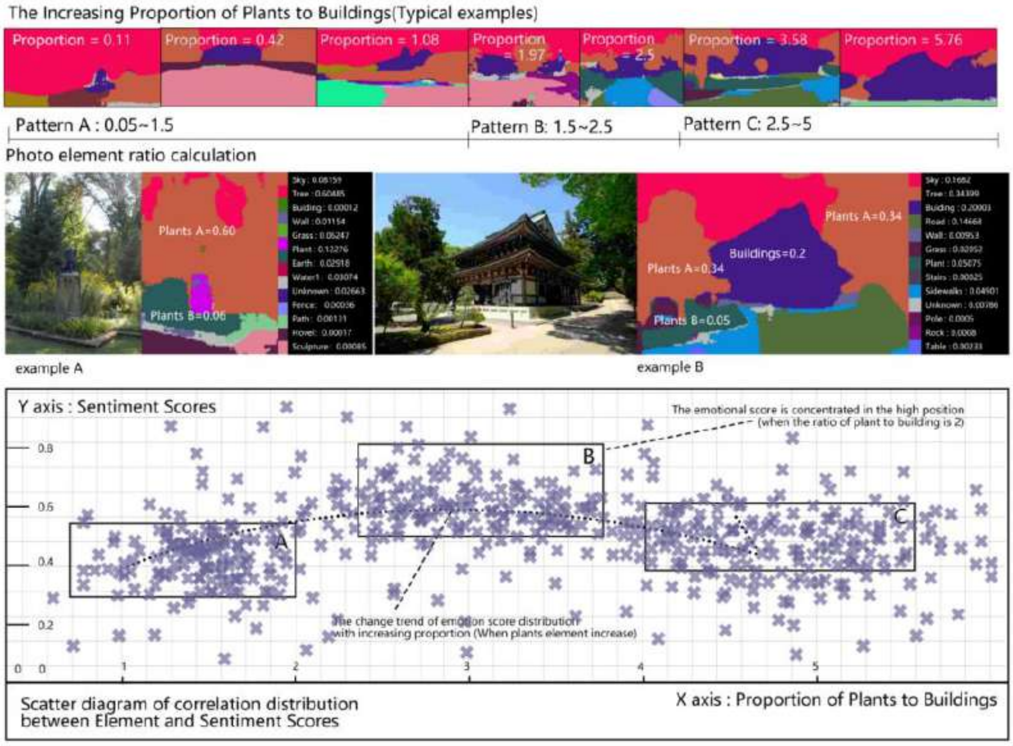


Figure 10. Analysis of proportion of plants to buildings

Furthermore, simply two elements are still needed to explain the problem entirely. Comparing the characteristics of multiple elements can more accurately respond to the aesthetic laws of foreign tourists. As shown in Figure 11, the pictures under the subcategory of the pavilion are traversed to call out the four elements of water, plant, building, and stone, according to which they are categorized into three types: building+plant, building+plant+stone, building+plant+stone+water. Plotting the distribution of the emotions of these three types of scenes stacked on each other, We found that scenes with all four elements have the highest scores, whereas the distribution of scenes with and without stones is approximate but higher overall. Having all the elements is another vital factor in attracting the attention of tourists, with water bodies having a more significant impact.

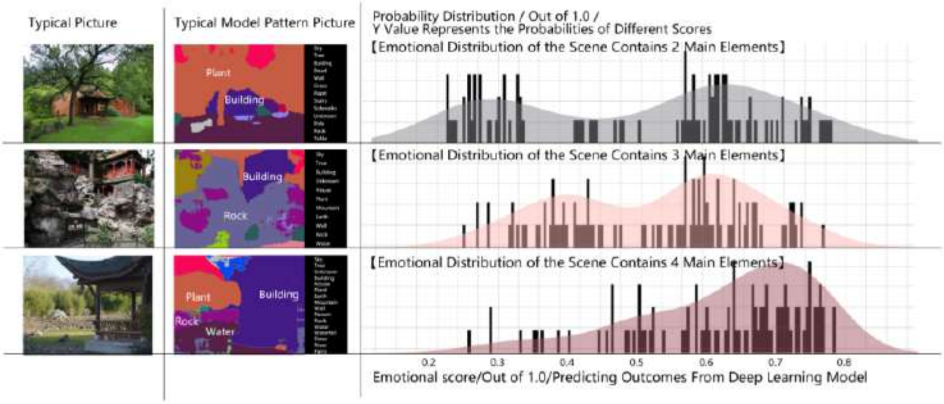


Figure 11. Analysis of multiple elements

3.4.2 The effect of spatial openness on emotions

For the effect of spatial openness on mood, we chose a landscape scene containing a gallery. In the landscape of corridors and walls, unique windows are also important to express the mood of Chinese gardens.In this study section, we chose the percentage of elements related to spatial division, such as walls. Considering that wall elements usually include walls on both sides of the space, we divide their percentage by two to reflect their proportion more accurately.As shown in Figure 14, through the scatterplot of wall occupancy versus mood distribution, we found that the mood scores decreased significantly when the wall occupancy exceeded 0.2, and the data showed a concentration of 0.1-0.3 points. This finding suggests that overly enclosed spaces may hurt people's emotions.

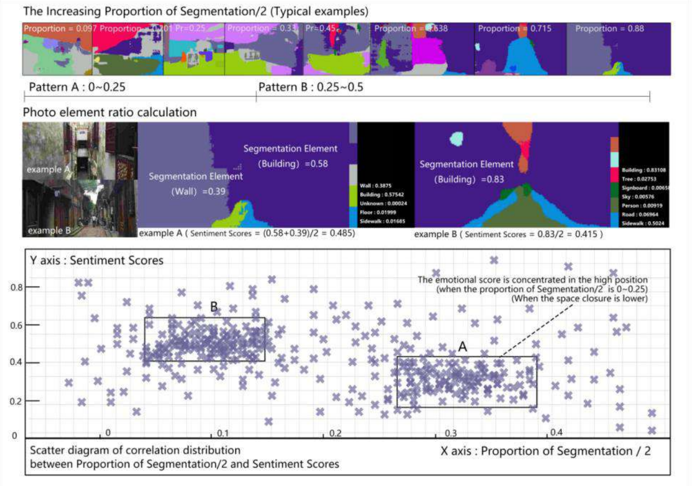


Figure 12. Analysis of proportion of segmentation

Next, we conducted an in-depth comparative analysis of the narrow space subcategory with the porch shelf subcategory and compared the leaky window subcategory with the window subcategory with each other. The study results in Figure 13 showed that the mood distributions of the porch shelf and leaky window categories generally showed a more positive trend.

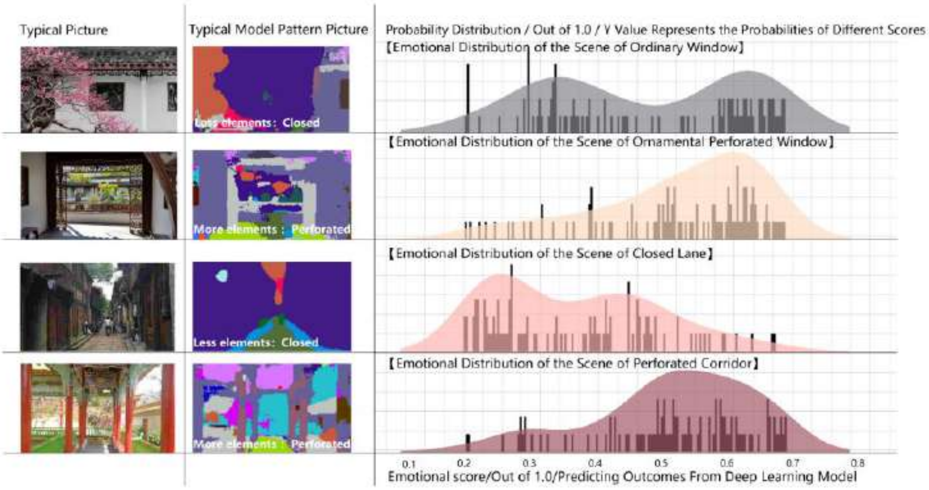
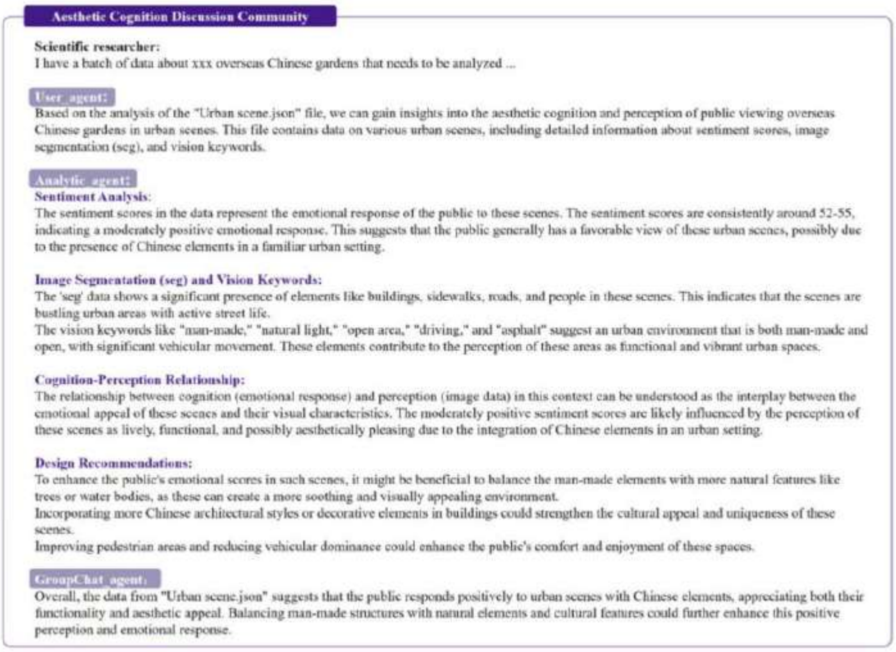


Figure 13. Analysis of elements of the narrow space

In summary, the pattern of overseas tourists' aesthetics of Chinese gardens conforms to the general pattern, which reinforces the above characteristic of overseas tourists' low level of awareness but high acceptance of Chinese gardens. Their evaluation of the design work comes from the quality of the scene design rather than the Chinese elements, and a scene with rich and harmonious elements can better arouse aesthetic pleasure.

3.5 AI Agent

In this study, researchers input the “Urban scene. json” file, which contains data related to various urban scenes, including sentiment scores, image segmentation, and visual keywords. Agents can comprehend this information and respond accordingly (Figure 14).



Aesthetic Cognition Discussion Community

Scientific researcher:
I have a batch of data about xxx overseas Chinese gardens that needs to be analyzed ...

User agent:
Based on the analysis of the "Urban scene.json" file, we can gain insights into the aesthetic cognition and perception of public viewing overseas Chinese gardens in urban scenes. This file contains data on various urban scenes, including detailed information about sentiment scores, image segmentation (seg), and vision keywords.

Analytic agent:
Sentiment Analysis:
The sentiment scores in the data represent the emotional response of the public to these scenes. The sentiment scores are consistently around 52-55, indicating a moderately positive emotional response. This suggests that the public generally has a favorable view of these urban scenes, possibly due to the presence of Chinese elements in a familiar urban setting.

Image Segmentation (seg) and Vision Keywords:
The 'seg' data shows a significant presence of elements like buildings, sidewalks, roads, and people in these scenes. This indicates that the scenes are bustling urban areas with active street life.
The vision keywords like "man-made," "natural light," "open area," "driving," and "asphalt" suggest an urban environment that is both man-made and open, with significant vehicular movement. These elements contribute to the perception of these areas as functional and vibrant urban spaces.

Cognition-Perception Relationship:
The relationship between cognition (emotional response) and perception (image data) in this context can be understood as the interplay between the emotional appeal of these scenes and their visual characteristics. The moderately positive sentiment scores are likely influenced by the perception of these scenes as lively, functional, and possibly aesthetically pleasing due to the integration of Chinese elements in an urban setting.

Design Recommendations:
To enhance the public's emotional scores in such scenes, it might be beneficial to balance the man-made elements with more natural features like trees or water bodies, as these can create a more soothing and visually appealing environment.
Incorporating more Chinese architectural styles or decorative elements in buildings could strengthen the cultural appeal and uniqueness of these scenes.
Improving pedestrian areas and reducing vehicular dominance could enhance the public's comfort and enjoyment of these spaces.

GroupChat agent:
Overall, the data from "Urban scene.json" suggests that the public responds positively to urban scenes with Chinese elements, appreciating both their functionality and aesthetic appeal. Balancing man-made structures with natural elements and cultural features could further enhance this positive perception and emotional response.

Figure 14. Analysis results from the Aesthetic Cognition Discussion Community

4. Conclusion

This study empirically analyzes the audience perception of overseas Chinese gardens, revealing a complex system containing multiple scenarios of cognitive responses and multi-level information dimensions. Through the multimodal analysis of social media data, this paper depicts the general trend of overseas Chinese garden audience perceptions. It demonstrates the feasibility of exploring cognitive patterns in specific scenarios. The core contribution of this study is to propose a new approach to understanding and analyzing audience perceptions in landscape gardening, which provides valuable insights into the practice of garden design and cultural communication.

In addition, incorporating AI agents and a Multi-Agent System (MAS) provides new dimensions and perspectives for studying aesthetic cognition. The incorporation of AI agents enhances the depth and breadth of the data analysis, while the application of MAS provides a more dynamic and interactive environment for the study, which makes it possible to understand and cope with the complexity of audience cognition. This provides a theoretical framework for understanding audience perceptions in cross-cultural environments and practical guidance for landscape designers and cultural communicators in practice.

In summary, the findings of this paper not only provide new perspectives and methods for the study of audience perceptions in the field of landscape architecture but also provide valuable guidance for future landscape design and cultural communication practices. Combining different research questions and methods can also apply this research framework to a broader range of research areas, providing new tools for understanding and addressing complex audience perception challenges.

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LA-GPT: Supermodel Forged by Intensive Training on Billion-Scale Landscape Architects Corpus

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Abstract

In the context of accelerating urbanization and increasing urban complexity, the field of human settlements construction, encompassing urban planning and landscape architecture, faces critical challenges. The urgency of ecological crises, the demand for sustainable development, and advancements in information technology necessitate innovative, interdisciplinary approaches. This study leverages Natural Language Processing (NLP) and Generative Visual Artificial Intelligence to construct a multimodal Large Language Model (LLM) for addressing diverse data formats, cultural sensitivities, and design complexities. By employing Retrieval-Augmented Generation (RAG) and Specific Fine-Tuning (SFT), the research demonstrates enhanced model adaptability, precision, and integration of text and image modalities. The findings highlight the potential of multimodal LLMs to innovate human settlements design, promote resilience, and advance sustainable urban development.

Keywords: Multimodal Large Language Model (LLM), human settlements construction, sustainable urban development, Retrieval-Augmented Generation (RAG)

1. Introduction

Human settlement environment construction spans multiple spatial scales, integrating urban planning, landscape gardening, and architectural design. It plays a pivotal role in national territorial planning, akin to fields like finance and medicine, by addressing critical issues such as complex urban systems, sustainable development, and socio-economic dynamics.

Practically, its execution involves collaboration among governments, corporations, communities, experts, and the public, requiring diverse documents like blueprints, contracts, and evaluations. Blueprints convey spatial design visually, while natural language supports abstract expressions such as requirements, evaluations, and feedback, ensuring effective communication.

Recent advancements in large language models (LLMs) have attracted attention to their application in this field. Researchers leverage LLMs for analyzing spatial needs and evaluations, proposing design solutions, and automating textual tasks. Multi-agent systems increasingly employ LLMs as coordinators, integrating generative AI technologies like intelligent image generation. However, open-source base models often underperform in specialized contexts, leading to semantic errors. Developing an LLM tailored for human settlement environments is essential for domain-specific text tasks and integration with AI technologies, advancing intelligent transformation.

Key challenges in applying LLMs:

Data Scarcity: The interdisciplinary nature of human settlement planning requires diverse datasets, encompassing planning documents, architectural drawings, legal statutes, and cultural context. These data must address geographic and scale-specific nuances to comprehend spatial semantics effectively.

Accuracy vs. Creativity: Unlike fields like medicine, this domain demands precision grounded in real-world conditions and legal standards while fostering innovation to generate creative, abstract spatial designs. General-purpose LLMs often struggle to balance these requirements.

Proposed solution: LA-GPT

This paper introduces LA-GPT (Human Settlements Construction Generative Pre-trained Transformer), a specialized LLM addressing the field's unique demands.

Key Contributions are as followed:

(1) Multidisciplinary Dataset: An efficient QA data generation method reduces time and cost. The dataset integrates urban planning, landscape gardening, and architectural design cases, providing realistic QA samples to enhance model adaptability.

(2) Innovative Model Framework: Combining external knowledge bases for accuracy and secondary pre-training on diverse planning cases ensures creativity. Fine-tuning by scenario classifications and model fusion addresses domain-specific challenges.

(3) Professional Evaluation Criteria: A novel evaluation benchmark assesses the model's performance, confirming LA-GPT's superiority in handling complex spatial semantics and multi-format data.

Experimental results demonstrate LA-GPT's capability to enhance the quality, efficiency, and creativity of tasks in human settlement environment construction, marking a significant step toward the intelligent transformation of this field.

2. Related Work

Large Language Model (LLM) is a type of pre-trained language model that is trained on large-scale text corpus and has parameters reaching tens of billions or even higher. Since the launch of the Transformer (Vaswani, A, Shazeer, N and Parmar, N, et al., 2017) architecture in 2017, the development characteristics of pre-trained language models are mainly reflected in the exponential growth of parameter size and the diversification of model types. For example, the GPT series has significantly increased the number of parameters from GPT-1 in 2018 to GPT-4 in 2023, as well as LlaMA (Touvron, H, Lavril, T and Izacard, G, et al.,2023), Koala, PaLM (Chowdhery, A, Narang, S and Devlin, J, et al.,2022), MOSS, ChatGLM (Zeng, A, Liu, X and Du, Z, et al.,2022), Pangu (Honglin Xiong, S W Y Z,2023), Wenxin (Zhang, H, Yin, W and Fang, Y, et al.,2021) and other diversified model developments mark the rapid progress and innovation in the field of language models.

In terms of language model research in professional fields, research teams in medical, financial, legal and other fields have explored and constructed professional language models that meet the needs of their respective fields. For example, in the medical field, medical models such as ChatDoctor (Li, Y, Li, Z and Zhang, K, et al.,2023), Materia Medica (Wang, H, Liu, C and Xi, N, et al.,2023), and DoctorGLM (Xiong, H, Wang, S and Zhu, Y, et al.,2023) built based on different large language models have performed well in multi-faceted ability assessments and were quickly built in the medical AI framework for use Diagnostic decision-making, electronic medical record entry and public health informatization, etc. The research team in the financial field promotes industry model innovation and process reengineering through the in-depth integration of large model technology and financial business. Open source legal intelligent question and answer systems in the legal field, such as LawGPT_zh and LawyerLLaMA (Huang, Q, Tao, M and Zhang, C, et al.,2023), have demonstrated outstanding capabilities in legal risk prediction, case key point extraction, and document processing. In addition, innovative applications have also emerged in the field of environmental science, such as the new weather forecast method pioneered by the Huawei team based on the Pangu large model (Bi, K, Xie, L and Zhang, H, et al.,2023). However, in disciplines related to urban ecological environment, the application of large language models is relatively lagging behind. It was not until 2023 that researchers began to use large language models in general fields to assist urban planning, landscape design, and architectural design.

To sum up, the construction of language models in 2023 shows a highly active and innovative trend. Language models in various professional fields not only promote the transformation and upgrading of traditional models in the industry, but also show the potential to subvert traditional data analysis and simulation prediction models in scientific research. For subjects related to urban ecological environment, although there have been some attempts to apply general models, building a professional language model adapted to this field and using knowledge graphs to optimize model performance and reliability are still important research directions that need to be explored in depth.

3. Data Collection and Preparation

3.1 Secondary pre-training corpus

Language models can significantly benefit from domain-specific corpora. To enhance the model's capabilities in the field of human settlements, we curated a specialized corpus comprising planning standards, books, and websites. The details are as follows:

3.1.1 Standards and specifications

The domain of human settlements encompasses three primary areas: architecture, planning, and landscape. Accordingly, we compiled an extensive collection of national standards and regulatory documents, including the Residential Building Design Code (GB 50096-2011), Urban Road Engineering Design Code (CJJ 37-2012), Landscape Greening Engineering Construction and Acceptance Code (CJJ 82-2012), General Rules for Tourism Planning (GB_T 18971-2003), and the General Design Code for Forest Parks (LY_T 5132-95), as well as master planning schemes for various provinces and cities. These documents form a critical foundation for domain-specific knowledge in planning, architecture, and landscape design.

3.1.2 Books

To build a comprehensive language model for the urban environment planning and design domain, we conducted a thorough review of core textbooks and seminal works across the three fields of architecture, planning, and landscape. This approach ensures the model covers essential knowledge and technical terminology.

In the planning domain, we incorporated texts such as History of Urban Development and Principles of Urban Planning, along with local urban planning regulations and green development frameworks, providing historical depth and geographic breadth. In architecture, resources such as Urban Architecture and History of Chinese Architecture were included to reflect architectural evolution, design philosophies, and the legacy of influential architects. For landscape design, the collection encompassed works ranging from History of Chinese Gardens to Garden Planning and Design and History of Western Gardens, enabling the model to generate and analyze landscape concepts with precision and innovation.

Additionally, we integrated literary and popular science resources related to garden landscapes, including The Artistic Conception of Gardens in Jiangnan, Quiet Reading of Gardens by Cao Lindi, and Popular Science Encyclopedia of Nature. These resources aim to capture the intersection of garden art and classical Chinese literature, enriching the model’s cultural depth and diversity.

3.1.3 Websites

To support the development of a large-scale language model in human settlements, we conducted an extensive review of professional websites related to urban planning, architectural design, and landscape design. This effort involved analyzing platforms such as Archello, Architecture, mooool Design Network, and the Urban Planning Conference, resulting in the collection of over 148,000 articles spanning theoretical studies and practical case applications.

In architecture, platforms like Archello and Architecture provided vast resources, including project case studies, design concepts, and industry insights. Archello alone contributed over 100,000 articles. Similarly, Chinese platforms like mooool Design Network and Design Book offered abundant localized design information, with Design Book contributing over 16,000 articles.

For landscape design, resources were gathered from platforms such as Landscape China, which offered case studies and theoretical insights to enhance the model’s understanding of landscape-related content. Other prominent sources included Turen Design and Green Guide, providing cross-disciplinary perspectives on design innovation.

In urban planning, platforms like the Urban Planning Conference delivered valuable articles covering the latest planning methodologies, conceptual frameworks, and urban development case studies, ensuring a comprehensive knowledge base for the model.

3.1.4 Data preprocessing

All collected materials underwent a standardized preprocessing workflow. The first step involved extracting relevant text while excluding non-text elements such as images, tables, and hyperlinks. Next, quality filtering techniques, including sensitive word screening, ensured the appropriateness of the data. Finally, to minimize redundancy and enhance training efficiency, duplicate content was removed at both the article and sentence levels.

3.2 Special-fields corpus

In order to alleviate the problem of structural domain bias and improve the model's performance in specific fields, we selected some high-quality data from the built human settlements database to build the instruction fine-tuning, and the construction method adopted diversified means, mainly focusing on self-guided semi-automatic and fully automatic instruction data construction by LLM.

Using the GPT-3.5-turbo interface, we developed a fast and user-adjustable data production method. This method can generate high-quality data in a short time, and users can design appropriate prompt templates, specify their own data cleaning templates, and generate multi-scenario question and answer data in the corresponding vertical fields.

We built 2.8w question and answer data based on this method, which covered various aspects such as urban development planning, community garden planning, waterfront space design, post-industrial site transformation, campus landscape design, residential building design, etc. At the same time, we also generated the automatic writing sections of design proposals for each field, including project background, design objectives, site characteristics and challenges, design strategies and conclusions, etc. In addition, we also considered how to integrate concepts such as child-friendly, resilient city, living circle, sponge city, smart city, etc. into the design, and the specific strategies and results analysis. This step provided the model with rich and realistic scenario-based human settlements construction dialogue samples, which helped the model better understand and adapt to the actual application scenarios.

In addition, we built a knowledge graph of the human settlements field based on the constructed dataset. For the processed data, the knowledge graph is used to check the accuracy of human settlements knowledge, and to ensure that the safety is not compromised while improving the fluency of the response.

3.2.1 Human settlements single-turn dialogue

In the initial stage, in order to explore more issues related to human settlements improvement, we used LLM to play the key roles in human settlements construction such as residents, urban planners, architectural designers, etc., and created a series of question and answer based on specific environmental knowledge.

3.2.2 Human settlements multi-turn dialogue

Following the single-turn dialogue mode, LLM played multiple roles at this time, and interacted autonomously in multiple rounds of discussion. In addition, we also used standards, specifications and other texts as external knowledge bases, in order to improve the accuracy and reduce the misunderstanding of the dialogue, so that LLM can locate the dialogue content around these knowledge.

Since the construction of human settlements covers a wide range of disciplines, in the construction of LLM, we also focused on building datasets for some scenarios, and will continue to improve the relevant scenarios in the follow-up research. The specific scenarios are shown in the following table.

4. Experiments

4.1 Baseline models

In this study, the base model selected for the secondary pre-training stage is chinese-llama-2-13b, and the model selected for the fine-tuning stage is Baichuan-13B. chinese-llama-2-13b is a Chinese pre-trained language model based on Llama-2, which expands and optimizes the Chinese vocabulary on the basis of the original Llama-2, and uses large-scale Chinese data for incremental pre-training, improving the basic semantic understanding ability of Chinese. Baichuan-13B is an open-source large-scale language model with 13 billion parameters developed by Baichuan Intelligence after Baichuan-7B, which achieves the best performance of the same size on authoritative Chinese and English benchmarks.

4.2 Experiments setups

The parameters for the secondary pre-training and fine-tuning stages are as follows (Table 1).

Table 1. Training parameters

Hyper parameter	Value
Precision	Fp16
Epochs	3
Batch size	64
Learning rate	1e-4
Warmup ratio	0.1
LR sheduler type	Cosine
truncation length of the input	1024

4.3 Evaluation

Metric evaluation is critical to the success of LLM. For LA-GPT, we not only want to inject domain-relevant knowledge into the model, but also pay attention to the model's general ability after incremental training.

To the best of our knowledge, there is no authoritative test on the human settlement environment domain. We built an evaluation set called EvalHSC, which covers six dimensions of evaluation, totaling 300.

The evaluation model covers six levels of difficulty: relevance, completeness, practicality, professionalism, originality, depth, arranged from low to high difficulty. Each question-answer pair is scored through these six modes, and by taking the average, each question-answer pair gets a comprehensive score. If a data set's average comprehensive score exceeds 8 points, it can be considered a high-quality data set.

Table 2. EvalHSC statistics

Category	#Subclass	#Questions
Relevance	4	50
Comprehensiveness	5	63
Utility	4	50
Expertise	6	74
Originality	3	38
Depth	2	25
TOTAL	24	300

4.4 Results and analysis

To test LA-GPT, we chose four baseline models to apply our test set EvalHSC and compared the responses generated by our model with the other three baseline models, namely Alpaca, Baichuan (Yang, A, Xiao, B and Wang, B, et al.,2023), and ChatGLM (Zeng, A, Liu, X and Du, Z, et al.,2022).

In the comprehensive evaluation of the models in the human settlement environment domain, LA-GPT model performed excellently with a total score of 159.36, with the highest scores in professionalism (9.90), originality (9.89), and depth (9.96), significantly higher than the other models. This result indicates that LA-GPT model has a significant advantage in providing in-depth professional knowledge, strong original solutions, and deep-level analysis. LA-GPT's high score reflects its profound understanding and ability of human settlements construction issues, and its ability to propose insightful and innovative strategies when facing complex environmental problems.

Alpaca model performed excellently in completeness (9.77) and originality (9.90), and its highest scores in these dimensions highlighted its comprehensiveness and innovation in the environmental domain. This indicates that Alpaca model can provide innovative and effective solutions while considering the comprehensiveness of environmental issues. ChatGLM model obtained higher scores in relevance (9.60) and practicality (9.70), and its score distribution showed the model's strength in identifying problems relevant to user needs and providing feasible solutions. Baichuan model did not have the highest score in any single aspect, but its performance was balanced in multiple aspects.

Through comparative analysis, it can be seen that although all models showed their respective advantages in the human settlement environment domain, LA-GPT model performed particularly well in key areas. These scores show the unique strengths and potential improvement areas of each model, providing valuable guidance for further development and optimization.

Table 3. Score table of each model

Model	Relevance	Comprehen-siveness	Utility	Expertise	Originality	Depth	TOTAL
Baichuan	8.09	7.59	9.75	8.17	5.98	9.80	133.36
Alpaca	8.85	9.77	7.53	9.69	9.90	9.19	146.09
ChatGLM	9.60	7.75	9.70	6.28	9.10	7.84	142.81
LA-GPT	8.17	9.56	8.11	9.90	9.89	9.96	159.36

5. Dicussion

In this study, we successfully developed LA-GPT, a large-scale language model specifically designed for the field of human settlements. Please translate Through extensive database construction and refined incremental training, we have improved the model's ability to handle various human settlement problems. We used a special test set in the field of human settlements for evaluation. The experimental results show that the model performs well in understanding and solving complex problems, reflecting significant performance improvements. However, despite achieving certain results, we have also observed that the model still exhibits hallucinations in some cases, that is, produces unrealistic or inconsistent outputs, which highlights the need for continuous improvement and accurate model tuning expertise. necessity.

We believe that illusory flaws in models may arise from insufficient or imbalanced data, or from inherent limitations of models in understanding deep levels of expertise. In order to further enhance the accuracy and reliability of the model, we plan to study these issues more deeply and explore related solutions in future work. Additionally, we recognize the importance of continually updating our knowledge base and data to keep our models sensitive and responsive to the latest human settlements trends and research.

6. Conclusion

To sum up, LA-GPT, as a large-scale language model specially designed for the field of human settlements, has demonstrated its powerful ability to handle complex problems in this study. Through extensive database building and customized incremental training, the model has made significant progress in professional capabilities. However, to further improve the accuracy and utility of our models, we recognize the need for in-depth analysis and systematic improvements of hallucination defects.

In the future, we plan to use a variety of advanced technologies, including knowledge base expansion and reinforcement learning, to further improve the performance of LA-GPT and make it a more powerful and reliable tool in the field of human settlements. Through continuous innovation and improvement, we expect LA-GPT to provide more in-depth and precise support to planners and researchers of human settlements construction and make greater contributions to promoting the development of this field.

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PROJECTING THE PROCESS

Research on Evolution of Agricultural Landscape in the Pearl River Delta

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Abstract

In the context of globalization and urbanization, the Pearl River Delta Basin, as the core region of China's economic development, holds significant research importance in the evolution of its agricultural landscape. With urban expansion and economic development, agricultural land in the Pearl River Delta faces immense pressure and challenges. Therefore, this paper delves into the evolutionary process of the agricultural landscape in this region. Leveraging Geographic Information System (GIS) technology, an overall analysis of the landscape ecological pattern is conducted based on land-use data. Combining this with a review of previous literature, the paper systematically reviews the historical changes and modern trends in the agricultural landscape of the Pearl River Delta Basin, analyzing changes in agricultural land use and their causes, as well as their impact on the ecological environment. The study reveals a gradual shift of agricultural land from the urban periphery to the hinterland, forming a new spatial pattern that has had a certain impact on the ecological environment. Finally, the paper puts forward a series of recommendations aimed at providing reference and insights for agricultural development and ecological environmental protection in the region.

Keywords: Pearl River Delta, Agricultural Landscape, Historical Evolution, Geographic Information System (GIS), Landscape Ecological Pattern

1. Introduction

Objectives:

This paper explores the evolution of agricultural landscape in the Pearl River Delta region. Utilizing Geographic Information System (GIS) technology, an analysis of the overall landscape ecological patterns derived from land use data is conducted. Combined with previous literature research, the historical changes and modern trends of agricultural landscape in the Pearl River Delta basin are systematically sorted out, and the changes in agricultural land use and its causes, as well as its impact on the ecological environment are analyzed.

Aims of study:

a. In academic research, most of the literature is a single historical analysis or a single data calculation study. There are few studies that sort out agricultural landscape types from the evolution and development of the ancient and modern agricultural landscape in the Pearl River Delta.

b. In the era of globalization and urbanization, the Pearl River Delta is the core area of China's economic development, and the evolution of its agricultural landscape has important research significance.

c. Amidst the growth of cities and the progression of the economy, the agricultural areas within the Pearl River Delta are encountering significant strain and formidable obstacles. This paper puts forward a series of suggestions to provide reference and inspiration for agricultural development and ecological environmental protection in the region.

2. Material and Method

We sorted through historical records and agricultural changes documented in ancient Chinese texts, primarily using sources such as the 'Books of the Sui Dynasty', 'Books of the Han Dynasty', 'Records of the Grand Historian', 'Complete Book of Agricultural Administration', and 'New Language of Guangdong', among others. From these, we identified various types of agricultural landscapes. Additionally, we integrated contemporary geographic data for an analysis of temporal changes, primarily relying on the Chinese National Land Use/Cover Change (CNLUCC) dataset to meet our geographical data needs.

Agricultural landscape evolution in the Pearl River Delta

Before the Sui and Tang Dynasties, the Pearl River Delta was still in a state of primitive agricultural cultivation. Since the beginning of the Song and Yuan Dynasties, a large number of immigrants from the north have poured in. Based on the literature of scholars (Zhong et al., 2020, Zhou, 1982, Zhang, 2010, Ye & Zhou, 2007, Wu, 2016, Wu, 1987, Zhang, 2019, Zhang et al., 2020, Xian & Wang, 2005, Lai, 2002, Dai & Zhong, 2022, Wu, 2011)and ancient books, the author summarized the evolution process of traditional agricultural landscape in the Pearl River Delta. (Figure 1)Due to the introduction of water conservancy technology and agricultural facilities, agricultural landscapes have been formed from enclosures to sandy fields to dry fields. The types of agricultural landscapes have gradually increased, and the degree of commercialization has continued to increase. In the Ming and Qing Dynasties, the pursuit of commercial value and the perception of market demand by the aborigines and immigrants further developed into the base pond agricultural landscape.

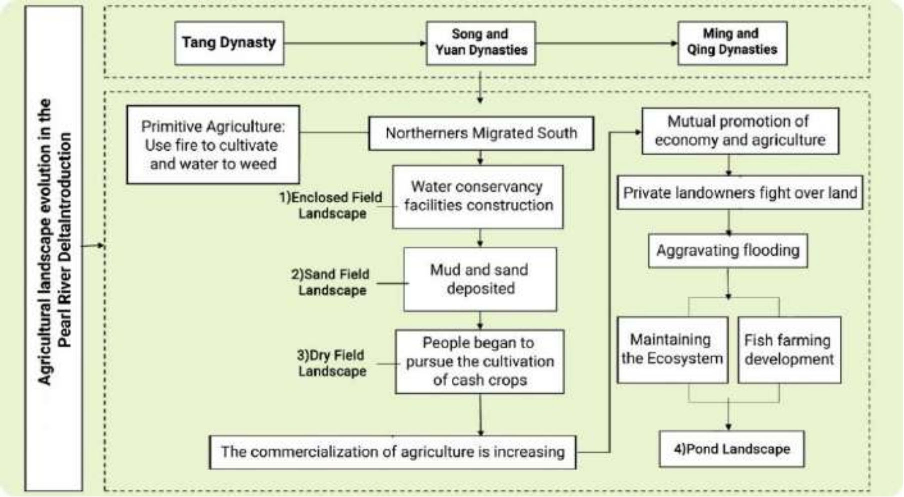


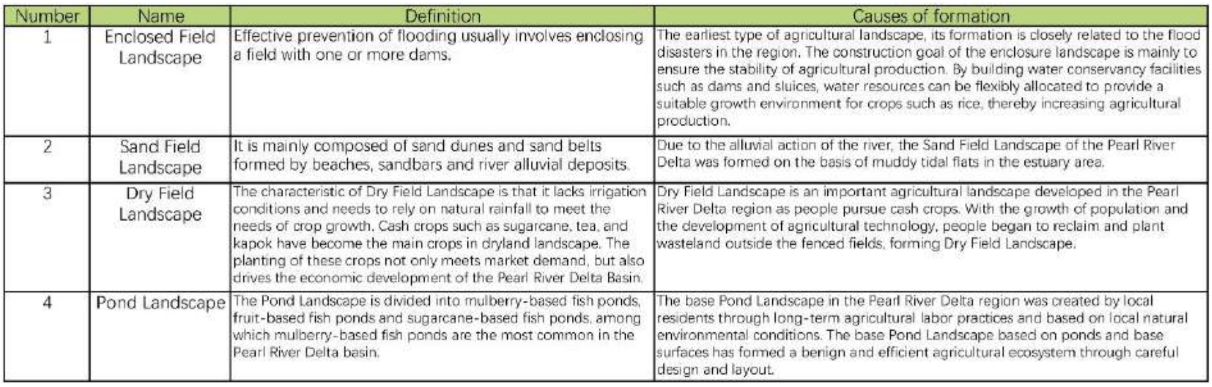
Figure 1. Illustration of the evolution of traditional agricultural landscape in the Pearl River Delta (Huang, 2024)

The landscape of fish ponds is categorized into those centered around mulberry trees, those focused on fruit cultivation, and those associated with sugarcane production. Within this classification, the mulberry and fruit-based fish ponds are the predominant types, whereas the sugarcane-based fish ponds are experiencing a decline, mirroring the downturn in the sugar industry. The pond-and-dike landscape also fosters the growth of associated industries, including fish farming and the processing sector, thereby enhancing the economic vitality of agriculture in the Pearl River Delta. The evolution of dike-pond system is a process of high adaptation to the natural environment and human environment, and is the result of the coupling and interaction of institutional, technological, social and economic factors and geographical environmental factors (Chen et al., 2021).

Agricultural landscape types in the Pearl River Delta Basin

Based on the evolution of the traditional agricultural landscape in the Pearl River Delta, this paper integrates the characteristics of the agricultural landscape that emerged during the evolution process and divides the agricultural landscape types in the region into four categories: enclosure landscape, sand field landscape, dry field landscape, and base pond landscape. (Table 1)The agricultural landscape in the basin is diverse and closely related to the local natural conditions, population migration, and socio-economic conditions. The development of these agricultural landscapes is a manifestation of people's adaptation and transformation of the natural environment as they have lived here for generations.

Table 1. Agricultural landscape types in the Pearl River Delta Basin (Huang, 2024)



Number	Name	Definition	Causes of formation
1	Enclosed Field Landscape	Effective prevention of flooding usually involves enclosing a field with one or more dams.	The earliest type of agricultural landscape, its formation is closely related to the flood disasters in the region. The construction goal of the enclosure landscape is mainly to ensure the stability of agricultural production. By building water conservancy facilities such as dams and sluices, water resources can be flexibly allocated to provide a suitable growth environment for crops such as rice, thereby increasing agricultural production.
2	Sand Field Landscape	It is mainly composed of sand dunes and sand belts formed by beaches, sandbars and river alluvial deposits.	Due to the alluvial action of the river, the Sand Field Landscape of the Pearl River Delta was formed on the basis of muddy tidal flats in the estuary area.
3	Dry Field Landscape	The characteristic of Dry Field Landscape is that it lacks irrigation conditions and needs to rely on natural rainfall to meet the needs of crop growth. Cash crops such as sugarcane, tea, and kapok have become the main crops in dryland landscape. The planting of these crops not only meets market demand, but also drives the economic development of the Pearl River Delta Basin.	Dry Field Landscape is an important agricultural landscape developed in the Pearl River Delta region as people pursue cash crops. With the growth of population and the development of agricultural technology, people began to reclaim and plant wasteland outside the fenced fields, forming Dry Field Landscape.
4	Pond Landscape	The Pond Landscape is divided into mulberry-based fish ponds, fruit-based fish ponds and sugarcane-based fish ponds, among which mulberry-based fish ponds are the most common in the Pearl River Delta basin.	The base Pond Landscape in the Pearl River Delta region was created by local residents through long-term agricultural labor practices and based on local natural environmental conditions. The base Pond Landscape based on ponds and base surfaces has formed a benign and efficient agricultural ecosystem through careful design and layout.

Sources of geographic data and research methods in recent years

The Resource and Environmental Science Data Center of the Chinese Academy of Sciences employs a Chinese land use dataset derived from the United States' Landsat satellite series, including MSS, TM/ETM, and Landsat 8 imagery (with a span of five years between 1980, 1990, and extending to 2020) as its primary data source (Note: Due to data confidentiality, the most recent available remote sensing data is from the year 2020) (Xu et al., 2018).

In order to reduce the impact of resolution on ecological pattern research, the data set will unify the resolution to 30m. This study uses ArcGIS software to preprocess the image data with a resolution of 30m. The processing results can be used as a base map and for mask extraction. Then import the Chinese land use remote sensing monitoring data, use the "Extraction Analysis" in the "Spatial Analyst Tools" window, input the data, and use the administrative boundaries of the Pearl River Delta region to "Extract by Mask", and then use the "Reclassification" in the "Spatial Analyst Tools" window to reclassify the data. The classification principle is compared with the national land use dynamic remote sensing monitoring LUCC classification system (Figure 2).

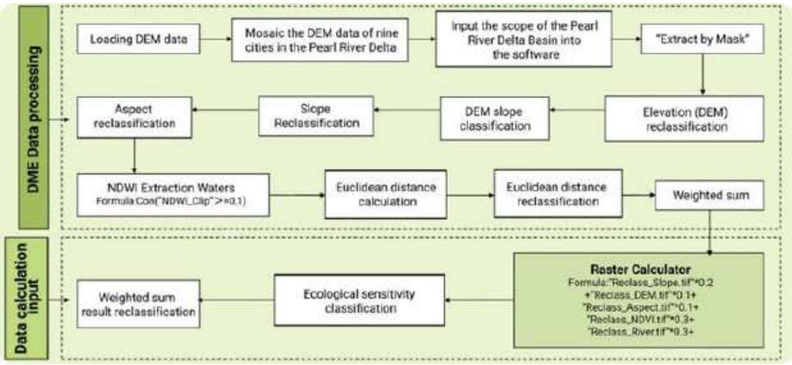
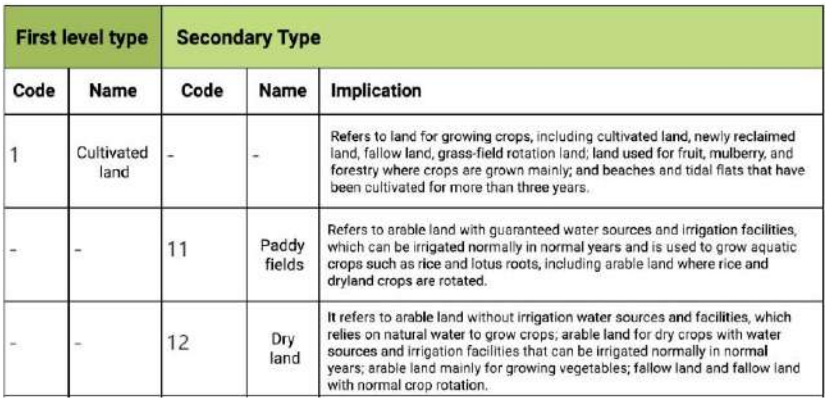


Figure 2. DEM data preprocessing process (Huang, 2024)

Due to the confidentiality of the data displayed by this classification system, only the classification of the secondary types is displayed. Here, the four types of agricultural landscapes in the Pearl River Delta mentioned above are corresponded and explained through the type meaning of this system. The secondary types under the first-level type of cultivated land (code 1) in this classification system are mainly paddy fields (code 11) and dry land (code 12). The definition of paddy fields is: arable land equipped with assured water supplies and irrigation systems, capable of regular watering during average rainfall years, utilized for the cultivation of aquatic plants like rice and lotus, including fields that practice a rotation between rice and non-rice crops. The definition of dry land is: cultivated land devoid of artificial irrigation sources and infrastructure, dependent on natural rainfall for crop cultivation; cultivated land equipped with water sources and irrigation systems, enabling regular watering during average precipitation years; land predominantly used for vegetable cultivation; and idle or restorative land engaged in standard crop rotation practices. Therefore, based on this definition and the above classification definition, the enclosure landscape, sand field landscape and base pond landscape are classified as paddy fields, and the dry land landscape is classified as dry land (Table 2).

Table 2. Agricultural landscape types in the Pearl River Delta Basin (Huang, 2024)



First level type		**Secondary Type**		
Code	**Name**	**Code**	**Name**	**Implication**
1	Cultivated land	-	-	Refers to land for growing crops, including cultivated land, newly reclaimed land, fallow land, grass-field rotation land; land used for fruit, mulberry, and forestry where crops are grown mainly; and beaches and tidal flats that have been cultivated for more than three years.
-	-	11	Paddy fields	Refers to arable land with guaranteed water sources and irrigation facilities, which can be irrigated normally in normal years and is used to grow aquatic crops such as rice and lotus roots, including arable land where rice and dryland crops are rotated.
-	-	12	Dry land	It refers to arable land without irrigation water sources and facilities, which relies on natural water to grow crops; arable land for dry crops with water sources and irrigation facilities that can be irrigated normally in normal years; arable land mainly for growing vegetables; fallow land and fallow land with normal crop rotation.

3. Findings and Discussion

Overall overview of agricultural landscape ecological pattern

By leveraging Geographic Information System (GIS) technology to analyze China's 2020 land use remote sensing monitoring data, we derived the land use classification data for the Pearl River Delta area as of 2020. It can be seen that paddy fields are distributed in large areas in sheets, mostly gathered together around the Pearl River, while dry fields are scattered in multiple blocks around the Pearl River Delta basin. The overall ecological pattern is in the formof "living together along the water and farming around the living". (Figure 3) Therefore, water resources have a unique importance in the Pearl River Delta water settlements (Chen, 2018).

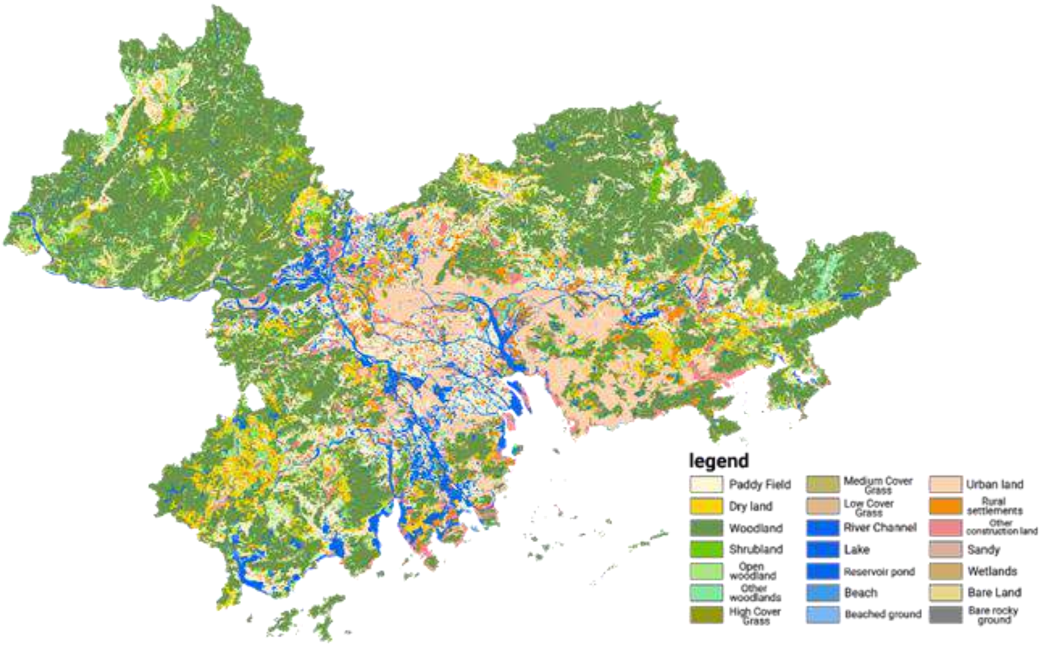


Figure 3. Analysis of land use data in the Pearl River Delta Basin in 2020 (Huang, 2024)

Research indicates that the primary factor for choosing settlement locations in the Pearl River Delta is proximity to farmland, which supports daily material and agricultural production needs and facilitates labor. After determining the principle of settlements close to farmland, it is also necessary to comprehensively consider the safety of the site selection, covering both natural and social aspects. In addition, sufficient water resources are also an important factor affecting the site selection of settlements. Therefore, water resources are of unique importance in the water town settlements in the Pearl River Delta. The distribution and utilization of water resources are not only related to the settlement and operation of residents, but also directly affect the agricultural landscape ecological pattern of the Pearl River Delta Basin.

Evolution trend of agricultural landscape ecological pattern

Based on the above-mentioned re-correspondence of the four types of agricultural landscapes in the Pearl River Delta Basin, the China land use remote sensing monitoring dataset was "extracted by mask" and "reclassified". The "reclassification" followed the principle of "retaining paddy fields (code 11), dry land (code 12) and water areas (code 4), and unifying the color blocks of the remaining types of codes". The agricultural landscape area data for the Pearl River Delta Basin for a total of eight years, namely 1980, 1990, 1995, 2000, 2005, 2010, 2015 and 2020, were obtained and then integrated to form a more intuitive evolution image (Figure 4).

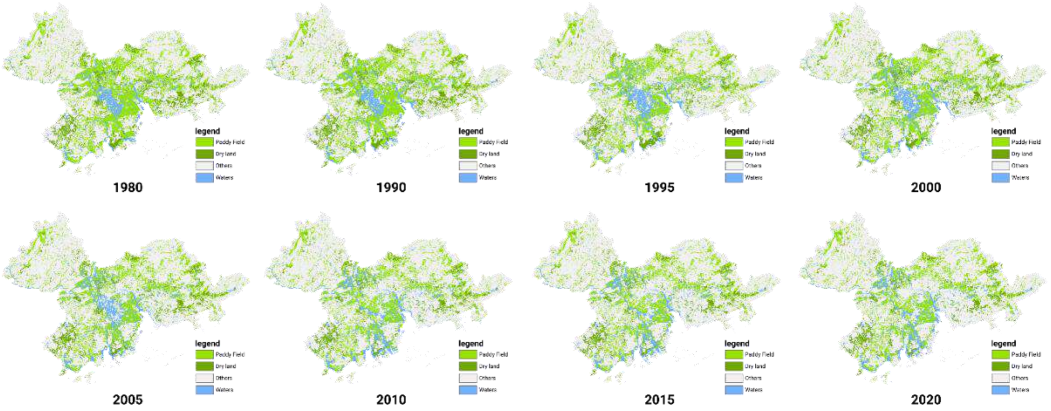
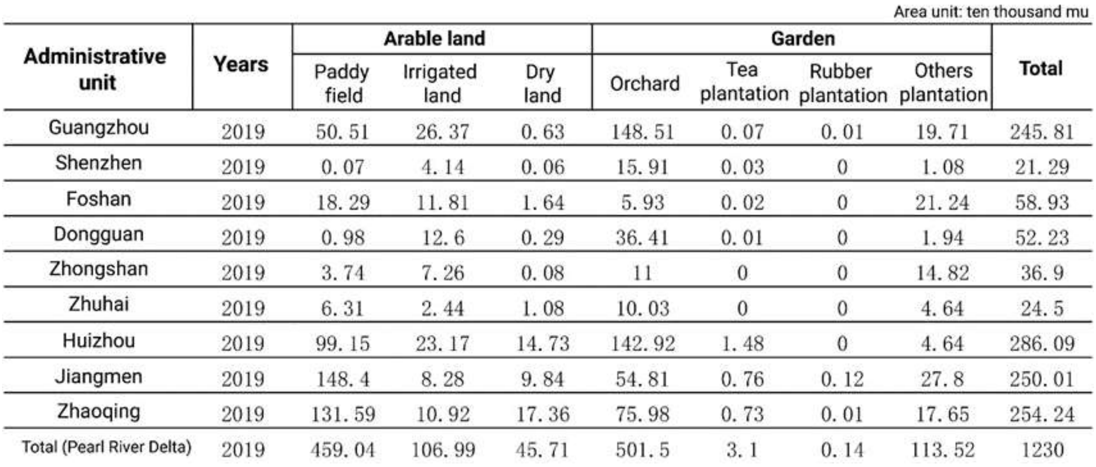


Figure 4. Changes in agricultural landscape area in the Pearl River Delta from 1980 to 2020 (Huang, 2024)

From a macro perspective, comparing the two data images over the 40 years from 1980 to 2020, it can be clearly seen that agricultural land in the Pearl River Delta region has gradually decreased and has been replaced by urban and industrial land. In addition, the author collected data on agricultural landscape land use area in the Pearl River Delta Basin from 2019 to 2021, and statistically integrated them into a data table (Table 3-5) to verify this conclusion. The aggregate agricultural land across the nine municipalities within the Pearl River Delta Basin has exhibited a consistent decline over time. This trend is expected to continue in the future, especially in economically developed urban areas, where the speed of urbanization of agricultural land will further accelerate. At the same time, with the continuous advancement of agricultural technology and the large-scale operation of agricultural production, the agricultural production methods in the region are also changing. Modern agricultural technology and management models have gradually replaced traditional agricultural production methods, thereby changing the ecological pattern and production model of agricultural landscapes.

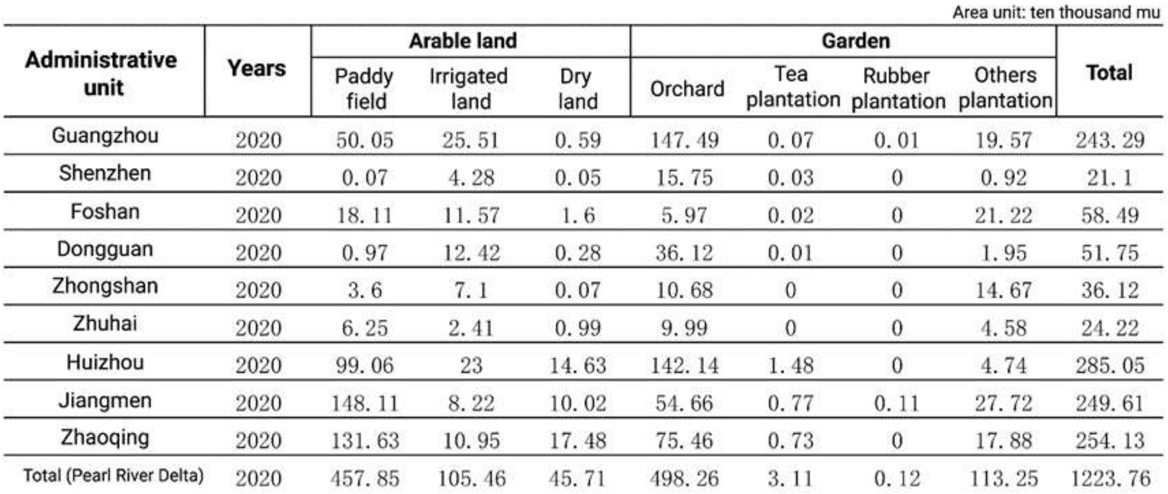
Table 3. Agricultural landscape land use area in the Pearl River Delta Basin in 2019 (Huang, 2024)



Area unit: ten thousand mu

Administrative unit	Years	Arable land			Garden				Total
		Paddy field	Irrigated land	Dry land	Orchard	Tea plantation	Rubber plantation	Others plantation	
Guangzhou	2019	50.51	26.37	0.63	148.51	0.07	0.01	19.71	245.81
Shenzhen	2019	0.07	4.14	0.06	15.91	0.03	0	1.08	21.29
Foshan	2019	18.29	11.81	1.64	5.93	0.02	0	21.24	58.93
Dongguan	2019	0.98	12.6	0.29	36.41	0.01	0	1.94	52.23
Zhongshan	2019	3.74	7.26	0.08	11	0	0	14.82	36.9
Zhuhai	2019	6.31	2.44	1.08	10.03	0	0	4.64	24.5
Huizhou	2019	99.15	23.17	14.73	142.92	1.48	0	4.64	286.09
Jiangmen	2019	148.4	8.28	9.84	54.81	0.76	0.12	27.8	250.01
Zhaoqing	2019	131.59	10.92	17.36	75.98	0.73	0.01	17.65	254.24
Total (Pearl River Delta)	2019	459.04	106.99	45.71	501.5	3.1	0.14	113.52	1230

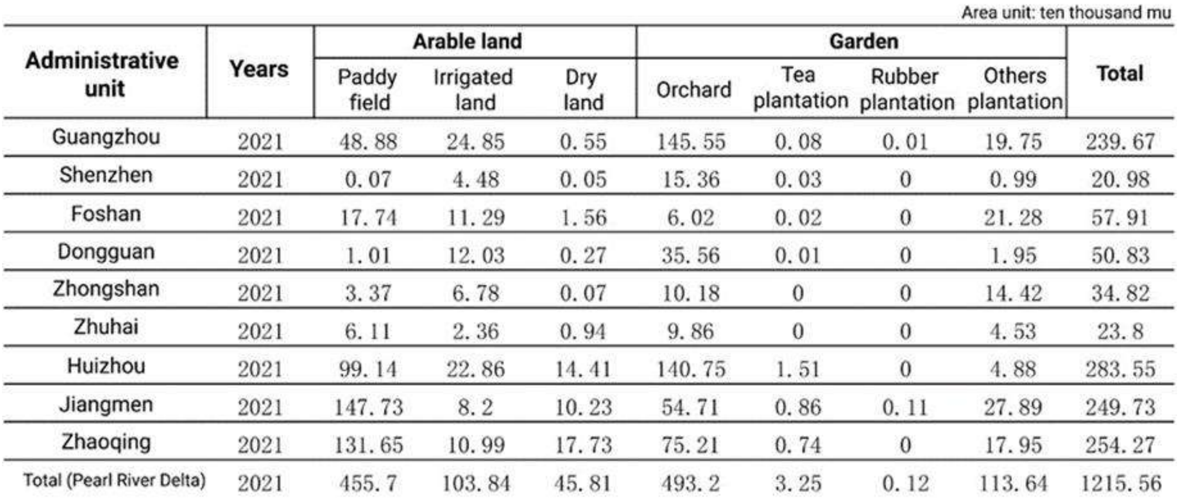
Table 4. Agricultural landscape land use area in the Pearl River Delta Basin in 2020 (Huang, 2024)



Area unit: ten thousand mu

Administrative unit	Years	Arable land			Garden				Total
		Paddy field	Irrigated land	Dry land	Orchard	Tea plantation	Rubber plantation	Others plantation	
Guangzhou	2020	50. 05	25. 51	0. 59	147. 49	0. 07	0. 01	19. 57	243. 29
Shenzhen	2020	0. 07	4. 28	0. 05	15. 75	0. 03	0	0. 92	21. 1
Foshan	2020	18. 11	11. 57	1. 6	5. 97	0. 02	0	21. 22	58. 49
Dongguan	2020	0. 97	12. 42	0. 28	36. 12	0. 01	0	1. 95	51. 75
Zhongshan	2020	3. 6	7. 1	0. 07	10. 68	0	0	14. 67	36. 12
Zhuhai	2020	6. 25	2. 41	0. 99	9. 99	0	0	4. 58	24. 22
Huizhou	2020	99. 06	23	14. 63	142. 14	1. 48	0	4. 74	285. 05
Jiangmen	2020	148. 11	8. 22	10. 02	54. 66	0. 77	0. 11	27. 72	249. 61
Zhaoqing	2020	131. 63	10. 95	17. 48	75. 46	0. 73	0	17. 88	254. 13
Total (Pearl River Delta)	2020	457. 85	105. 46	45. 71	498. 26	3. 11	0. 12	113. 25	1223. 76

Table 5. Agricultural landscape land use area in the Pearl River Delta Basin in 2021 (Huang, 2024)



Area unit: ten thousand mu

Administrative unit	Years	Arable land			Garden				Total
		Paddy field	Irrigated land	Dry land	Orchard	Tea plantation	Rubber plantation	Others plantation	
Guangzhou	2021	48. 88	24. 85	0. 55	145. 55	0. 08	0. 01	19. 75	239. 67
Shenzhen	2021	0. 07	4. 48	0. 05	15. 36	0. 03	0	0. 99	20. 98
Foshan	2021	17. 74	11. 29	1. 56	6. 02	0. 02	0	21. 28	57. 91
Dongguan	2021	1. 01	12. 03	0. 27	35. 56	0. 01	0	1. 95	50. 83
Zhongshan	2021	3. 37	6. 78	0. 07	10. 18	0	0	14. 42	34. 82
Zhuhai	2021	6. 11	2. 36	0. 94	9. 86	0	0	4. 53	23. 8
Huizhou	2021	99. 14	22. 86	14. 41	140. 75	1. 51	0	4. 88	283. 55
Jiangmen	2021	147. 73	8. 2	10. 23	54. 71	0. 86	0. 11	27. 89	249. 73
Zhaoqing	2021	131. 65	10. 99	17. 73	75. 21	0. 74	0	17. 95	254. 27
Total (Pearl River Delta)	2021	455. 7	103. 84	45. 81	493. 2	3. 25	0. 12	113. 64	1215. 56

From a microscopic perspective, from 2005 to 2010, the water area in the center of the Pearl River Delta (the border between Foshan and Zhongshan) changed significantly from sheet to strip, replaced by large areas of paddy fields and some dry lands. It is observable that agricultural areas within the Pearl River Delta are transitioning from urban peripheries towards more inland locations. Because after entering the 21st century, competition has intensified as cities have started to transform their urbanization strategies. With the adjustment of population size and industrial structure, the scale of urban construction land, roads and other land has gradually expanded, and urban expansion has continuously encroached on agricultural land (Wang, 2022). As a response to the escalating demands of expanding urban demographics and the momentum of economic progress, these areas have been repurposed for residential, commercial, and industrial uses. This has resulted in urban regions progressively occupying what was once agricultural land, consequently causing a transformation in the spatial layout.

4. Conclusion

In modern times, the base pond landscape has gradually been unable to meet the needs of modern agricultural technology. And with the continuous maturity and improvement of freshwater fish pond farming technology, the refinement of fishery farming can bring higher net output value, labor productivity and economic benefits (Liu, 2008). As a result, the Pearl River Delta Basin has increasingly emphasized fishery farming, reduced the planting of base crops, and the originally complex ecological circulation system has gradually become single. In addition, with the rapid economic growth and urbanization process in the Pearl River Delta Basin, agricultural land has gradually migrated from the edge of the city to the inland, and its total amount has gradually decreased.

In summary, through a relatively comprehensive study of the evolution process of agricultural landscape and modern ecological pattern in the Pearl River Delta Basin, it is concluded that the modern agricultural landscape in the Pearl River Delta Basin needs to be more intensively managed to improve production efficiency and achieve sustainable development, and effective measures must be taken to protect land resources and the ecological environment. For example, we can diversify development and transform business models, research and develop safe agricultural products, effectively improve the ecological environment, beautify the living environment with agricultural landscapes, strengthen industrial integration, broaden and extend the industrial chain of agricultural landscapes, and drive rural revitalization through agricultural cultural heritage.

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Policy-Driven Brownfield Transformation in Declining Mining Cities in China

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Abstract

This study examines the transformation and drivers of brownfield sites in China's declining mining cities, focusing on Fushun, Liaoning Province, through its "General Plan for Mineral Resources of Fushun (2001-2010)". Using ENVI's unsupervised classification on Landsat7 ETM data from 2000, 2005, and 2010, it analyzes urban land shifts in central Fushun. The research tracks land use changes, using increased vegetation as a marker of successful brownfield regeneration and ecological restoration. A systematic literature review develops an index for influencing factors, while principal component analysis determines the mechanisms behind brownfield transformations. Results show a policy-driven disparity: from 2000 to 2005, 2 km² of brownfield became green space mainly in large core areas; from 2005 to 2010, 14 km² were transformed, spreading across urban brownfields. This variation is linked to the policy phase objectives and attributes, with urban economic factors and temperature significantly correlating with brownfield-to-green space transformations. These findings provide essential insights for future policy development and implementation in similar contexts.

Keywords: Declining mining cities, policy-driven, brownfield regeneration, remote sensing

1. Introduction

In 2008, 2009, and 2011, China designated three batches of 69 resource-exhausted cities, with Fushun, a non-renewable coal city, listed among the first batch. Fushun burgeoned due to its abundant underground coal reserves during the wartime and early post-establishment periods. However, as coal extraction progressed, exacerbated environmental issues coupled with shifts in domestic and international industrial structures led to the continuous closure of mining and industrial lands, initiating their transition into land reuse processes.

The regeneration of these industrial and mining brownfields is predominantly driven by government urban development policies. However, urban development, construction, and land use transformation are not solely top-down processes dictated by policy. Brownfield regeneration is inherently part of urban land transition, influenced by a myriad of factors beyond policy directives, including geographic, economic, and sociocultural elements (Mehdipour et al., 2024; Dixon et al., 2006). Extensive research exists on the policy drivers of urban brownfield regeneration. For instance, some studies have shown that stakeholder needs and preferences directly affect the efficiency and outcomes of brownfield redevelopment (Martinat et al., 2018; Beames et al., 2018;), while some scholars have noted the significant but not absolute impact of government economic policies on the expansion and regeneration of industrial areas in Hangzhou (Maimaiti et al., 2017).

However, few studies have quantitatively analyzed the spatial dynamics of brownfield ecological restoration within specific policy periods or investigated other urban factors driving policy effectiveness during these periods. This study employs ENVI's unsupervised classification method to densely process multiple years of Landsat7 ETM remote sensing data for Fushun (Figure 1), quantitatively examining the ecological restoration of industrial and mining brownfields in central Fushun under the first "General Plan for Mineral Resources of Fushun (2001-2010)." Principal component analysis was conducted on these findings to identify key urban factors influencing policy implementation, aiming to reveal potential non-policy drivers of brownfield regeneration in resource-exhausted cities and provide insights for future brownfield regeneration policy-making.

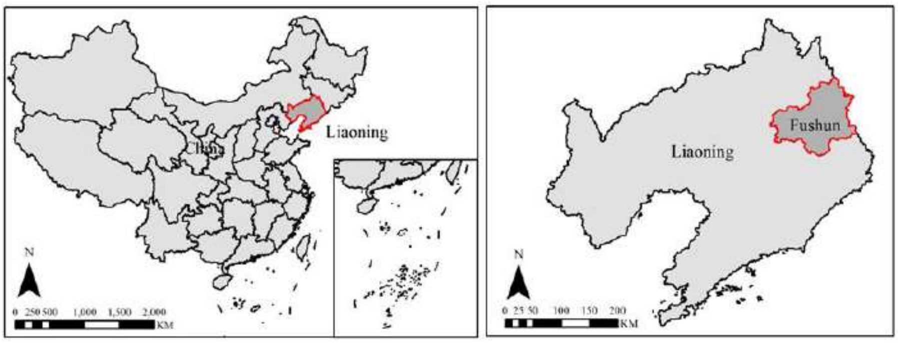

Figure 1. Overeiew map of the study area. (a) and (b) respectively show the locations of Liaoning Province and the study area, Fushun City.

2. Material and Method

The study utilizes open-source Landsat7 ETM remote sensing data with a resolution of 30m. In accordance with the "General Plan for Mineral Resources," which divides the implementation period into two phases, 2000-2005 and 2005-2010, remote sensing data from the years 2000, 2005, and 2010 were selected for subsequent interpretative analysis.

It is important to note that due to the failure of the Scan Line Corrector (SLC) on the Landsat-7 ETM+ on May 31, 2003, images acquired subsequently exhibit data strip losses, significantly impacting the usability of Landsat ETM remote sensing images. Some scholars have conducted studies to repair the damaged data, and now ENVI software includes a plugin that uses interpolation methods to mend the missing strips. However, minor errors remain, and it is generally accepted in the academic community that the data restored by interpolation is sufficiently robust for scientific purposes. Moreover, considering the influence of cloud cover at the time of capture, changes in photography timing on land cover, and the vegetation growth cycle, remote sensing data from August 27, 2001, September 7, 2005, and September 18, 2009, were ultimately selected as the basis for this study.

Using ENVI 5.3 software, the remote sensing images underwent two preprocessing steps: radiometric calibration and atmospheric correction. Based on the research requirements, urban land use was classified into three categories: impervious surfaces, vegetation cover, and water bodies. After reclassifying the raster values, land use maps for the central urban area of Fushun for three years were produced. These maps were processed through cross-analysis to generate land use transition maps. The attributes of the layers were then exported and processed in Excel to obtain a land use transition matrix. A visual interpretation of the 2006 remote sensing images of the central urban area of Fushun was conducted, identifying the distribution of industrial and mining lands in 2005 based on visual element characteristics (Figure 2). Cross-analysis with the aforementioned land use transition maps in ArcMap led to the creation of a map showing the distribution of green-oriented brownfield regeneration and corresponding areas.

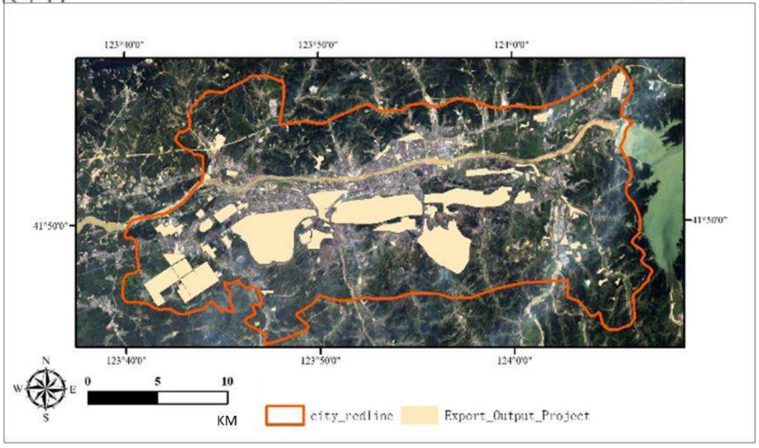

Figure 2. Distribution of Industrial and Mining Brownfields in the Central Urban Area of Fushun in 2005

3. Findings and Discussion

Analysis of the land use transition map (Figure 3) reveals that during the first phase (2000-2005) of implementing the "General Plan for Mineral Resources," no specific quantifiable ecological restoration targets or workflows were effectively established. Consequently, urban land use transitions were predominantly characterized by the expansion of impervious surfaces. Compared to 2000, the green spaces in the central urban area of Fushun in 2005 suffered significant encroachment by urban impervious surfaces.

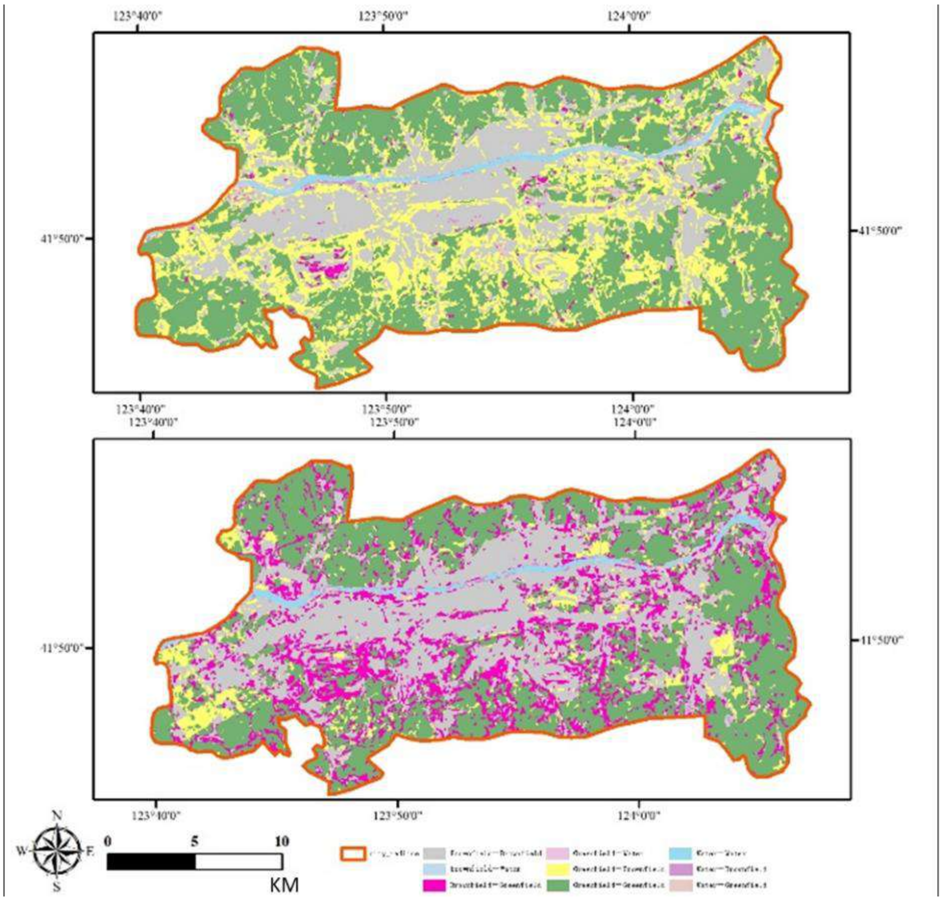

Figure 3. Land Use Transition Maps for the Central Urban Area of Fushun (arranged from top to bottom for the periods 2000-2005 and 2005-2010)

In the second phase (2005-2010), the policy requirements on the ecological level were explicitly enhanced with the further implementation of the "Fushun Urban Mining Ecological Environment Restoration and Land Reclamation Plan." This phase included the closure of all mines within certain distances of the city's outskirts, transportation arteries, cultural heritage conservation areas, scenic tourism areas, and major infrastructure projects, accompanied by corresponding ecological restoration measures. These explicit requirements for transforming the characteristics of mined land resulted in noticeable signs of ecological restoration, particularly around the East Open Pit, West Open Pit, and the horizontal linear distribution of mining sites at Dongxi Shed Field. It can be stated that this phase witnessed a rapid transition of urban land characteristics towards green spaces.

A quantitative analysis was conducted on urban land use transitions under policy influence using land use transition matrices from two time periods (Tables 1 and 2). During the first phase of policy implementation, approximately 127 km² of green space was encroached upon by urban impervious surfaces, while only about 6 km² of impervious surfaces were converted into green spaces. In the second phase, which had explicit ecological restoration goals from 2005 to 2010, the rate of urban expansion significantly decreased. During this period, only about 29 km² of green space was encroached upon by impervious surfaces, whereas approximately 87 km² of impervious surfaces were transformed into green spaces. This shift indicates a substantial change in land use dynamics, highlighting the effectiveness of policy measures aimed at ecological restoration and urban land use planning.

Table 1. Land Use Transition Matrix from 2000 to 2005 (Units: km²)

	Impervious Surfaces	**Green Space**	**Water Bodies**
Impervious Surfaces	117.756	126.789	3.425
Green Space	5.881	216.443	2.632
Water Bodies	2.183	2.055	7.794

(Note: The horizontal axis represents land use data from the year 2000, while the vertical axis represents land use data from the year 2005.)

Table 2. Land Use Transition Matrix from 2005 to 2010 (Units: km²)

	Impervious Surfaces	**Green Space**	**Water Bodies**
Impervious Surfaces	158.938	28.935	2.446
Green Space	86.800	194.441	2.602
Water Bodies	2.221	1.610	7.126

(Note: The horizontal axis represents land use data from the year 2005, while the vertical axis represents land use data from the year 2010)

In the preceding analysis, through a macro-level examination of urban land use transitions, we quantified the extent to which impervious urban surfaces were converted into green spaces during the policy implementation period (Figure 4). This undoubtedly includes the ecological restoration of industrial and mining brownfields driven by policy. Subsequently, using cross-analysis on the GIS platform, the areas depicted in Figure 4 were intersected with the area in Figure 2 to identify the ecological restoration processes where all industrial and mining lands were transformed into green spaces during the policy implementation period (Figure 5).

We determined that during the 2000-2005 policy implementation phase, approximately 2 km² of green space was developed, primarily concentrated around the West Shed Field area, with only minor and scattered green developments around the East and West Open Pits and East Shed Field. In the subsequent 2005-2010 policy phase, which focused on a longer-term vision, about 14 km² of green space was developed. In addition to continued development in the West Shed Field, green spaces were established around the peripheries adjacent to the city at both the East and West Open Pits, with considerable greening also occurring at the edges and within the East Shed Field.

Over the entire policy period from 2000 to 2010, approximately 7 km² of industrial and mining land was transformed into green space, with the ecological restoration efforts at West Shed Field proving to be the most effective. However, the ecological restoration process under policy guidance was not a completely smooth and linear progression. In the first phase of the policy, the focus was on establishing a baseline, with all requirements and objectives being relatively vague, which did not effectively prevent the construction and expansion of urban industrial and mining lands. As the policy shifted into the second phase, characterized by clear ecological restoration directives and more precisely defined goals, methods, and scopes, the outcomes in terms of both the extent and distribution of ecological restoration on industrial and mining lands were significantly better than in the first phase.

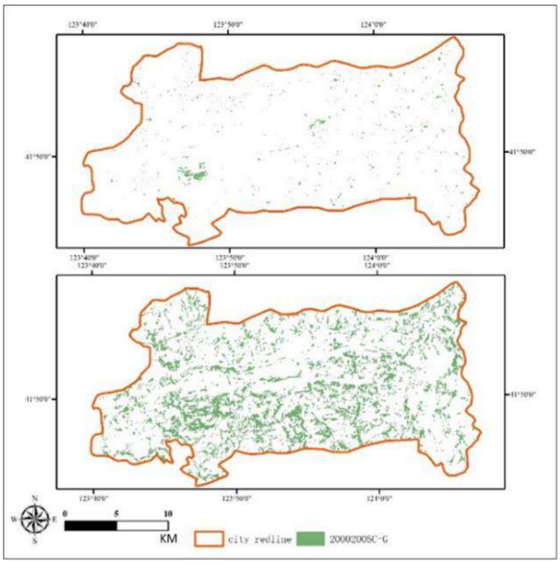

Figure 4. Urban Green Space Development during the Policy Implementation Period (arranged from top to bottom for the periods 2000-2005 and 2005-2010)

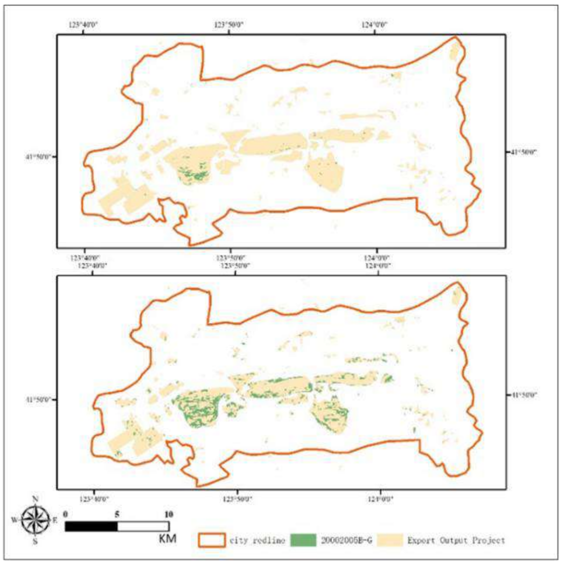

Figure 5. Transition of Industrial and Mining Brownfields to Green Spaces Under Policy Guidance (arranged from top to bottom for the periods 2000-2005 and 2005-2010)

The formulation and implementation of policy is a process in which subjective decisions impact objective laws. Behind every policy implementation, there are objective urban factors that drive actions. Based on the theoretical framework of urban green space construction driven by ecological policy orientation, this study selected multiple indicators from secondary industry, ecological conditions, and socio-economic sectors. Principal Component Analysis (PCA) was employed to quantitatively analyze the driving forces behind the transformation of industrial and mining lands into green spaces in the central urban district of Fushun during the policy-guided period. The principal component loadings matrix was derived using SPSS software (Table 3).

Table 3. Principal Component Loadings Analysis

	Principal Component		
	1	**2**	**3**
GDP(V1)	**.791**	**.417**	**.402**
Total industrial output value (V2)`	**.762**	.383	.444
Number of industrial enterprises (V3)	**-.587**	-.316	-.573
Precipitation (V4)	**.668**	.346	-.004
Proportion of industry to GDP (V5)	**-.730**	.583	.145
Number of industrial employees (V6)	**.691**	-.644	.035
Proportion of services to GDP (V7)	**.867**	-.175	-.258
Number of service sector employees (V8)	**.865**	-.406	-.088
Per capita urban road area (V9)	**.899**	.372	.073

Economic growth, service sector development, and infrastructure improvements are the primary drivers for regenerating industrial and mining brownfields into green spaces. Regions with higher economic output, a larger proportion of the service sector, and better infrastructure, such as urban roads, demonstrate more significant progress in brownfield regeneration. However, regions with a higher industrial proportion, despite their economic strengths, exhibit different characteristics in the regeneration process, particularly where industrial employment is lower.

4. Conclusion

The implementation of ecological policies may not follow a linear process. Based on the brownfield regeneration outcomes in Fushun City, the effectiveness in the latter period is significantly higher than in the earlier period. Additionally, the implementation of ecological policies typically begins with concentrated, large-scale brownfields and gradually extends to smaller brownfield sites across a broader area.

Economic growth, especially in regions with strong service sector development and infrastructure improvements, was a key driver of successful brownfield regeneration, while regions with a higher industrial proportion experienced less pronounced transformation, particularly where industrial employment was lower.

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The Effectiveness of Community Participation Processes in Aotearoa New Zealand

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Abstract

In the island nation of Aotearoa New Zealand, the reality of cultural diversity brought about by the history of migration and increased globalisation places more diverse demands on social and cultural frameworks. These diverse demands in relation to different cultures represent a range of community interests and needs, which participatory planning processes can respond to and draw out for representation in public open space planning and design. It is the community participation that is trying to create a higher sense of community for a wider range of population and ethnicity. Society should not only accept and maintain this cultural difference, it is also necessary to effectively incorporate these different perspectives from multiple ethnic groups into the community participation process.

This research aims to discover preferences for different participatory planning processes in relation to ethnicity, and to identify which are the most effective planning process for New Zealand European, Māori, Chinese and Pasifika community members. These aims are addressed by examining people's experiences of participatory planning processes and their outcomes through a sequence of focus groups. Community participation is discussed with participants from each of the four ethnic groups independently to understand how to effectively encourage sense of community in Aotearoa New Zealand. The discussions link the reasons given by participants for preferred participation methods to their cultural backgrounds. Finally, the similarities and differences of the preferences of the different ethnic groups are analysed and discussed.

Keywords: Community participatory planning, effectiveness, sense of community

1. Introduction

In the island nation of Aotearoa New Zealand, there have been several waves of migration, beginning with Māori, who arrived from the Polynesian islands 1000 years ago. The next stage of migration started in the 1840s, following the signing of the Treaty of Waitangi between Māori and the British Crown. These migrants, whom the Māori referred to as Pākehā, were mainly from the British Isles. In the 1860s, discoveries in the Otago goldfields attracted Chinese immigrants who established themselves as gold miners and traders. From 1910 onward, people from the Pacific Islands began to migrate to New Zealand (Thompson, 2000).

With this history of colonisation and increased globalisation, Indigenous Māori have witnessed a decline in the quality of natural ecosystems, which has led to significant challenges for their way of life (Harmsworth & Awatere, 2013). For instance, Māori well-being is influenced by a combination of cultural beliefs and values, with a diverse set of contemporary cultural practices and by interactions with a non-Māori world, which is primarily based on western values. Moreover, this reality is exerting pressure on existing social and cultural frameworks. These challenges are from the progressively widespread nature of migrants with multiple national backgrounds who consider themselves both members of their country of origin and of New Zealand society (Velden, 2010). On the other hand, immigrant adaptation can be construed as a process of community-making that involves the negotiation and the integration of cultures from the original context to a new context and the development of connections with the new country (Sonn, 2002). New Zealand's metropolitan areas are becoming more culturally diverse as people from Europe, Asia, and the Pacific islands are migrating to New Zealand.

In the 21st century, we are facing new threats to public open space - not of disuse, but of patterns of design and management that exclude some people and serve to reduce cultural diversity. Such exclusion can reduce the vitality and vibrancy of the space or reorganise it in a way that only one kind of person or ethnic group feels welcomed (Low et al., 2005b).

To deal with the increasing cultural diversity within cities from migration, a psychological sense of community provides a valuable tool for understanding community and community change, including immigration. In addition, public open spaces and their related policy and design approaches present an opportunity to help to create places that are socially sustainable and promote the values of cultural diversity. Public spaces are defined as social locations, such as streets, parks and local neighbourhoods, and are spaces where individuals or groups encounter and interact with one another. It is also an element of the built environment that may foster a sense of community by facilitating chance encounters between neighbours (Low et al., 2005a; Talen, 2000). As noted by Gehl, people rely on public open spaces for social interaction and access and connection to the surrounding communities (Gehl, 2011). Participatory planning and design provide a process for people to become actively involved, often by disseminating information to individuals or small groups who may have a vested interest or to the public more widely (Smith, 1973). Creative participatory planning, when conducted around the development of public open spaces, can contribute to the place-making process, helping to fulfil the requirements of both the users and the space (Cilliers & Timmermans, 2014). Society should not only acknowledge and maintain cultural differences but also work effectively to incorporate minority groups into cultural activities, dialogues and public spaces.

In the above situations, exploring how people from different ethnic groups in Aotearoa New Zealand can be fully integrated into the public open space is critical. Based on the hypothesis that a sense of community appears to be strongly associated with the presence of high-quality public open spaces in local neighbourhoods (Francis et al., 2012) and the need for collaboration with and inclusion of Indigenous communities in participatory planning processes (Low et al., 2005a), it is essential to develop a participatory planning process that can bring people from different ethnic groups in Aotearoa New Zealand and public open spaces consistently closer to each other.

In this context, the current study examines how community participation in the planning process engages community members with different ethnic groups and how this help to foster a sense of place and community. The activity of community participation is based on the principle that the environment works better if citizens are active and involved in its creation and management instead of being treated as passive consumers (Sanoff, 2000). The study seeks to operationalise community participation processes within the communities that are home to people with different ethnic heritage. The research examines whether participation in the planning and/or design processes can encourage people-space engagement and usage of public open spaces and ultimately enhance the sense of community for major ethnic groups in Aotearoa New Zealand (Figure 1).

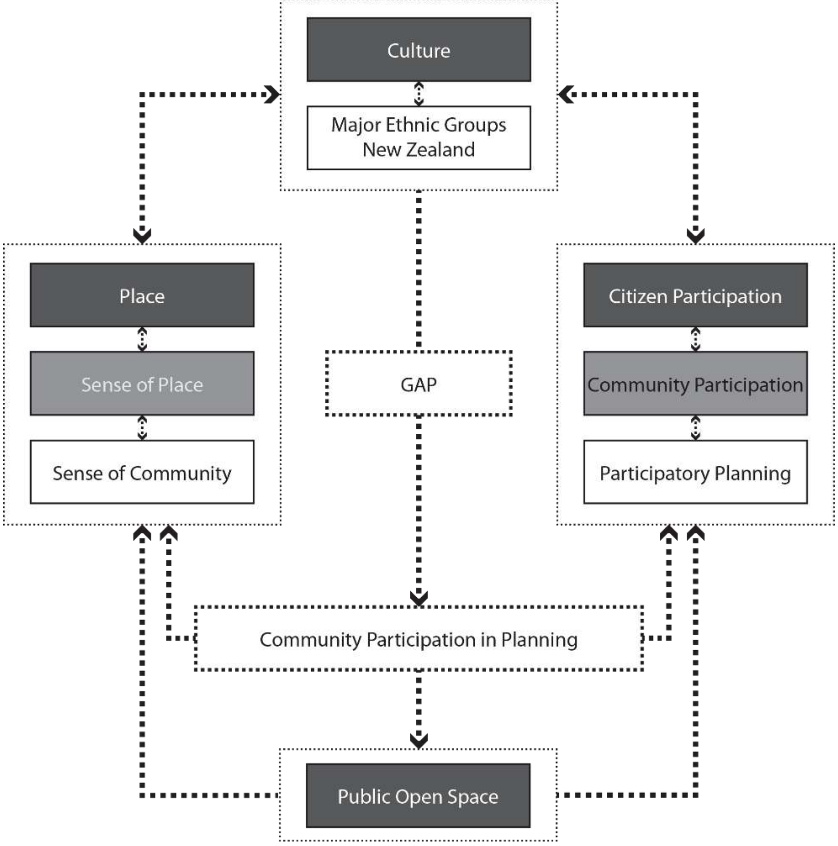

Figure 1. Gap and opportunity

2. Literature

From a sociological viewpoint, place is a unique spot in the universe; its physicality with people and investment of meaning and value makes a place meaningful (Gieryn, 2000). Lynch also mentions that place is an environment that can provide meanings and associations for clustering and organisation. Such a meaning of place enhances every human activity and encourages the deposit of a memory trace (Lynch, 1960). Then, a good relationship is created and developed through long-time connections between a person and place in a particular locality, which is described as sense of place (Lynch, 1990).

Why search for the community? Firstly, community is always treated as a synonym for place and an essential aspect of the sense of place (National Academy of Sciences, 2002). Moreover, *"people spend most of their time and meet most of their needs within local ecologies, and the community is the smallest form of society and the most comprehensive social unit one can experience first-hand"* (Wilkinson, 1986, p. 3). In this study, we are focusing on sense of community or community as a form of social networks and effective relationships in order to establish community member's identity, cultivate their attachment to a place, and encourage a sense of place within those who are living there (Ellery & Ellery, 2019).

In 1974, psychologist Seymour Sarason first introduced the concept of a psychological sense of community as *"the sense that one was part of a readily available, mutually supportive network of relationships and is one of the major bases for self-definition"* (Sarason, 1974, p. 13). Building on this, McMillan and Chavis' definition of a sense of community is the most influential and the starting point for the research on the psychological sense of community. They defined the sense of community as a feeling that members have of belonging, a feeling that members matter to one another and to the group, and a shared faith that members' needs will be met through their commitment to being together (McMillan & Chavis, 1986).

Community has been a never-fading theme in planning theory and practice (Hou & Kinoshita, 2007). Its connection to planning dates to the development of regional planning theories at the turning point of the 20th century, when it was treated as an essential planning unit focused mainly on decentralisation (Hall, 2014). Community participation in planning is centred on the principle that the community improves when its members are actively involved into the participation process of planning, rather than just being treated as the unrelated inhabitants living there (Sanoff, 2006). And it can also be treated as strategies for including individuals or groups in the decision-making for planning and design (Morris, 1996). Current approches to community participation acknowledge that ordinary people should be included in the development process because it provides opportunities for them to be involved and share in the development process of communities (Sanoff, 2021).

The four major ethnic groups in Aotearoa New Zealand are considered in this research (Figure 2), including New Zealand European, Māori, Chinese and Pasifika (Statistics New Zealand, 2019). Each of them has a specific background and perspective.

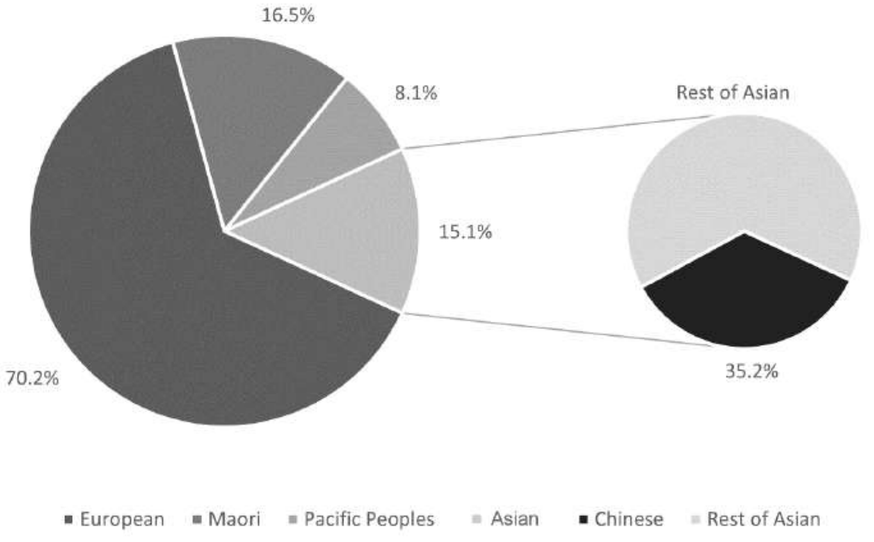

Figure 2. Major ethnic groups in Aotearoa New Zealand

Around 1300 AD, Māori as Polynesian settlers found their way from their native islands to the islands of Aotearoa. As the settlers set foot on the land, they developed their distinctive Māori culture and identity for more than 800 years, where the land represents its people and a strong sense of connectedness to place has allowed Māori to thrive in the rich endemic environment (Marques et al., 2018; Mein Smith, 2012). The traditional Māori worldview acknowledges a natural order to the universe or a balance and that when part of this system shifts, the entire system goes out of balance. This world view is embedded with the diversities of life through connections with all living things as dependent on each other. Māori seek to understand the whole system (Harmsworth & Awatere, 2013).

For New Zealand Europeans, the decisive moment for a remarkable change was in 1840, when the Treaty of Waitangi was signed, extending legal rights as citizens to British migrants. This initiated the immigration from Europe for the next century and beyond (King, 2003). Western philosophy begins with immense faith in the human capacity to know everything. In traditional western philosophy, the relationship between man and nature seems more linear and generally characterised by man being influenced by nature, reacting to nature, and then finding ways to tame elements of nature through technology and policy. This places humans outside natural constraints and empowers them to solve problems (Chen & Wu, 2009).

As for Chinese, in 1865, the first record of Chinese immigrants to New Zealand was of a small group of gold miners from Canton (Chui, 2008). Historically, the community in China was based on a patrilineal kinship network, where extended family lived proximately within a geographic area and cared for each other in times of need. Then, before 1978, China's urban residents lived in public housing provided by their workplaces. A sense of community is rooted in traditional Chinese collectivistic values with interpersonal harmony, social ties and kinship in the workplace community. Finally, housing reform launched nationwide after 1978 transformed the welfare-oriented housing system into a market-oriented system. Instead, a sense of community must be nurtured and collective efficacy needs to be instilled so that people will want to participate to collectively address their community needs and problems (Gaubatz, 2008).

Concerning Pasifika, they left their homelands in search of a place where they hoped to find wellbeing, safety, acceptance by others, and a sense of belonging. The migration of people from the pacific islands to Aotearoa New Zealand, and vice versa, continues (Manuela & Sibley, 2014). From the perspective of Pasifika, aspects of identity and wellbeing are generally not viewed separately but as integral parts of the overall self, which is viewed holistically, with various related components intertwined in a reciprocal relationship (Manuela & Sibley, 2014). In addition, healthy social connections are vital to Pasifika's wellbeing and a sense of purpose. The relational spaces between Pacific peoples are essential for their sense of belonging in their Pasifika communities. It is the space in which NZ-born Pasifika form their cultural identities and find ways to feel accepted in their wider Pasifika communities (Mila, 2012).

In summary, community participation for public open space planning can provide opportunities for potential interactions in decision making process so as to help stimulate sense of community. More importantly, these four New Zealand ethnic groups represent a diversity of community interests and needs, which participatory processes can respond to and draw out for representation in public space planning and design. This research grapples with the issue of how this can best be achieved in the context of this diverse cultural makeup in Aotearoa New Zealand.

3. Method

Use of an online survey and focus groups were approved by the Victoria University of Wellington Human Ethics Committee.

Table 1. Measurements and analysis methods for survey

Measurements		**Data Analysis Methods**
Sense of Community Index	*Reliability Analysis*	Cronbach's Alpha
Sample Description (Age, Gender, Educational Background, Ethnicity)		Descriptive Analysis
Sense of Community Index	*1) Comparison of Means*	Multifactor ANOVA
	2) Comparison of Means	Descriptive Analysis
	3) Comparison of Means	Independent Sample T-test

First, the online survey, written to incorporate the Sense of Community Index-2, was conducted through the Qualtrics online platform and distributed intermittently in New Zealand via web-based channels during a nine-month period in 2020-21. A snowball sampling method was utilised, leading to 172 responses. When removing incomplete and invalid responses, we were left with 145 eligible responses to analyse.

For this survey, the data were coded and analysed by using IBM SPSS Statistics 28 (Table 1).

Second, throughout all focus group sessions, the researcher took precautions to ensure that ethical and cultural issues were considered and protected. To build the relationship of trust and connection, the researcher was advised by several local residents' associations, community centres and city councils. The person in the liaison group and the researcher worked together to ensure the collected data would be well protected and in line with cultural and Treaty of Waitangi protocols.

Table 2. General description of focus groups

Community	Ethnic Group	Location	Number
Newtown	New Zealand European	Newtown Community Hall	3
		Newtown Community Centre	2
	Chinese	Online	4
Porirua	New Zealand European	Online	4
	Māori	Online	3
	Chinese	Online	3
		Online	2
	Pasifika	City Hub, Porirua	2
		Online	7

Table 2 presents the general description of all focus group sessions. Each focus group was arranged exclusively for participants from that ethnic community.

Moreover, the six numbers in Table 3 represent the six participation methods concluded from the literature.

Table 3. Participation methods coding

Coding	Participation Methods
No. 1	Participatory Mapping
No. 2	Guided Tour
No. 3	Focus Group
No. 4	3D Visualisation
No. 5	Interactive Planning
No. 6	Visual Preference Survey

Numbers 1 to 3 represent the prioritisation of the effective participation methods selected by the participants during the focus groups. Participants rated the effectiveness of those methods, from No. 1 - extremely effective to No. 3 - slightly effective (Table 4).

Table 4. Scale of effectiveness

Coding	Scale
①	Extremely Effective
②	Moderately Effective
③	Slightly Effective

A total number of 30 participants were recruited for this research, including New Zealand European, Māori, Chinese and Pasifika. As the snowball and purposive sampling methods were employed, the local associations and city councils provided tremendous help in spreading the information and recruiting potential participants, as they have built and maintained a longstanding relationship with the local residents and local iwi, such as Ngāti Toa, which would assist the researcher in recruiting Māori participants and following appropriate meeting protocols.

4. Findings and Discussion for the First Phase of Online Survey

This first phase of study investigates the Sense of Community Index-2 scores for four New Zealand ethnic groups concerning their participation in community planning of public open spaces. The key findings from this research are summarised below.

In the context of Aotearoa New Zealand, the analysis provides strong evidence that people's sense of community is significantly higher for those who participated in the participatory planning process of community public open spaces, than for those who have not participated (Figure 3). It is consistent with the literature based on other contexts; that the residents of the focused communities developed with significant participatory planning have a stronger sense of community, which is attributed to the participatory planning process (Valle, 2008). Similarly, it is consistent with the previous finding that involvement in more neighbouring activities (comprised of local residents' associations, community action groups and community planning) was significantly and positively associated with sense of community (Francis et al., 2012). Moreover, aligned with the previous study findings, each ethnic group of people has unique histories and world views. Understandably, these differences affect their sense of community and lead to differences in the level of sense of community amongst different ethnic groups (Kenyon & Carter, 2011).

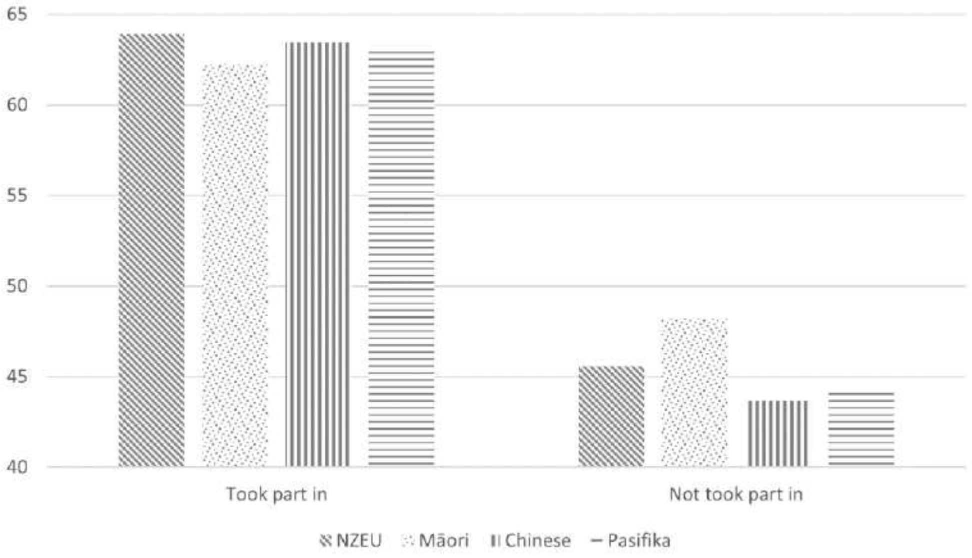

Figure 3. Between-Group comparisons of mean SCI-2 scores

The findings from the first phase of research confirm the importance and contribution of participatory planning processes in the formation of positive sense of community amongst the four ethnic groups of interest. Moreover, there will be a challenge for planners and community leaders to find ways to include as many people as possible during these community participation processes without making them inefficient. At least based on the data collected in this research, the statistics points out the reality of insufficient numbers of community participation for the finished projects. The possible contributing factor would be the low effectiveness of recruitment or participation processes, leading the potential participants to be reluctant to participate.

Firstly, there may have been technical issues related to online participation, including the accessibility to the Internet and the availability of appropriate digital equipment. This may have affected participation by younger people as well as those who are older. According to the literature, some online options can be difficult for community members to access because of technical issues, meaning that the potential communication would be hampered. Furthermore, the global spread of Covid-19 and ensuing pandemic forced the survey and the discussions around community participation in the following stage to move from on-site to the online option, thereby exacerbating the possibility of community participation in relation to the young generation mentioned above.

On the other hand, this provides the platform and opportunity for this research to be extended into a second phase, where the intention is to explore a series of community participation methods with each of the four ethnic groups, aiming to evaluate their effectiveness.

5. Findings and Discussion for the Second Phase of Focus Groups

This second phase of focus groups examined the experiences of the community member's participation process and explored the effectiveness of the participation methods in relation to their ethnicity and cultural background (Table 5).

Table 5. Different series of effective participation methods by ethnicity

Ethnic Group	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	hui	talanoa
New Zealand European		③		①		②		
Māori		①	②			③	★	
Chinese		③		②		①		
Pasifika		①		③	②			★

The cultural relationships and background for the selections are explored and discovered through the focus group data. Focus group findings indicate the importance of the cultural role in the selection of the most effective community participation methods by targeting ethnic groups: 1) for New Zealand Europeans, their selection of the highly effective participation method is a representation of their cultural viewpoint and pursuit toward new technology and innovation; 2) for Māori, their selection of the highly effective participation method is closed related with their Indigenous history, connections to the land and the distinctive pursuit of health and wellbeing; 3) for Chinese, their selection of the most effective method and their cultural element of collectivism are inner connected; and 4) for Pasifika, their selection of the highly effective method is connected to their cultural component of interactivity.

The findings also reveal similarities and differences in the selections of all the targeting ethnic groups, including the least effective participation method and a different series of relatively effective participation methods. For the least effective participation method, findings highlight that participatory mapping is selected as the least effective community participation method for all four ethnic groups in this research. Generally speaking, this method is standard to designers but is not necessarily applicable to non-professional community members. For the series of relatively effective participation methods, it is suggested that different combinations and series of participation methods should be embraced for different ethnic groups.

This research introduced the effectiveness of community participation methods to fill the gap by providing community members with different ethnicity the opportunity to engage in the planning of public open spaces. In addition, this research allowed for different strategies to occur in relation to ethnicity, which complements the existing participation process.

Note

Responsible Author: Yiwen Cui

This paper is based on two published papers as below:

1. Cui, Y., Gjerde, M., & Marques, B. (2023). Encouraging sense of community in Aotearoa New Zealand: exploring the role of community participation in public open space planning. Cities & Health, 8(4), 566–575. https://doi.org/10.1080/23748834.2023.2230619

2. Cui, Y., Gjerde, M., & Marques, B. (2024). Mapping and Assessing Effective Participatory Planning Processes for Urban Green Spaces in Aotearoa New Zealand's Diverse Communities. Land, 13(9), 1412. https://doi.org/10.3390/land13091412

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BUILDING BRIDGES BREAKING BARRIERS

Exploring the A&T Center through the "Phenomenology of Perception"

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Abstract

This study is grounded in the spatial perspective of "phenomenology of perception," focusing on the Art and Technology Center located at the National Taipei University of the Art. Different from the traditional sensory designs that anticipate user experiences, we adopt Merleau-Ponty's viewpoint, suggesting that the meaning of the objective world varies according to individual spatial planes and experiences. Thus, this research employed a first-person perspective to experience the space's most primal state while attempting to alter the spatial plane within the same environment to perceive it from different orientations and derive meaning. Utilizing the four critical aspects of the phenomenology of perception—Spatial plane, Depth, Movement, and Subjective experience—we will analyze how the building's space, environment, and materials influence users' experiences. We aim to provide building insights into the architecture of sensory designs and future architectural design by proposing various experiential approaches to spatial levels.

Keywords: Phenomenology of perception, sensory design, built environment

1. Introduction

Modern architecture evolved not only for functional purposes but also to convey architects' ideas, and it can be a form of art through the material and the surrounding environment to create human-centered sensory experiences. As Merleau-Ponty said, "An interface with the world or forever rooted in the world because this perceptual field constantly entangles and surrounds subjectivity like waves surrounding the wreck of a ship stranded on a beach. " From this, we can understand that the relationship between people and the world is due to the existence of perception. The world will give our bodies different sensory experiences at any time, changing according to the situation and the environment. Humans spent most of their lives in buildings, and sensory design becomes crucial. The objective is to leverage spatial design techniques and materials to enhance user comfort and provide novel experiences. This study used the Art and Technology Center as a case study to explore sensory design.

2. Material and Method

Merleau-Ponty said, "Perception is not merely an event to be explained causally, but a continual recreation and reconstruction of the world. "Thus, we base our study on his ideas of perception of space, exploring the sensory architectural experience at the building. By analyzing visual, auditory, and tactile elements, we examined the architect's design methods and materials and understand how they affect observers' perceptual experiences. This involved field investigations and detailed analyses of design techniques and concepts, narrating personal experiences during the spatial exploration.

3. Findings and Discussion

Multisensory design of the center for art and technology

The five senses serve as an essential bridge for interaction between the body and the external world. Through sensory receptors, the body receives stimuli that are transmitted to the brain, enabling us to perceive our surroundings. This understanding highlights the dynamic nature of perception, which can change over time and through experience. The relative influence of the five senses on our perception of the world is as follows: Vision 87%, Auditory 7%, Tactile 3%, Olfaction 2%, and Gustatory 1%. (Translated by Zhang Lei, 2014).

First and foremost, vision is one of our primary senses. It provides perception of objects' shape, color, and size through our eyes. Secondly, the auditory is vital for perceiving sound, offering additional environmental cues that support visual information and clarify our spatial awareness. Olfaction allows us to detect different odors, enhancing the atmosphere of a space. Tactile enables us to experience the texture and temperature of objects, conveying their unique characteristics to our sensory perception. Lastly, gustatory helps us distinguish various flavors. Together, these five senses create our perception of the world, allowing the body to interact with the environment, understand it, and experience different aspects of life.

3.1 Visual

3.1.1 Floating box

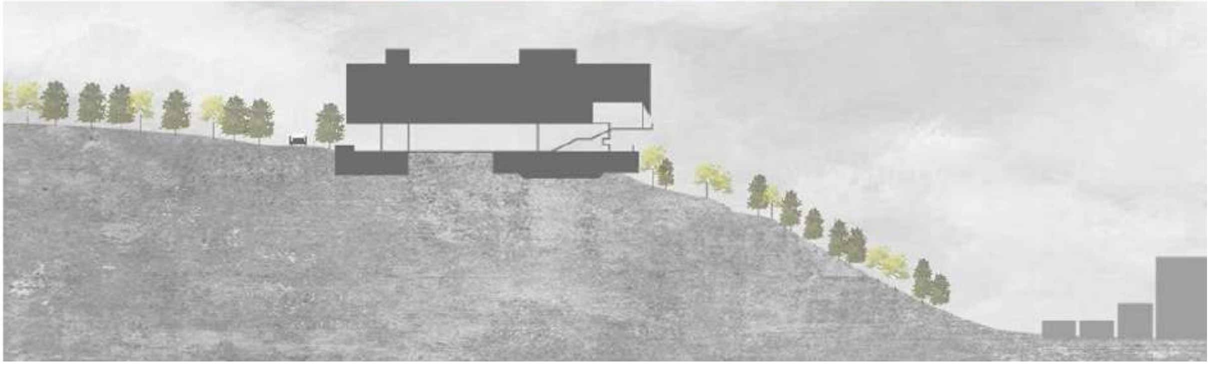

Figure 1-1. Southwest entrance; **Figure 1-2.** Plaza (Source: Photographed for this study); **Figure 1-3.** Floating view (Source: Photographed by Luo Xin, Li Yi Dao, and Cai Yue Lun.); **Figure 1-4.** Environment Section (Source: Illustrated for the study)

In Figure 1-1, from the vantage point of the southwest plaza, the building's massing extends the line of sight towards the distant mountains and clouds, creating the illusion that the building is floating above the distant hills, akin to hovering at the edge of a cloud. Walking along the southwest pavement towards the plaza, the visual perception consistently conveys that the building mass is levitating in the air. Although the use of gray and the elevation of the building reduce the visual pressure, the sense of visual pressure and the proportion occupied within the field of view progressively increases while one approaches the building.

Figures 1-2 further demonstrate the overall floating effect, where the opening to the right of the staircase plays a pivotal role. This architectural feature allows the distant mountain scenery to seamlessly merge with the sky and mountains on the right side despite being partially obscured by the building mass. Consequently, it can be inferred that although the building does not float, the integrity of the floating form combined with a seamlessly integrable underlying landscape indirectly imparts the visual sensation of levitation.

3.1.2 Framing

Figure 2-1. View of the third-floor platform; **Figure 2-2.** Main exhibition space;

Figure 2-3. View of the second-floor platform (Source: Photographed for this study)

In Figure 2-1, the building frames the Guandu Plain and distant mountains, presenting a scene comprising (25%), sky(25%), mountain views and urban landscape(50%). However, the observer's distance from the railing influences the visual perception of this framed view. When standing further from the railing, the view primarily features the distant mountains and sky, but as one moves closer, the proportion of the city increases (Figure 2-2).

In Figures 2-3, a floor-to-ceiling window is situated within the main exhibition space, breaking away from the traditional closed-space design of regular exhibition rooms. The framed view primarily features the treetops from the plaza across from the building, which ensures high visual consistency in color and composition and minimizes external visual distractions within the exhibition space.

In Figure 2-4, the floor-to-ceiling window in the staircase area provides ample natural light and a vertical view that changes as observers move up or down the stairs. Moving from the second to the first floor, the framed view successively includes the sky, distant mountains, cityscape, trees, shrubs, grass, and roads. Unlike the platform, this framing effect alters the sensory experience by changing the observer's vertical field of view. (In Figure 2-5).

Figure 2-4. Staircase on the second floor (Source: Photographed for this study)

3.1.3 Staircase

Figure 3-1 shows the large staircase connecting the second and third floors. As one's eye level rises, there is a growing sense of spatial compression due to the proximity of the third-floor slab, intensifying the feeling of pressure. However, upon passing through this compressed area, the observer is greeted by an broad view framed by the elevated ceiling and platform. From a side view of the large staircase, the closer one moves toward the third-floor slab, the stronger the sense of pressure becomes. After the slab is passed the space opens up to reveal a high ceiling and a broad, open Vista.

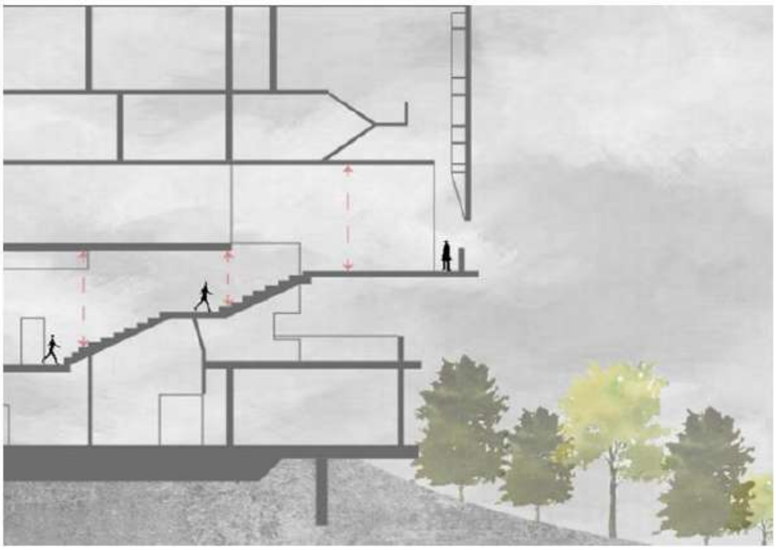

Figure 3-1. Front of the staircase; **Figure 3-2.** Side of the staircase;

Figure 3-3. Analysis of the stairs (Source: Photographed and drawn for this study)

3.1.4 Light and shadow

Figure 4. Outdoor staircase on the third floor and the texture of light and shadow projections (Source: Photographed for this study)

In Figure 4, expanded metal mesh varied shadow effects under sunlight. These overlapping shadows are projected onto the walls, stairs, and ground, generating intricate textures on the otherwise gray concrete surfaces. The mosaic pattern is produced by projecting the expanded metal mesh onto the metal steel panels on the wall. The organized mosaic pattern has blurred edges, creating a soft and diffused effect. This visual phenomenon often evokes a desire to touch the steel panels to verify whether the texture is physically existed. This makes it an intriguing example of a sensory interplay between vision and tactile.

3.1.5 Passthrough

Figure 5. The expanded metal mesh's Interior, exterior, and details. (Source: Photographed for this study)

In Figure 5, while the expanded metal mesh casts a grayish filter over the scenery, the view remains faintly visible. This is due to the expanded metal mesh's angular properties, which allow for selective transparency. From certain angles, the exterior of the mesh partially blocks sunlight, while from the interior, it maintains a degree of visual penetration. This design effectively reduces sun exposure while simultaneously allowing for airflow.

3.2 Auditory

On the hillside, the building faces the bustling city, where the noise of cars and people fills the air. Amid the urban clamor, birds chirping can still be heard, occasionally accompanied by the distant chime of a campus bell. The auditory experience is filled with a variety of information. Inside the building, the architecture seems to become an extension of myself—I am grounded here, receiving sounds from all directions, along with the surrounding views. These auditory elements give me a tangible sense of reality, making me aware of the passing of time.

3.3 Tactile

3.3.1 Railings and handrails

Figure 6-1. Second-floor railing; **Figure 6-2.** Third-floor railing. (Source: Photographed for this study).

In Figures 6-1 and 6-2, the railings on the second and third floors utilize different materials. The third-floor railing on the central observation platform is constructed from wood, providing a warmer, more inviting feel than colder materials. This choice of material reflects the spatial arrangement's intention to encourage people to linger in areas where comfort is prioritized for the users.

4. Merleau-Ponty's Spatial Concept

4.1 Spatial orientation

Spatial orientation is a fundamental element of Merleau-Ponty's phenomenology of perception. He posited that space is not an independent entity; instead, it exists through the interplay of our bodies, sensory systems, and the world, resulting in related perceptual interactions. The body receives and interprets information through individual experience, gradually piecing together the spatial environment. Before receiving perceptual information, the body must first engage in sensing. We can assemble the spatial environment through perception, understanding, and constructing spatial orientations through our body's position, movements, and visual transformations. This allows us to define different spatial orientations and, based on personal experiences to judge objects' location. Spatial orientation is fluid, and people define it through their experiences and interpretations of spatial forms.

4.1.1 Floating gray cube

The floating architectural structure on the hillside is perceived as visually floating, which relates to the viewer's height and the angle from which the building is viewed. The hillside terrain allows for easy changes in spatial orientation as one shifts position. As seen in Figures 7-1, 7- 2, and 7-3, the architect's predetermined spatial orientation effectively presents the floating gray cube only at the southwest entrance. In Figure 7-1, a lower viewing point on the Z-axis below the mass results in a reduced distance between the ground and the building, diminishing the sense of floating. Figure 7-2 depicts a higher viewing point on the Z-axis. Although some space between the mass and the ground is visible, the proximity of the eyesight level to the building's height limits the sense of elevation. In contrast, the mass itself completely obstructs the framing created by the floating mass. Consequently, at this spatial orientation, the perception of floating is challenging to convey. Figure 7-3 illustrates the architect's intended Z-axis height, where the sense of floating is felt due to the elevated mass and shadows, along with the framing of distant mountains and city views, creating the illusion that the mass is suspended above the ground, mountains, and urban landscape.

Figure 7-1. View from the southwest sidewalk; **Figure 7-2.** View from the western grass area; **Figure 7-3.** View from the southwest entrance. (Source: Photographed for this study)

4.1.2 Discussing the grand staircase from the perspective of spatial orientation

Suppose we confine our exploration of the spatial composition of the staircase to the notion of spatial orientation, the grand staircase leading to the third floor is an excellent example. Before we recognize it as a staircase to the third floor, our bodies must undergo a series of perceptual receptions. The gray color of the concrete, the varying shades of gray perceived visually, and the sunlight filtering through the third-floor platform create a stark contrast in the shadows. Coupled with our subjective experiences, past encounters inform us that the formation of gray scales results from the interplay of light and shadow rather than being a two-dimensional image composed of different gray surfaces.

Humans are naturally drawn to bright spots in darkness, and this instinctive attraction allows us to accurately and confidently identify the structure as an upward staircase rather than a flat surface made up of gray shades devoid of direction. The formation of spatial orientation establishes a reciprocal relationship between the body and the object while directly influencing the significance of this object concerning reality and the body. Then the body judges whether to engage with this object and the world, thereby generating spatial depth.

4.2 Spatial depth

Spatial depth is an essential element of existence in Merleau-Ponty's phenomenology perception. After establishing spatial orientation, we can only determine the relative position of objects to the body subject in two-dimensional, which does not allow for the affirmation of an object's existence. Hence, we require another element of spatial perception—Spatial Depth. Spatial depth is often misconstrued as width or the distance between an object and the subject; however, depth refers to the relationship formed by the distance between the perceptual subject and the object. When we use spatial orientation to determine the relative position of an object to the bodily subject, we reach out with our hands until we make contact. At this point, we can be assured that this physical object exists before us, thus confirming the existence of this space in our body. Therefore, before this perception of depth emerges, bodily perception remains in a planar state, allowing only for the confirmation of significance without proving the existence of both the object and the self. Depth provides a three-dimensional concept of space, thus enabling objects to affirm the reality of the self and vice versa.

4.2.1 Discussing reality through light and shadow of textures

As the previous sensory analysis mentioned, the mosaic pattern-like texture created by projecting a metal expanded mesh onto a metal plate exemplifies spatial depth. Once we have established spatial orientation, we can discern this is a gray-and-white mosaic pattern. Is it planar? Is it smooth? Is it bumpy? Or does the plate have perforations through which internal lighting creates effects? We must determine the object's existence before contact is made between the body and the object, and we cannot even ascertain if the metal plate truly exists. However, once contact is made, confirming the plate's existence and realizing that the mosaic pattern is merely a result of light and shadow, the concept of "existence" emerges.

Spatial depth can be illustrated in sensory design as a method of perception confusion, allowing viewers to imagine various possibilities for space. With the questions that Does this space, material, and sound genuinely exist in front of me? The chaos and disarray caused by the interplay of perceptions can lead to a sensory design that is not solely confined to the architect's predetermined design effects but may elicit new psychological responses based on different observers' experiences.

4.3 Spatial level

The spatial level is a three-dimensional concept formed through spatial orientation and depth. Each individual's spatial level is subject to change, and each person's spatial level can be different. Through different spatial levels, we can develop varying perceptions of objects. For instance, when a tree is understood from a conventional spatial level, it is evident that the leaves are above and the roots are below. However, this situation would become incomprehensible if the spatial level were upside down, revealing the roots above and the leaves below. This illustrates that while the spatial level can change, whether the information received by the bodily subject can be understood and hold meaning depends on the circumstances.

4.3.1 Meaningful spatial level

The formation of spatial orientation imbues meaning into the spatial level. An individual's spatial level emerges by affirming the mutual existence between himself and the object through spatial depth. However, the spatial level is constantly changing. The spatial level of the first step of a staircase differs from that of the second step. In exploring space, the architect often predetermined states and spatial levels, which hold significance for the architect. For example, a 110 cm high wall may provide security for someone with a spatial level of 170 cm high, not impacting their visual perception. In contrast, for someone with a spatial level of 120 cm high, it may not offer security and instead act as an obstructive barrier. Both represent meaningful spatial levels that can be understood but have different effects. In architectural design, control of the three axes can give meaning while simultaneously considering the significance of various spatial planes.

4.3.2 Static and dynamic spatial level

Merleau-Ponty posited that human perception of the world involves merely the reception of information and an active experience resulting from our interaction with the surrounding environment. Thus, the senses are not simply ways for receiving external stimuli; they form part of our construction and understanding of the world. Regarding the spatial level, Merleau- Ponty suggests that perception is the process of moving through space and positioning ourselves, encompassing the accumulation of perception and our understanding and engagement with the environment. The static spatial level is stable, while the dynamic one is unstable; both are meaningful. For example, under a static spatial level, one can see the grid structure of a metal expanded mesh and the objects behind it. Under dynamic spatial level, the grid blurs, casting a gray veil over the objects behind the metal mesh, which carry meaning but result in significantly different visual effects.

4.4 Subjective experience of space

4.4.1 Life is architecture, architecture is life

In the book "Season, Construct, Wholeness: Architecture of the Five-Dimensional Space," Yan Wei-Chun and Cai Cai-Jing stated, "The architecture presentation reflects the architect's values and attitudes. Thus, the architect's self-awareness and values shape their architecture's presentation, reflecting their life essence." In this different era, architecture evolves with contemporary customs and environmental characteristics. Architecture is not merely a wall and a ceiling where people living within structures seek a place to reside. Through this, life unfolds within architecture, and as time flows, the values and lives of architects and users shift. Thus, we live in architecture while simultaneously constructing our feelings and values upon it. The National Taipei University of the Art and Technology Center exemplifies this. The exhibition hall can appear as a monotonous and enclosed box. However, on this hillside, it transcends that simple form, establishing a relationship with its environment.

The corridor allows the wind to permeate the structure, encouraging students to linger and admire the view of the Guandu Plain. The floating mass diminishes the heaviness of the gray box, imparting a sense of lightness and floating in the clouds. The outer shell's material allows natural wind, rain, and sunlight to pass through, creating varied layers of gray in response to the sunlight. Thus, the exhibition hall becomes integrated into the lives of students and the public, and the notion of floating takes on new meaning. Architecture exists as a tangible presence in reality and as an intangible presence in life.

4.4.2 The meaning of experience

"A gun has very different meanings for someone who has lost a child in a hunting accident compared to a child who yearns for the romantic image of a cowboy in the American West. For the former, the gun is associated with sadness and fear, while for the latter, it evokes joy, excitement, and heroic fantasies of duels for life and death and horseback riding" (Huang Bo-Han, 2002). The same object can evoke different associations depending on one’s growth environment and life experiences; the same applies to architecture. For example, the Art and Technology Center's corridors and stairs feature numerous grids and metal meshes. For those who appreciate transparency, this undoubtedly reduces visual obstruction and fosters interaction with the surrounding environment. However, for some individuals, these materials may create insecurity. For instance, in the experience of entering the Art and Technology Center, ascending the slope from the campus to the plaza allows one to feel the shadows on the ground and perceive the mass's suspension through visual impact. Stepping beneath the mass evokes a sense of spaciousness due to the height, alleviating the visual pressure of shadows. The brightness above the staircase attracts visitors due to the human tendency to be drawn to light.

The process involves continually interpreting through bodily experiences and established impressions of objects—impressions of shadows, impressions of floor heights, and the instinctual movement towards brightness—all of which leverage bodily experiences. While individual experiences may differ, many are commonly shared. By understanding bodily experiences, one can speculate on the possible backgrounds and established impressions of viewers, thus controlling and designing experiences to convey specific feelings while creating distinct perceptual designs that differ from general bodily experiences.

4.4.3 Subjective experience

The "framing"—created between the two-layered mass and the ground, the framing of the third-floor platform, and the framing of the Floor-to-ceiling window in the main exhibition area—all can be searched style within realistic and traditional landscape paintings. Throughout history, art has been a meaning of recording contemporary life. Zhang Zeduan’s "Along the River During the Qingming Festival" captured the prosperity and daily life of the Northern Song dynasty through realistic landscape painting. At the same time, Georges Seurat's "A Sunday on La Grande Jatte" depicted contemporary weekend life and serene imagination through pointillism. The framing served a similar purpose in this context, capturing the best aspects of the Guandu Plain, mountains, and city on the hillside, allowing one to experience the sky and mountains fully.

The visual broads and the tactile sensations of the wind create the illusion of floating alongside the architectural body. This is likely the concept of floating that the architect aims to present—not merely in physical form but through porous materials in framing and corridors, enabling observers to approach the sky and distant mountains closely. The main exhibition area provides a Floor-to-ceiling window, separating the treetops and campus buildings, allowing viewers to contemplate the frame between reality and illusion. Is the view seen through the window real, or is it a screen wall? The framing offers visual sensations and communicates the architect's intended beauty of life to the viewer, achieving a complementary effect between visual aesthetics and reality.

Texture—the entire architecture constantly uses different textures to control visual and tactile feelings. Still, because these textures have touchable and non-touchable characteristics, the observer can have room for imagination and touchable textures. There are floors, walls, and railings, and the texture that cannot be touched is the metal mesh above and the light and shadow effects projected by the expansion mesh onto the wall. When the visual image is imaged in the mind, it is necessary to confirm its authenticity through touch—the exciting point of perception in this imagination process. The application of these materials makes observers willing to come closer and touch. They are eager to follow the corridors in different directions of the building to appreciate the scenery and the building itself. Even light and shadow cause the black-and- white mosaic pattern to be projected onto the wall. Whether the interview is actual or not further demonstrates the importance of the interaction between perceptions.

5. Conclusion

Based on Merleau-Ponty's phenomenology of perception, we can observe numerous techniques in the Art and Technology Center located at the National Taipei University of the Arts that guide viewers through spatial orientation, create visual experiences through spatial depth, and generate different meanings through variations in spatial levels. Additionally, the building utilizes subjective bodily experiences to lead observers into the architecture. This study analyzed and articulated the principles of these subjective spatial experiences through phenomenology, exploring methods that may create similar effects in the future.

Perception exists in life, and phenomenology explains how individuals are influenced by their perceptions in every action. Architectural design impacts perception, while perception, in turn, influences architectural design. The relationship between perception and the design effects that arise from meaning is bidirectional. It is recommended that future sensory design not only pre-establish spatial levels but also consider the possibilities of other spatial levels. This allows perception to guide design rather than relying solely on architectural design to elicit desired perceptual effects. Different perceptions support one another by employing interactions between two or more forms of perception, creating a complicated sensory design.

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Experiencing the Atlantic Forest

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Abstract

This paper presents a didactic experience carried out between 2017 and 2023, in the context of a Landscape Planning discipline in the Federal Institute of São Paulo (IFSP). The activity pursued a rapprochement between the Architecture and Urbanism students and the Atlantic Forest biome, a biodiversity hotspot that stretches along the east coast of Brazil and is one of the most threatened tropical forests on the planet. Highlighting the importance of conceiving landscape design within an ecological vision, two interconnected practices were adopted: on-site observation and drawing, both fundamental for a deeper understanding of the ecosystem's characteristics and overcoming the view that 'all plants are the same'. The results were the production of plates presenting the biome and its vegetation types, sketches of observed species and the context where those plants were found – allowing an approximation to the biome's vegetation, and showing new possibilities for planting design, in a country where the native flora is still largely undervalued and the so-called 'plant blindness' is increasingly common.

Keywords: Education, ecological landscape design, Atlantic Forest

1. Introduction

This paper presents a didactic experience carried out with students from the IFSP Architecture and Urbanism course, in the context of the discipline Landscape Planning, between 2017 and 2023. The activity, entitled 'Vegetation study: the Atlantic Forest biome', pursued a rapprochement between the students – many of whom had never hiked or closely observed the forest – and this important Brazilian biome, a biodiversity hotspot that stretches along the east coast of the country and is one of the most threatened tropical forests on the planet. The experience sought to awaken interest in the biological, spatial and social dimensions of vegetation, in a context in which the so-called *plant blindness* (Wandersee, Schussler, 1999) is increasingly common.

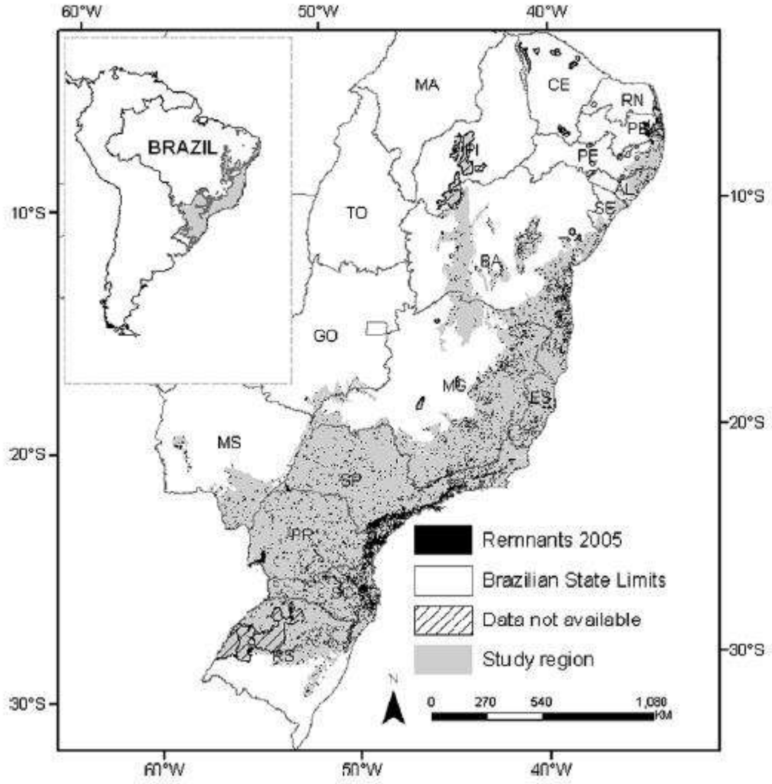


Figure 1. Current coverage of the Atlantic Forest in Brazil, according to Ribeiro *et al*, in a study published in 2009 (Luvictoria, 2020/ Wikimedia Commons).

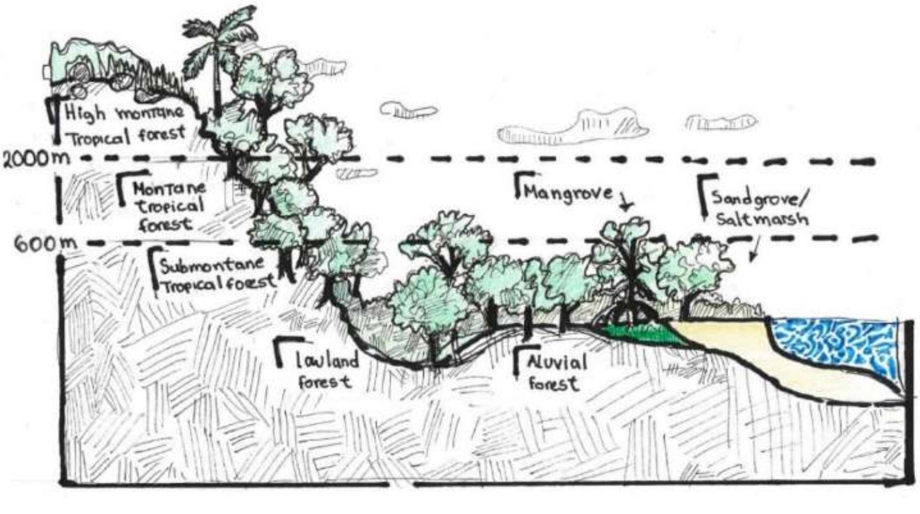


Figure 2. Atlantic Forest vegetation types (Araújo, 2024)

One of the main goals of the work was to highlight the importance of conceiving landscape design within an ecological vision – considering how territory and landscape evolve together with the ecological processes, as an interacting mosaic of ecosystems, connected by flows of energy and matter (Pellegrino, 2000). In this sense, the work of landscape designers such as Roberto Burle Marx (for whom the garden is a 'living association' of 'plants, soil, climate and people' (Motta, 1986), Fernando Chacel (whose concept of *ecogenesis* proposes that plant species and associations from native biomes are the basis for the formation of gardens) and Gilles Clément (with his *planetary garden*, a garden without fences, whose citizen-gardeners act locally and think globally), were fundamental references, demonstrating the power of ecological studies for landscape creation.

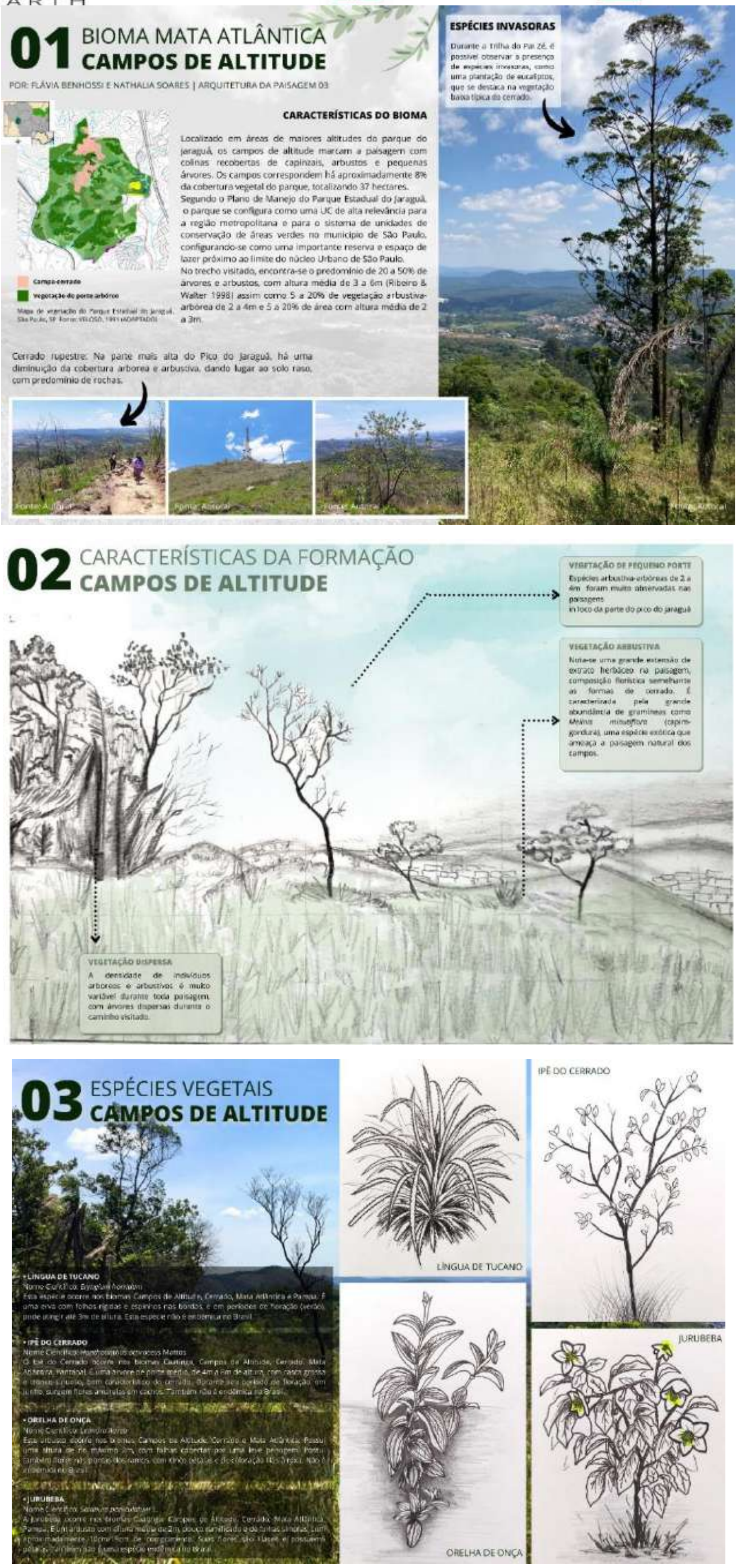
2. Materials and Methods

Figure 3. Experiencing the Atlantic Forest, in Paranapiacaba, Brazil (Carmona-Ribeiro, 2023)

The method adopted involved two interconnected practices: firstly, the on-site observation, carried out during visits to environmental preservation areas in the Metropolitan Region of São Paulo, which provided a corporeal, *lived* experience. Some of the visited places were Paranapiacaba, with its great environmental and cultural potential, as a 19th century railway village – protected by National Heritage and surrounded by environmental preservation areas, such as the Paranapiacaba Springs Natural Park; the Parque Fontes do Ipiranga, a large forested area in the middle of São Paulo, housing the Botanical Garden and several environmental research institutions; and the Jaraguá State Park, part of which is indigenous territory, and forest formations and grasslands. Secondly, together with the on-site observation, the practice of drawing was fundamental for a deeper understanding of the ecosystem's characteristics and plant species, and for overcoming the view that 'all plants are the same', as a student once noted.

2. Findings and Discussion

The results of the work were the production of plates bringing together information about the biome and its vegetation types (phytophysiognomies), sketches of species observed during the on-site visits (and later identified), and a drawing showing the complexity of the context where those plants were found.



01 BIOMA MATA ATLÂNTICA
CAMPOS DE ALTITUDE

POR: FLÁVIA BENHOSSI E NATHALIA SOARES | ARQUITETURA DA PAISAGEM 03

CARACTERÍSTICAS DO BIOMA

Localizado em áreas de maiores altitudes do parque do Jaraguá, os campos de altitude marcam a paisagem com colinas recobertas de capinzais, arbustos e pequenas árvores. Os campos correspondem há aproximadamente 8% da cobertura vegetal do parque, totalizando 37 hectares.
Segundo o Plano de Manejo do Parque Estadual do Jaraguá, o parque se configura como uma UC de alta relevância para a região metropolitana e para o sistema de unidades de conservação de áreas verdes no município de São Paulo, configurando-se como uma importante reserva e espaço de lazer próximo ao limite do núcleo Urbano de São Paulo.
No trecho visitado, encontra-se o predomínio de 20 a 50% de árvores e arbustos, com altura média de 3 a 6m (Ribeiro & Walter 1998) assim como 5 a 20% de vegetação arbustiva-arbórea de 2 a 4m e 5 a 20% de área com altura média de 2 a 3m.

Mapa de vegetação do Parque Estadual do Jaraguá, São Paulo, SP. Fonte: VELOSO, 1991 (ADAPTADO)

Cerrado rupestre: Na parte mais alta do Pico do Jaraguá, há uma diminuição da cobertura arborea e arbustiva, dando lugar ao solo raso, com predomínio de rochas.

ESPÉCIES INVASORAS

Durante a Trilha do Pai Zé, é possível observar a presença de espécies invasoras, como uma plantação de eucaliptos, que se destaca na vegetação baixa típica do cerrado.

Fonte: Autoral

02 CARACTERÍSTICAS DA FORMAÇÃO
CAMPOS DE ALTITUDE

VEGETAÇÃO DE PEQUENO PORTE

Espécies arbustiva-arbóreas de 2 a 4m foram muito observadas nas paisagens
in loco da parte do pico do jaraguá

VEGETAÇÃO ARBUSTIVA

Nota-se uma grande extensão de extrato herbáceo na paisagem, composição florística semelhante as formas de cerrado. É caracterizada pela grande abundância de gramíneas como *Melinis minutiflora* (capim-gordura), uma espécie exótica que ameaça a paisagem natural dos campos.

VEGETAÇÃO DISPERSA

A densidade de indivíduos arboreos e arbustivos é muito variável durante toda paisagem, com árvores dispersas durante o caminho visitado.

03 ESPÉCIES VEGETAIS
CAMPOS DE ALTITUDE

Figure 4. Jaraguá State Park vegetation study plates (Flavia Benhossi and Nathalia Soares, 2021)

The exercise contributed to multiple learning processes. Bibliographic reviews reinforced basic knowledge about the biome, such as its geographic distribution, relief, hydrography, climate – aspects little addressed in Architecture courses, but essential for the Landscape Architect. The students acquired a better understanding of the concept of phytophysiognomy and the differences between the various plant domains of the same biome (in the case of the Atlantic Forest, the humid tropical forest, the mixed forest, coastal ecosystems such as mangroves and salt marshes, altitude fields, and areas resulting from natural regeneration processes after human disturbance).

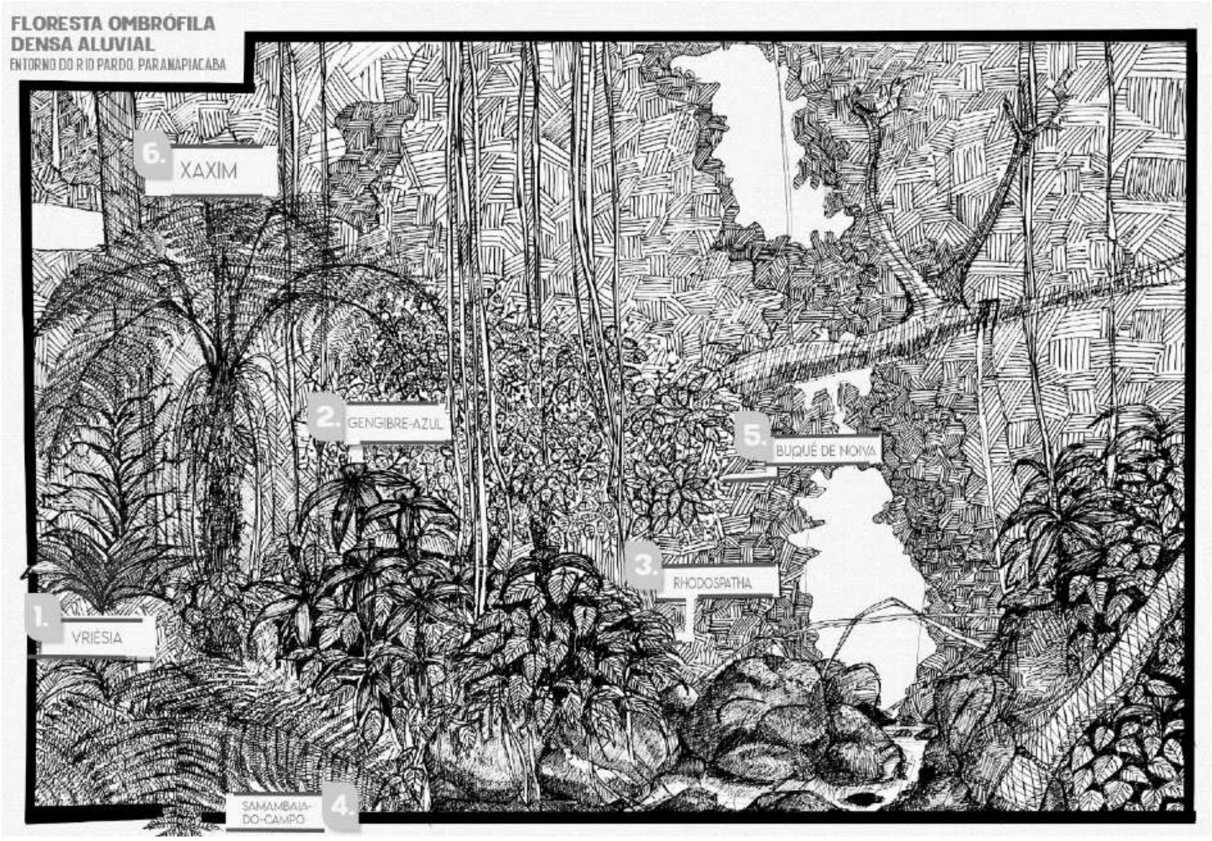


Figure 5. Paranapiacaba Springs Natural Park, riparian forest (Melissa Araújo and Caroline Baldrighi, 2022)

They were also able to figure out the relationships between the various species – for example, understanding the difference (obvious to a biologist, but unclear to most people) between an epiphytic plant and a parasitic plant; or the relationships between biotic and abiotic elements (such as plants, animals and soil or water); or the impact of disturbances caused by human action on the borders of preservation areas (with the replacement of native vegetation by invasive species).

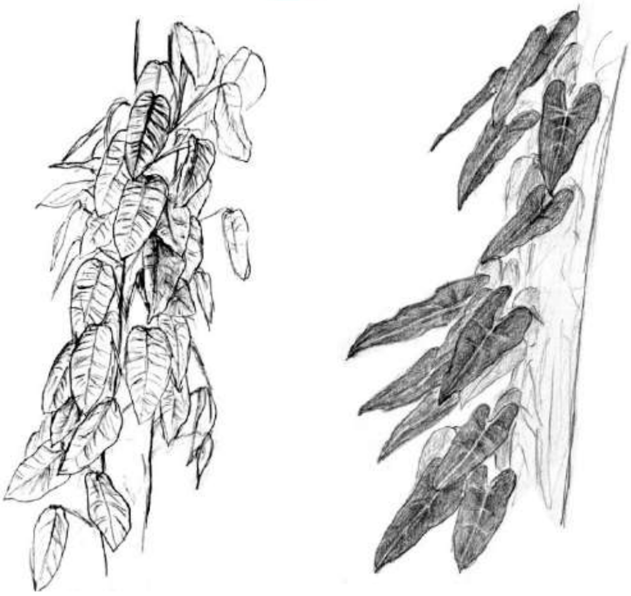


Figure 6. Two Araceae from the Serra do Mar State Park: possibly a *Rhodospatha* and a *Philodendron* (Lavínia Tikayuki, 2022)

3. Conclusions

Analyzing the students' production, it can be said that from this experience, they were able to approach – not only in terms of scientific knowledge, but also more subjectively – the native and endemic species of the biome, discovering new possibilities for planting design, in a country where the native flora is still largely undervalued. This double aspect (objective and subjective-affective) of the contact with the Atlantic Forest provides a more solid education for undergraduate students and future Landscape Architecture professionals, establishing landscape ecology as an essential element of landscape thinking.

Acknowledgments

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Revealing The Hidden Landscapes of Halicarnassus by Incorporating Modern Technologies

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Abstract

The demand for innovative approaches to educate landscape architecture is becoming more and more noticeable in context with the global environmental problems and code red alert. This study was carried out as part of the Istanbul Technical University's Department of Landscape Architecture's 2023–24 Spring Semester graduation project. Archaeological landscape studies have gained more attention in recent years in academic literature. However, there is a shortage of research that details the design process of archeological landscapes. This study seeks to reveal the historical, cultural, and architectural layers of Halicarnassus in order to influence the future development of Bodrum City by considering its current natural and cultural characteristics. With the objective of designing landscapes, students will perform an in-depth examination of ancient sites utilizing rapidly developing new technologies including drone shooting, orthophotography, and 3D mapping. Experts obtained data during fieldwork while students observed the procedure, and they utilized the resulting data to study the specific historical characteristics of the archeological sites. This study demonstrates how incorporating modern 3D mapping technologies and drone photography grounded in historical and cultural legacy may better prepare and raise students' awareness of environmental concerns, therefore influencing the direction of landscape architecture education.

Keywords: Landscape architecture education, archaeology, Halicarnassus, 3D mapping, drone photography

1. Introduction

With the growing global ecological problems and the increasing importance of sustainability principles, landscape architecture demands new and interdisciplinary approaches. Urban, cultural, and environmental dynamics are changing rapidly, making it necessary to change how this field is discussed and implemented. By maintaining the spatial legacy of the past, landscape architecture education takes on the responsibility of coming up with innovative approaches for the future in addition to creating visually appealing and functional designs.

As part of this study, the Istanbul Technical University 2023–24 Spring Term Graduation Project's Department of Landscape Architecture conducted a thorough examination of the historical, cultural, and fragmentary layers of ancient Halicarnassus (modern-day Bodrum). Bodrum's multilayered structure, natural geography, and rich archaeological structure make it an open air laboratory. The study investigated this unique arrangement, how developments blend in with the surrounding environment, and the choices available for preserving historically significant buildings and features. The focus of the study is the Hekatomnid city wall system, which is the Carian civilization's most notable engineering accomplishment. These walls provide critical data for comprehending both the old methods of warfare and the interaction between areas of settlement and the topography. In this context, students aim to illustrate that Bodrum's configuration of space has changed over time, starting with the ancient Mausoleum.The studio objective and one of the study aims is to make the case study area for landscape architecture students, Bodrum, sustainable as a tourism destination that respects its past but accepts growth in modern times, by combining the historical fabric with contemporary landscape architectural techniques. In this context, this study emphasizes the study of archaeological sites as input and discusses the use of contemporary landscape architecture in the reconstruction of the historical and cultural layers of the city. Although archaeological landscape studies have been gaining popularity in academic literature in recent years, they are underrepresented in contemporary design processes.

Thus this study aims to fill this gap by demonstrating how landscape architecture designed using modern technologies results in a historical site. To this end, it is also intended to serve as a model from which innovative and sustainable practice and teaching methods can be developed.

2. Material and Method

The initiative aimed to integrate archaeological heritage into contemporary landscape design, proposing a novel approach to landscape architecture education and utilising cutting-edge technologies throughout the process. The main objectives of using technologies such as drone photography, orthophotography, and three-dimensional mapping are to increase students' awareness of environmental issues while preparing them for future landscape architecture challenges.

As part of the study, the natural, historical, and cultural strata of the area were thoroughly explored, as well as Bodrum's ancient legacy known as Halicarnassus. The project sought to address issues including uncontrolled urbanization, excessive population expansion, and environmental degradation by creating design proposals that are considerate of the area's natural and historical heritage. Thus the literature review part included an extensive overview of the natural and cultural features of Bodrum, which were significant inputs for the students.

The students attended an introduction meeting at the initial phase of their assignment when the goals, parameters, and methods of the study were thoroughly described. The frameworks (Figure 1) that would guarantee the incorporation of ancient sites into modern landscape design were pointed out to the pupils. Then, with the assistance of the Archaeologists Association and the backing of the Bodrum Municipality, a field trip was conducted. The Halicarnassus Walls were thoroughly examined during this journey, and extensive data regarding the walls' historical background was gathered.

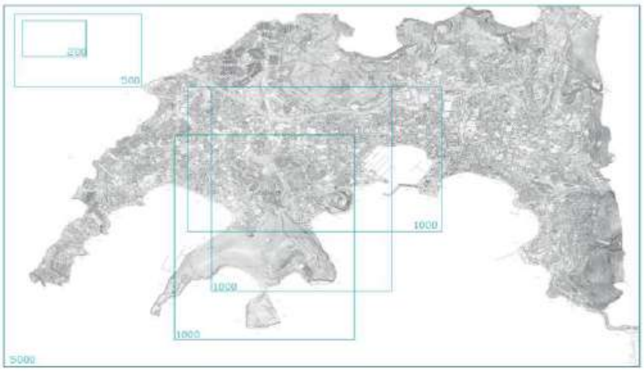

Figure 1. Frameworks of the working sites

The fieldwork comprised a four-day technical visit to natural and archaeological sites in the region. In this process, visual data were collected, three-dimensional mapping studies were conducted, and drone flights were carried out. Consequently, students were able to utilise the outputs of the applied technology with hands-on experience, thereby examining the spatial characteristics of archaeological sites.

Figure 2. Drone image shoots on-site in by Architectural Photographer Emre Dörter and drone operator Mustafa Erkatırcı.

The three-dimensional mapping models developed during fieldwork provided the students with a significant and invaluable dataset, comprising a wealth of information (Figure 3). The resulting models constituted the analytical and creative foundation for the design process, exhibiting clarity regarding the spatial dimensions and structural details of the archaeological sites. Students were able to extract sections from these models, conduct comprehensive analyses on the surfaces, and process their proposed designs directly on these bases. The high accuracy and level of detail of these 3D mapping models facilitated the comprehension of the structural features present. They enabled the production of designs responsive to both the historical and spatial contexts of the area.

Figure 3. Three-dimensional maps of the project (Produced by Emre Dörter and Mustafa Erkatırcı).

Throughout the project, students provided the requirements for each design scale from 1/5000 to 1/200 throughout the process, detailed their designs, received their feedback in four jury sessions to move to the next scale and level of detail. They presented their designs in the jury sessions, received critiques on their work, and made the necessary revisions to their projects, thus advancing with each jury.

After the completion of the studio, students had the opportunity to present their work to the public and the academic community in a research exhibition in collaboration with the Bodrum municipality. This exhibition provided students with the opportunity to introduce their designs to a wider audience and receive feedback (Figure 4).

Figure 4. From the Graduation Project exhibition in Bodrum.

The methodology followed in this study aimed to help students develop innovative designs by supporting historical and environmental inputs with technological infrastructure. This study also presented an advanced model for using contemporary technologies in landscape architecture education. The research also emphasized the importance of environmental sustainability and aimed to show the value of a teaching strategy that integrates theory and practice.

2.1 Case study area: Bodrum Peninsula

The Bodrum Peninsula is a distinctive case within the field of landscape architecture studies, characterised by its rich cultural history and diversified natural features. The region is situated at the confluence of the Aegean and Mediterranean Seas, a location that has been identified in academic literature as offering distinctive geographical and ecological qualities. The area exhibits karst topography, scarce subterranean water resources, and a Mediterranean climate, underscoring the necessity for sustainable management and conservation of these resources (Çömez, 2020; Özkan, 2018). However, considerable pressures from urbanisation and tourism pose a significant threat to both ecological integrity and cultural heritage (Koç et al., 2020).

The historical significance of Bodrum is evidenced by the presence in the area of two of the Wonders of the World: the Mausoleum at Halicarnassus, an ancient city which is itself of great historical importance, and the Palace of Minos in Knossos, both of which are UNESCO World Heritage sites. These characteristics represent an optimal combination of cultural and natural environmental concerns regarding architectural and urban heritage in orthogonal grid planning of the Hellenistic period, together with the traditional whitewash of houses (Apaaydın et al., 2021; Feray and Bayram, 2017). This places Bodrum in a favourable position with regard to developing an appropriate understanding of how historic preservation can be combined with contemporary landscape design.

From an ecological perspective, the marine ecosystems, forested areas, and maquis vegetation in Bodrum represent some of the most significant regional biodiversity sites. However, such development inevitably gives rise to a number of environmental concerns, including water scarcity, pollution and the deterioration of habitats. This highlights the urgent need for a more innovative approach to conservation. The overuse of groundwater sources has resulted in their gradual salinisation, thereby underscoring the necessity for sustainable development strategies at the local and national levels (Yarmacı, Keleç, & Ergil, 2017; Atacan Öğüt, 2011). This research is supported by the continually increasing interest in archaeological landscapes, increasingly considered a relevant topic for landscape architecture. Despite the extensive documentation of the historical and ecological importance of areas such as Bodrum, there remains a gap in the discourse concerning the application of these insights to the modern design process.

The project is therefore a response to the identified gap in this field, employing advanced technologies in drone photography, orthophotography and 3D mapping to facilitate the analysis and interpretation of the historical and natural layers of the site. The project will assist in the provision of information pertinent to future planning and design practices in a sustainable manner. It thus integrates the principal mapping technologies, focusing on contemporary strategies for addressing the challenges of cultural and ecological heritage. Additionally, it contributes to and is embedded within the broader discourse surrounding innovation in landscape architecture education. The objective is to demonstrate the value of such methodologies for students in developing ecological awareness and design competencies that can contribute to addressing current global environmental challenges.

3. Literature review: ıncorporating modern technologies in landscape design education

In recent years, the rapid advancement of technology has significantly influenced the profession and education of landscape architecture. The growing reliance on technological tools and computer programs in design processes has highlighted the necessity for integrating technology into landscape architecture education (Stephenson, 2007). Zube's (1998) study identified computers and related technologies as some of the most frequently discussed topics in landscape architecture journals from 1980 to 1997. Additionally, both LABOK and ASLA have underscored the importance of producing graduates skilled in technology, recognizing computer technologies as fundamental to the profession (LABOK, 2004; ASLA, 2007).

Technological advancements have significantly influenced accreditation and curriculum arrangements in landscape architecture education, increasing the importance of integrating technology into these processes (Stephenson, 2007). In 2003, ASLA incorporated technology-based skills into its accreditation criteria, underscoring technology as a core component of professional standards. Stark (1998) highlighted that while accreditation establishes educational benchmarks, the expertise of qualified professionals plays a crucial role in shaping these frameworks. Winterbottom (2002) described traditional educational models that emphasized experiential learning and problem-solving approaches, notably the Beaux Arts method. Incorporating these methods into modern curricula has enhanced both individual and team-based learning (Stephenson, 2007). In the 21st century, digitalization has revolutionized educational practices through innovative approaches like the Virtual Design Studio (VDS). Research by Elger and Russell (2003) and Kvan (2001) demonstrated that collaboration and team dynamics are essential components of the learning process in VDS projects. Furthermore, the post-pandemic shift toward digitalization has accelerated the adoption of these tools, making the integration of digital technologies in landscape architecture education an imperative.

The new design options and tools lead to new design methods changing the nature of traditional design processes based on hand drawing in many aspects such as sketching, idea development, form creation, and visualization (Stephenson, 2007). While some defend the hand-oriented design process, some scholars claim that computer technology provides alternatives to sketching for the creation of ideas (e.g. Buchal, 2002; Chastain & Elliot, 2000; Gibson, 2000; Won, 2001). Madrazo (1999) highlights how computers facilitate creative visualization by enabling "variations on a theme" and "changing shape." Conversely, CAD follows the "draw and modify" idea, methodically expanding a topic (Gibson, 2000).

Studies have revealed that 3-D computer modeling helps human cognitive functions and visualization, which is essential for creativity in design progress (Bilda & Demirkan, 2003; Buchal, 2002; Madrazo, 1999). According to these studies, the visualization process occurs differently when using computer technology and manual drawing, yet both approaches enhance design innovation. Schön's (1983) concept of design as a "conversation" is consistent with this. Whether using technical tools or conventional approaches, this conversation between the designer and the equipment or other people keeps it consistent. The link between drawing and idea production has been the focus of extensive study on the function of sketching and visualisation in design (e.g. Bilda & Demirkan, 2003). Visual thinking is considered as an essential component of the design process (Stephenson, 2007).

It is evident from Tai's (2002) research and Cooper and Schendel's (1976) work that incorporating computer technology into a curriculum alone will not provide positive outcomes. Restructuring the teaching strategies and material to maximize the benefits of technology is necessary when integrating it into the curriculum. The distinction between integrating and use of technology is that the former completely incorporates technology into the curriculum, while the latter extends beyond teaching students how to operate hardware and software (Pierson, 2001). Stated differently, effective integration involves more than just integrating technology; it also involves matching its functionality with teaching.

The integration of computer technologies into education is regarded as a pivotal advancement in transforming design studios (Brusco et al., 2000). This evolution has the effect of reshaping the creative process, introducing novel design opportunities and necessitating a reorganization of design teaching methodologies. In this context, the Department of Landscape Architecture at Changchun University of Architecture and Civil Engineering is seeking to align its curriculum with the evolving demands of the profession by embedding modern technologies (Boachang, 2021).

1. Knowledge Mapping and Ability: The department is focused on building knowledge and aims to improve mapping the learning level in the school to give a direction to the current teaching. This stage stands on the developing capabilities in innovation and application, taking future projects into account, and directly connecting to the associated top-notch instructional materials, design techniques, and theoretical knowledge (Boachang, 2021).
2. Digital Information Teaching Platform: It is composed of three main actions; incorporation of resources in public networks for digital information teaching (online lecture halls, public forums of famous teachers, public MOOC materials including models, videos, drawings, texts, pictures etc.), digital information teaching supplies (video materials, online lectures, excellent designs etc.), and practical educational platform (VR platform) (Boachang, 2021).
3. Learning Path: To ensure the completion of the learning process successfully, digital tools and resources are provided in all pre-course, in-course practice, and post-course development processes in order to strengthen the abilities of personal learning and design criticism (Boachang, 2021).
4. Blended Learning: To increase the student-centered individualized and also interacted learning, the traditional and new methods are merged with incorporation of new technologies with access to both public and school digital resources, and interactive class courses ensuring the off-line learning process and self-study (Boachang, 2021).

The curriculum Boachang stated is a new step into the future of landscape architecture education removing the borders between the traditional and new design thinking and learning, leading to a new kind of design teaching understanding incorporating the new technologies as the system structure, not an additional tool. The method experienced in the graduation project of Istanbul Technical University Landscape Architecture Department for the spring semester 2023-24 is the introduction to such a new kind of design education system, which aims to integrate it to the curriculum and make it an essential part of the education in the future.

4. Findings and Discussion

The aim of this study is to discuss the developments in landscape architecture education in terms of analysis and design along with the rapidly expanding technology. These developments, which were carried out by investigating the archaeological, cultural, and ecological layers of Bodrum City in the Landscape Architecture Department of Istanbul Technical University, emphasize the expansion of innovative methodologies in landscape architecture education. The study is evaluated in three categories; revealing the complex relationships in the analysis process, opening new horizons in the design process, and reflection of design to the real world in representation.

Revealing the complex relationships ın the analysis process

The strategies used in the project included drone images, orthographic photography, and 3D mapping techniques that contributed greatly to the analysis process. These strategies provided students with a comprehensive understanding of the historical and cultural aspects of Bodrum City. These technologies enabled a more comprehensive analysis of the natural and cultural aspects of the region, especially in the process of revealing the historical and architectural layers of Halicarnassus. Students enhanced their understanding of the complex interactions between topography, structure, and natural elements using 3D imaging techniques that they then integrated into their analysis systems. In this context, the following visual representation (Figure 5) illustrates a student project in which the sections, orthographic photographs, and supplementary analyses obtained through the use of the 3D Mapping technique have been schematized. The utilization of three-dimensional modeling data facilitated a more comprehensive comprehension of the existing condition of the land and the design process. In particular, the integration of topography and articulated design modules in the sections, and the consolidation of images on diverse surfaces and scales in a unified collage, enhanced the visual representation of the work.

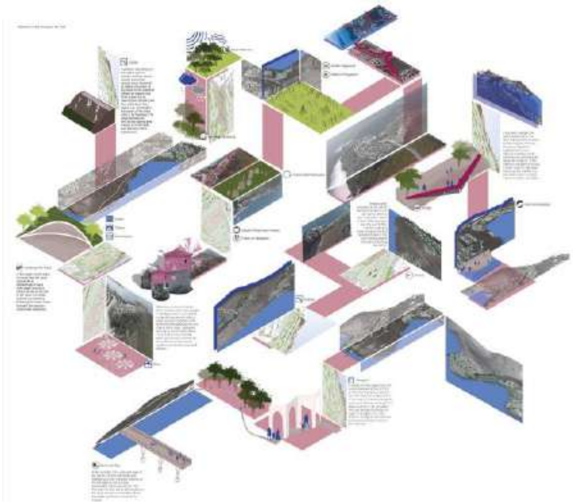

Figure 5. Illustration example of a schematized representation using mixed technological visual data techniques.

Opening new horizons ın design process

The use of drone and 3D mapping data allowed students to not only analyze the physical environment in question but also to create detailed projects based on the data collected. The cross-sectional studies focused on the topography of the region, while also investigating the geological layers that students incorporated into their designs during the analysis phase. Detailed schematic productions for this purpose not only increased the aesthetic appeal of the design but also provided a scientific basis for its development. Moreover, such studies emphasized that landscape design is not only a physical intervention; it is also a historical, ecological, and place-sensitive process (Figure 6).

Figure 6. Cross-section Representation from Student Work

In the example in Figure 6, following a cross-section of the topography of the area using 3D mapping data, the student explored and investigated the geological layers, incorporating this information into the analysis representations. This inspiration and production contributed to the overall design concept.

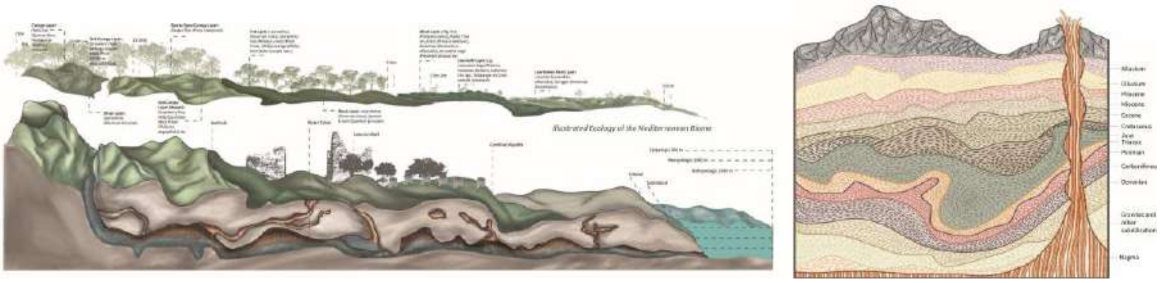

Figure 7. Topographic Section and Geological Analysis from Student Work

Reflection of design to the real world in representation

The utilisation of 3D mapping techniques enabled students to visualise their designs with highly realistic representations. The students were able to transfer their designs onto 3D terrain models using the data they had obtained, thereby facilitating an assessment of the applicability of their designs in this process. These techniques permitted the realistic modelling of elements such as material use, scale and form. Furthermore, these methods enhanced the feasibility of the projects by providing an indication of how the design would appear when implemented.

The following images (Figure 8) show how the images obtained with the 3D Mapping technique are represented. Visually, students analyzed the area in a versatile way and developed designs using 3D data.

Figure 8. Two different student work examples related to the reflection of design to the real world in representation.

Bringing together and evaluating the information presented in the article, it can be concluded that the inclusion of modern technologies in the landscape architecture educational process has truly far-reaching promises for environmental awareness and at the same time develops a person's analytical and creative ways of thinking. The availability of drone photography and orthophotography up to 3D maps encouraged students to conduct significant research on historical and cultural landscapes, which strengthened the analysis. These findings are in line with the existing literature on this topic, such as the work of Ismail and Matouk (2024), Yefimenko (2023), and Semenescu, Antonescu & Chiva (2020), showing that digital technologies can enhance analytical and creative processes in education.

As an initial step of incorporating the new technologies in landscape design education in ITU Landscape Architecture Department, the experience has achieved some goals in the Changchung University’s strategies stated in literature review. The students were supported with digital materials of the site as a digital library, including various types such as 3D mapping, orthography, and drone photography. The fact that the materials are editable and modifiable made the individual design thinking possible in the design process, which contributed to strengthening the personal learning and design criticism by trying different designs on the models. It also improves the learning the path by learning by doing, and also consolidates the ability of incorporating the digital materials and tools in the design by feedback loops in each jury. With the incorporation of new and old techniques such as sketch exams, physical model making, face-to-face juries, digital materials, representing and design making in digital mediums created a blended learning and experience environment for the students, which is a rehearsal of the profession before they are graduated. With the cumulative experience that will increase over time, it will be possible to create and map a body of knowledge on incorporating new technologies in design.

This research demonstrates how the use of the latest technologies in a historically and culturally significant location can change not only the design process but also the wider attitude toward landscape architecture education. Therefore, future research into the application of such innovations on a wider scale is recommended.

5. Conclusion

Recent studies show that integrating modern 3D scanning and drone photography into landscape architecture education will increase students’ preparation and knowledge on issues related to environmental issues. Technologies not only contribute to the understanding of complex relationships through analysis but also provide new perspectives through multidimensional perceptions and detailed information processed during the design phase. Moreover, landscape architecture produces design concepts that are translated into real-world representations and opens new perspectives from these representations. In this study, most of the technical barriers were caused by technical barriers such as difficult-to-access hardware, time constraints to run the required software, and software knowledge for the implementation process. As a result of the study, it is envisaged that the integration of artificial intelligence with design fields, in general, will be even more advanced and comprehensive in the future for further studies.

Three-dimensional mapping and drone photography are widely applied in construction, agriculture, mining, and environmental control, but these tools have not been integrated with project design, topo-analytical research, and ecological planning applications in landscape architecture education. This will further develop technical skills among students and make them more environmentally sustainable. To that end, landscape architecture programs will help prepare students to solve more complex real-world problems, such as designing and building sustainable urban green spaces using existing technologies or the changing impact of climate on natural ecosystems. Allowing students to work with 3D mapping and drone photography to develop new ways of looking at and evaluating the landscape allows them to create unique solutions that balance human demands and environmental protection.

The increased involvement of technology in landscape design education is preparing a new generation of professionals who can create resilient and environmentally friendly built environments. Furthermore, the incorporation of new technologies in landscape architecture education leads to better-informed and more effective environmental solutions by developing students' analytical and creative thinking skills. The adoption of such new techniques in education will make future landscape architects more knowledgeable and caring professionals who will be in a position to confront the major environmental concerns they face today. This holistic approach will prepare students well with the right kinds of skills and perspectives to address diverse environmental concerns, develop new solutions that meet human needs, and protect the environment. Placing design theory in the real world of representations bridges theory and practice, preparing students to make a real impact on landscape architecture.

Overall, this study demonstrates that the use of cutting-edge technologies to incorporate studio techniques is a transformative move in teaching the next generation of landscape architects to address pressing environmental issues through more informed and therefore effective solutions.

Note

We would like to begin by expressing our gratitude to Bodrum Municipality, the guest jury members Melike Yapıcı and Selim Yiğit, who participated in our jury on behalf of Bodrum Municipality, and the entire team for their invaluable collaboration and support in this project. We would also like to extend our gratitude to Architectural Photographer Emre Dörter and Drone Operator Mustafa Erkatırcı for their instrumental role in ensuring the successful completion of this project. Furthermore, we would like to express our gratitude to our guest jury members, Zeynep Kuban Tokgöz, Deniz Aslan, Nesli Naz Aksu, and Emre Dörter, for their invaluable contributions of knowledge and experience. We would like to express our gratitude to our students, who demonstrated remarkable proficiency in the studio; Sedef Ülkü Yıldırım, Zehra Bıyıklı, Almira Endican, Emine Öykü Şenol, Beyza Nur Öztürk, Ayşe Şimal Gürdamar and Ayşe Berru Demirkol. The following students were involved in the project: Melisa Yurdakul, Ayşe Aleyna Çolak, Dicle Yıldız, İrem Kaba, Yiğit Eren Şahin, Rabia Genç, Yelda Nur Özcan and İlayda Amina Ekil. We also extend our gratitude to ITU and the Department of Landscape Architecture for providing invaluable support that enabled the success of this work.

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Potential of Antalya's Urban Landscapes Regarding to Environmental Education

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Abstract

Environmental education aims to foster an understanding of the ecological systems people live in and encourage active participation in environmental problem-solving. This paper evaluates landscape patterns in Antalya, focusing on protected areas and urban green systems such as forests, sand dunes, wetlands, and cliffs. These areas are classified by size, accessibility, and plant species to explore their potential for environmental education.

The study uses literature review, field research, and observation to assess the environmental education potential of Antalya's urban landscapes. By examining the region's geographical, ecological, and demographic characteristics, the research identifies educational opportunities. Environmental elements like natural life, water resources, green spaces, and waste management were observed to document current conditions and identify possible educational activities.

The findings indicate that Antalya's urban landscapes can significantly contribute to environmental education and support sustainable development goals. The success of such programs relies on continuous evaluation, feedback, and improvement. Ultimately, this research lays the foundation for incorporating Antalya's urban landscapes into environmental education, ensuring the protection and transmission of the region's natural and cultural heritage to future generations.

Keywords: Landscape, Environmental education, Antalya, Learning tool

1. Introduction

Environment is defined as the entirety of environmental conditions that impact the existence of all living organisms (Çepel, 1990). Environmental education began in 1970 with World Earth Day, aiming to inform, raise awareness, and foster concern. The 1972 "Human Environment" conference by the UN in Stockholm laid the foundation for World Environment Day. In 1975, UNEP and IEEP were initiated, and in 1977, the Tbilisi conference established the need for international cooperation in environmental education (LePage et al., 2023). The fundamental objective of environmental conservation is to shield both humans and their surroundings from negative influences, minimising and striving to eradicate resulting harm while contributing to the enhancement of living standards (Arora et al., 2018). Meanwhile, the purpose of environmental education is to foster an understanding of the ecological systems within which individuals exist, enabling them to grasp their role within these systems, cultivate perspectives on harmonious coexistence with nature, and equip them with the ability to actively participate, acquire skills, and develop habits to address environmental challenges. In pursuit of this objective, environmental education seeks to encourage the appreciation of natural environments, living organisms, and inert elements in nature, highlighting their ecological, aesthetic, cultural, social, and economic significance, thereby raising awareness about environmental issues. It is clear that environmental education is centred on instilling in individuals the consciousness, capabilities, attitudes, and practices necessary for environmental conservation (Ardoin, et al., 2020).

The increasing prevalence of environmental challenges on a global scale emphasises the growing indispensability of environmental education (Yıldız et al., 2021). Within our national context, efforts to foster environmental consciousness and heighten sensitivity towards environmental issues have led to the incorporation of dedicated courses or modules on environmental education across higher education, secondary education, and primary education curricula. Notably, higher education, primarily tasked with imparting specialised and vocational training alongside cultivating scientific understanding and behaviour, has been exempted from these provisions. Furthermore, while primary education mandates exist within our nation, the imperative of compulsory secondary education remains subject to ongoing deliberation. Nonetheless, given the notable rates of urbanisation and the substantial student populations in our urban centres, there emerges a critical exigency for a recalibrated approach to environmental education (Gülersoy et al., 2021).

The assurance of individuals' rights to live in a healthy, sufficient, clean, and aesthetically pleasing environment is safeguarded both by national and international legislation. However, the extent to which citizens uphold these rights and fulfill their responsibilities is contingent upon their level of awareness. Environmental education is considered a far more effective method than legal regulations and penalties in ensuring environmental protection, conservation of significant species and natural habitats, and the improvement of living standards (Fang et al., 2023).

Protected areas and various types of urban green spaces and landscape values play a significant role in providing recreational opportunities, improving climate, supporting biodiversity, offering habitat and nourishment for wildlife, and exerting regulatory and ameliorative effects on built-up areas (Threlfall et al., 2017). Additionally, they possess undeniable potential in environmental education thanks to their socio-economic, scientific, aesthetic, and recreational contributions, as well as their preserved natural structure, vegetation, and geological composition, enabling on-site learning experiences (Ardoin, et al., 2020).

In environmental education, various tools are used to understand the relationships between humans and their environment and to instill environmental awareness in the community. Protected natural areas like national parks and urban green spaces are particularly evaluated for educational purposes, treating human and natural environments as a laboratory for learning. Taking the example of Antalya as a case study, this research aims to classify natural landscape values such as forests, natural shrublands, coastal dunes, wetlands, and cliffs based on criteria such as area size, accessibility, represented species and habitat richness at both the level of protected areas and urban green spaces. The integration of these classifications into the existing education system and environmental education at various levels in our country is targeted. Implementing environmental education through on-site practices and nature-based conservation efforts will contribute to the long-term increase in environmental awareness and support the preservation of the environment, natural areas, and resources through public enlightenment.

2. Material and Method

Urban landscape values of Antalya were determined as a case study shown in Figure 1. Forests, natural shrublands, coastal dunes, wetlands, and cliffs could play an educational role based on criteria such as area size, accessibility, represented species and habitat richness at both the level of protected areas and urban green spaces.

Figure 1. Location of the study area

As a methodology, literature review, field research and observation were conducted to evaluate the environmental education potential of Antalya's urban landscapes. By examining the existing literature containing the geographical, ecological and demographic characteristics of Antalya, a basic framework was created to understand what kind of opportunities the region offers in terms of environmental education. Then, environmental elements such as natural life, water resources, green areas and waste management was observed and documented by visiting different urban landscapes of Antalya. This stage would help to identify potential educational activities and analyse the current situation.

3. Findings

3.1 Environment, nature conservation, and environmental education

The primary goal of environmental conservation is to protect humans and their surroundings from adverse effects, endeavouring to reduce and eliminate resultant harm as much as possible, while contributing to the improvement of living standards. Knox & Morgera (2022) defines nature conservation as the protection of natural elements and the flora and fauna living therein, along with their growth and living conditions, for the guarantee of human health and life, based on specific criteria. The purposes of conserving natural, semi-natural, or cultural areas are listed socio-economically, scientifically, aesthetically, morally, and recreationally.

Education is often conceived primarily as a means to address environmental issues (Guerrero, 2024). The aim of environmental education is to enable individuals to comprehend the ecological systems within which they live, grasp their place within these systems, develop perspectives on how to live in harmony with nature, and equip them with effective participation, skills, and habits in solving environmental problems.

In environmental education, efforts are made to understand the reciprocal relationships between individuals and their environment and to instill environmental awareness in society using various tools. Today, in environmental education, nature conservation areas such as national parks and urban green spaces are particularly utilised for educational purposes, with human and natural environments being considered as a laboratory.

3.2 Environmental education tools

Environmental education in conservation can be approached in two groups. Environmental education takes place in protected areas with existing conservation status such as national parks, nature reserves, and wildlife conservation areas, as well as in rural and urban areas that lack conservation status but encompass various landscape types, traditional land uses, or geological formations.

3.2.1 Environmental education in conservation areas

National parks, nature reserves, biosphere reserves, and other protected areas are extensively utilised in environmental education to enhance understanding of nature, achieve success in nature conservation, and facilitate effective public participation in conservation efforts. These provisions are also envisaged by conservation laws, and among the criteria of the International Union for Conservation of Nature (IUCN) for national parks is the provision of educational, cultural, and recreational opportunities at a level that does not compromise the area's natural features (Dudley, 2008).

Guerrero (2024) defines protected areas as spaces where a moral philosophy of nature conservation is tested and examined for the benefits of humanity, where the impacts of human influence on other systems are compared and learned from. For instance, environmental education provided in the South African Waterberg Biosphere Reserve has been more successful in ensuring sustainable land use practices on privately owned land than legal regulations (Mokubedi, 2022).

Supporting environmental education in protected areas and fostering a better understanding of nature is carried out through various methods such as visitor centers, nature schools, informational signage in the field, guided tours, exhibition activities, and printed materials. In protected areas, environmental education involving the participation of the public, schools, and visitors is considered not only a social responsibility but also a crucial factor in the success of nature conservation. However, the use of protected areas for on-site educational purposes within the current educational practices in Türkiye depends on the sensitivity of teachers or school administrators.

3.2.2 Environmental education in non-protected rural and urban areas

Environmental education can be integrated into various levels of education, including primary, secondary, and relevant university departments, by utilizing natural and cultural green spaces in urban and peri-urban areas without protected status. These areas encompass a variety of species, different types of habitats, and, most importantly, living examples within reachable distance, facilitating the planning and implementation of environmental education. Besides helping students familiarise themselves with their surroundings, such education can also play an effective role in raising awareness of existing environmental issues and increasing environmental consciousness.

Urban green spaces, such as parks, natural areas, and urban forests, not only contribute to stable and sustainable urban development and provide regulatory and ameliorative effects on built-up areas but also offer recreational and aesthetic opportunities to urban dwellers. Additionally, they should be recognised for their educational function, as noted by Semeraro et al. (2021), who emphasised that teaching geomorphological processes, landforms, and their ecological characteristics through environmental education can alter individuals' perspectives beyond mere conservation.

Urban green spaces facilitate interactions between humans and plant-animal communities over extensive areas and serve as a link between past and present times. Remnant species representing natural structures and vegetation characteristics before urbanization often serve as vivid examples of urbanization's impact. Providing individuals with firsthand, contextual information about the areas they encounter daily can foster their adoption and protection of these spaces. Environmental education, in essence, entails individuals' recognition, experience, and understanding of their surroundings, ultimately leading to the development of consciousness and behavior conducive to environmental conservation (James, 2024).

3.2.3 Utilising natural and cultural landscape types in environmental education

The foundation of environmental education is directed towards the conservation of nature and natural resources. However, understanding how air, soil, water, flora, and fauna can be conserved necessitates a comprehensive understanding of the entire environment, including the biosphere, biomes, and ecosystems (Mosoh et al., 2024). Nevzati et al. (2023) asserted that classifications of areas based on landscape factors and potentials serve as a tool in translating scientific knowledge and experiences into social services, facilitating communication between nature and human communities. In other words, the identification of natural and cultural environmental factors and their values, along with transforming this information into a format conducive to learning, is essential. Here, diversity, naturalness, locality, and accessibility criteria are highlighted. For example, in South Africa, the Watterberg region was chosen as the most suitable area for environmental education in the biosphere reserve due to its landscape features, clean environment, clean rivers, rich biodiversity, and safety for youth and children (Mokubedi, 2022).

Semeraro et al. (2021) noted that landforms in protected areas such as national parks often captivate people's interest, but the underlying details are often unknown. Mammadova (2017) and Taş (2023) highlighted that environmental education provided in urban recreational areas, such as school camps, wildlife enhancement areas, and nature excursions, beyond traditional school classrooms, enlightens the public about nature and natural processes through teaching about natural landscape types. Especially in applied, on-site environmental education, coastal areas, seas, sand dunes, wetlands, and natural forest landscape types are widely used, particularly at the scale of protected areas. However, when selecting natural features or landscape types for inclusion in environmental education, several criteria such as surface shape, surface morphology, soil, slope, vegetation cover (number of species, species diversity, presence of cultivated plants, natural species), wildlife, habitats, if present, water surfaces and associated features, recreation potential, land use pattern, accessibility and creating a "representative landscape" in a narrow area can be considered.These criteria can be detailed according to the degree and level of environmental education to be provided. They guide the selection of appropriate and effective natural areas or landscape types for environmental education and contribute to its success.

3.3 Urban landscape values of antalya and opportunities for using them in environmental education

Antalya has a significant diversity of urban landscape values, with its numerous protected areas and various types of urban green spaces. The potential for evaluation in environmental education have been examined primarily at the scale of easily accessible natural and cultural urban landscape values, especially those requiring conservation approaches and understanding. The diverse natural and cultural landscape types in Antalya offer ample opportunities for environmental education, contributing to the understanding and conservation of local ecosystems and heritage.

Since its establishment by the Bergama Kingdom under King Attalos in the 2nd century BC, the city of Antalya has been witness to various civilizations, becoming a synthesis of natural features and archaeological remnants. However, in recent years, increasing urbanization and construction pressures have become significant threats to both natural landscapes and biodiversity, even in the absence of archaeological remains. Göktürk (1994) conducted a study on the city's flora, determining that 1023 different plant species, comprising 863 natural and 160 cultural species, are distributed within the urban fabric of Antalya. This highlights the necessity of preserving Antalya's urban landscape values, particularly in terms of biodiversity.

Antalya Coastal Cliffs: The coastal cliffs between Antalya's Lara and Konyaaltı beach areas represent a unique coastal formation specific to the region. These cliffs, which can rise up to 25 meters from the sea as shown in Figure 2, exemplify rare coastal morphological features reflecting different geomorphological periods over short distances.

Figure 2. The coastal cliffs (Original 2024)

Lara Coast Sand Dunes: Sand dunes, formations that require many years to develop, vary depending on their location along coasts, seas, and lakes, representing different environmental conditions with their physical and chemical properties, vegetation, and dominant plant species. The Lara coastal sand dunes (Figure 3), stretching over 9 km in the east of Antalya, possess natural and touristic value. Despite being surrounded by settlements, they still exhibit a homogeneous dune morphology and contain typical coastal vegetation species, allowing for excellent observation of both foredunes and inland dune shrubs.

Figure 3. The Lara coastal sand dunes

The topics covered in environmental education regarding Lara Coastal Sand Dunes include understanding the typical morphology of sand dunes, observing sand dune vegetation in situ, including plant characteristics such as texture, form, and color, the function of sand dunes within the urban fabric as a transitional buffer zone between the coast and settlements, the need to protect fragile dune ecosystems under pressure from intense urban development.

"Wetlands" encompass a wide range of terrestrial, coastal, and marine habitats. According to the Wetlands Conservation Regulation, wetlands include all natural or artificial, permanent or temporary, stagnant or flowing, freshwater, brackish, or saltwater bodies, as well as marshes, reed beds, wet meadows, and peatlands (Çakaroz et al., 2020), and they are the most productive areas within global ecosystems.

Yamansaz Marsh: As the only coastal wetland in the Western Mediterranean Region, Yamansaz Marsh, located just 15 km from the city center, provides habitat for approximately 160 bird species for nesting, feeding, and breeding. Despite being designated as a first-degree natural conservation area, Yamansaz Marsh is under intense pressure from urban development as demonstrated in Figure 4.

Figure 4. Yamansaz Marsh (Original 2024)

The topics covered in environmental education regarding Yamansaz Marsh include the formation stages of wetland systems such as Yamansaz Marsh, the contribution of wetland systems to biological diversity and the groundwater cycle, the visual function of water surfaces within the urban fabric, wetland vegetation and the need to protect wetland systems under pressure from urban development.

Atatürk Park: Coupland (2022) stated that one of the functions of green cover and urban forestry in settlement areas is their "educational" role and that forests and vegetation are best utilised in understanding ecology. Atatürk Park (Figure 5), the largest green area in Antalya, spans a vast area from the Konyaaltı viaduct to the city center, offering a combination of natural trees, shrubs, perennial and annual plant species, natural maquis, and typical examples of cliff-top rock vegetation. The park also provides an opportunity to compare the composition of species within the natural structure and the aesthetically planted showy flowers, trunks, leaves, and so on.

Figure 5. Atatürk Park (Antalya, 2024)

Atatürk Park offers a visual perspective of city panoramas and urban land use from various points along the extensive coastal strip. The topics covered in environmental education regarding Atatürk Park include its contribution as a green area system to the urban ecosystem, biodiversity it harbors, comparing natural and cultural species, characteristics of different plant vegetation types, its function within the urban fabric, acting as a protective band for coastal cliffs and preventing urbanisation pressure on the coast.

Karaalioğlu Park: Like Atatürk Park, Karaalioğlu Park, located along the coastal strip, provides an ideal observation area for exotic ornamental plants brought to the region for visual appeal, in addition to containing natural plant species as shown in Figure 6.

Figue 6. Karaalioğlu Park (Original 2024)

The topics covered in environmental education regarding Karaalioğlu Park include urban green area organization, meeting the recreational needs of the public, living and artificial elements of green areas, biodiversity, especially experiencing exotic ornamental plants, its contribution as a green area system to the urban ecosystem.

Vakıf Farm: Vakıf Farm represents a typical example of traditional agricultural use specific to the region, where local fruit species such as olives and citrus are cultivated as demonstrated in Figure 7. It is an ideal area for observing the production methods of drought-resistant natural species in the region, emphasising the reasons for their use, advantages, and the importance of preserving socio-economic and traditional land use patterns and habits.

Figure 7. Vakıf Farm (Antalya, 2024)

Kadınyarı Stream: Kadınyarı Stream, designated as an Urban Conservation Area, is largely covered by upper concrete structures due to infrastructure and drainage works. However, in certain areas, it still showcases natural valley formations typical of Antalya's urban structure before urbanization (Figure 8). It also exhibits characteristics such as biodiversity, the transport of plants by water, and its contribution to the urban water cycle.

Figure 8. Kadınyarı Stream (Akdeniz, 2020)

Topics covered in environmental education regarding Kadınyarı Stream include natural valley formation, observation of the surface water cycle, biodiversity and transported species, the contribution of the moving water surface and valley formation to the urban fabric and the need to preserve natural valley formations under pressure from urban development.

Structural Landscape Values: Yang et al. (2022) stated that the main purpose of environmental education is to raise citizens with environmental responsibility and that the most important message to be conveyed in environmental education is awareness of one's surroundings and environmental issues. Thus, an instinct for embracing and protecting the environment will develop in children. Urban elements such as residences, structures, traffic routes, or individual small industrial centers, factories, etc., which constitute the urban core, can be used to develop environmental awareness by considering their socio-economic positive aspects but environmental negative aspects.

4. Conclusion

The conservation of natural habitats involves protecting natural elements such as vegetation, soil, water, air, and climate while ensuring their sustainability for future generations. Environmental education plays a critical role in developing environmental ethics and behaviours, especially among urban populations, by integrating environmentally sensitive habits into daily life. Without this integration, effective environmental protection cannot be achieved (Pinho & Gomes, 2023).

Environmental education should not be limited to a standalone course, as this approach risks disconnecting it from interdisciplinary connections and real-world applications. Instead, environmental education should be embedded in various disciplines, including social sciences and natural sciences, to ensure students gain both theoretical knowledge and practical skills (Guerrero, 2024).

In Türkiye, landscape values, particularly at the primary education level, are effectively used to promote environmental awareness, attitudes, and a sense of conservation responsibility. A phased educational model is proposed, where students first experience and explore their environment, then observe and analyse local environmental issues, and finally articulate their observations verbally and, especially, in writing. However, the centralised education system in Türkiye limits regional or teacher-specific adaptations, making it difficult to apply environmental education based on local environmental values.

Antalya, with its rich natural and cultural landscapes, offers a unique opportunity for environmental education. These landscapes can serve as educational resources to help students understand local ecosystems and develop sensitivity to environmental issues. A curriculum that integrates open-air lessons with region-specific environmental values tailored to different age groups is suggested. For high school students, the curriculum should align with university and lifelong learning strategies to reinforce environmental awareness.

Collaboration among educators, curriculum developers, urban and regional planners, and environmental professionals is essential to enhance the effectiveness of environmental education. Such an approach will contribute to achieving sustainable development goals and preserving regional natural and cultural heritage for future generations. Over time, it will also help raise public awareness of environmental issues and support the conservation of natural resources and ecosystems (Sullivan-Wiley et al., 2023).

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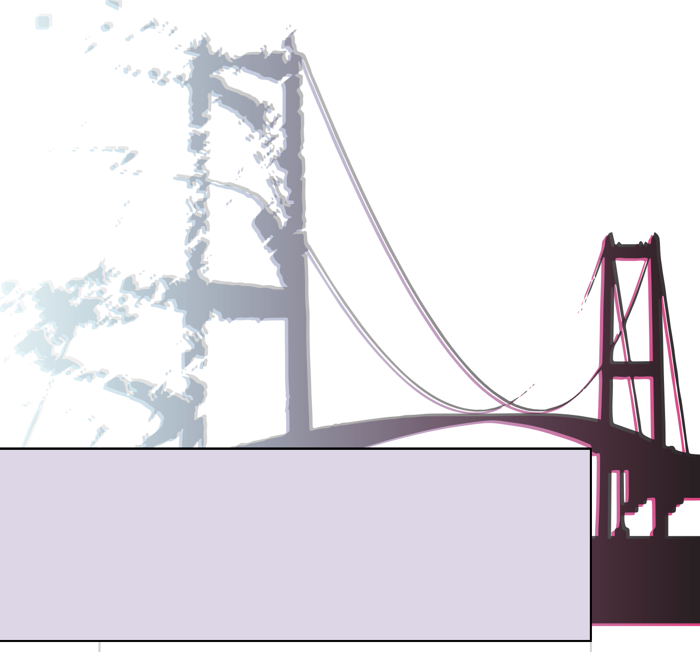

Days / Hours		HALL	THEME	DAY 1 - SEPTEMBER 4, 2024 (WED)
08:00	09:00	Congress Center Entrance Hall		REGISTRATION
09:00	10:00	Main Hall (Üsküdar Hall)	OPENING	Opening Ceremony Opening Remarks
10:00	10:30		AWARDS	Sir Jellicoe Award 2024
10:30	**11:00**			***Break***
11:00	11:30	Main Hall (Üsküdar Hall)	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											
				Session Chair: DAMIAN TANG			Session Chair: MARIA IGNATIEVA			Session Chair:ŞÜKRAN ŞAHİN			Session Chair: TANER OZDIL
14:00	14:15	Break-out Session 1 (Üsküdar 2 Hall)	Codifying Code Red: Eco-Emergency, Global Solidarity	Landscape Architecture Accreditation in a Code Red Era: Comparative Perspectives - **Ebru Ozer**, Kristopher Pritchard, Gert Bischoff, Torey Carter Conneen	Break-out Session 2 (Üsküdar 1 Hall)	Cultivating Resilience: Sustainable & Resilient Communities	Te kori a te kō redefining our sustainable, prosperous future - **Debbie Tikao**	Break-out Session 3 (Üsküdar 3 Hall)	Sustaining Life: Protection, Mitigation & Management	Impact of New Urbanization on Landscape Patterns' Spatial Characteristic - **Yaxuan Ning**, Hao Yin	Break-out Session 4 (Beylerbeyi 1 Hall)	Building Bridges, Breaking Barriers: Education & Practice	Integration of the tools of landscape-architects to the architecture studies - **Frédéric Dellinger**
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
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
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
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
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

		15 min Oral Presentations									
				Session Chair: PATRICIA ODONNELL			Session Chair: YING LI			Session Chair: SADIK ARTUNÇ	
14:00	14:15	Break-out Session 5 (Beylerbeyi-2 Hall)	Sustaining Life: Protection, Mitigation & Management	Construction and Optimization of North-China Leopard Habitat Network in Jinzhong - **Jiarui Liu**, Lu Yang	Break-out Session 6 (Yıldız-1 Hall)	Engaging with the Digital: Innovation, Technology & Big Data	Emerging trends in the digital revolution in landscape planning - **Beata Dreksler**, Katarzyna Rędzińska	Break-out Session 7 (Hamidiye Hall)	Design Projects	Bantayo Subayi: Obu Manuvu Pusaka as Panigan-Tamugan Watershed Management Approach - **Jyllean Marye Tupaz**	
14:15	14:30			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			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			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			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			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***

		15 min Oral Presentations											
				Session Chair: PAT CRAWFORD			Session Chair: PAUL Y K CHAN			Session Chair: YIN-LUN J CHAN			Session Chair: CARLOS JANKILEVICH
16:00	16:15	Break-out Session 8 (Üsküdar 2 Hall)	Building Bridges, Breaking Barriers: Education & Practice	Revealing The Hidden Landscapes of Halicarnassus by Incorporating Modern Technologies - Gülşen Aytaç, Elif Kutay Karaçor, **Lâl Dalay,** Rabia Ezgi Beyen	Break-out Session 9 (Üsküdar 1 Hall)	Codifying Code Red: Eco-Emergency, Global Solidarity	Campus Climate Effects on Student Well-being: Mapping Heat Resilience - **Hamide Somuncu**, Celen Pasalar	Break-out Session 10 (Üsküdar 3 Hall)	Cultivating Resilience: Sustainable & Resilient Communities	Design scenarios for floating architecture to mitigate, adapt climate change - **Dilara Ayşegül Köse**, Ayşem Berrin Zeytun Çakmaklı	Break-out Session 11 (Beylerbeyi 1 Hall)	Acting for All: Diversity, Equity & Inclusion	The Flow of Power: Shifting Socio-Ecological Memory of Alakır River - **Çisem Demirel Koyun**, Arzu Güler, Ebru Erbaş Gürler
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
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
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
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
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			*

		15 min Oral Presentations									
				Session Chair: XIONG LI			Session Chair: ARIYA ARUNINTA			Session Chair: CAREY DUNCAN	
16:00	16:15	Break-out Session 12 (Beylerbeyi 2 Hall)	Projecting the Process: Monitoring, Assessment & Applications	Spatiotemporal monitering of urban hot spots and land change relation - **Burcu Çevik Değerli**	Break-out Session 13 (Yıldız-1 Hall)	Sustaining Life: Protection, Mitigation & Management	Transformative Landscape Design for Carbon-Neutral Camping Experiences - **Bingrui Yang**, Yipeng Zhang	Break-out Session 14 (Hamidiye Hall)	Design Projects	Cruz do Montalvão Park, a lively urban park - **ateliervmdo arquitectura paisagista**	
16:15	16:30			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			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			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		Design Projects	Landscape in the process: Jinjiao Shore Park - **Shixian Shen**		Design Projects	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			*			*			Cerro Calán, Ecological Rehabilitation of an Urban Island Hill - **Paula Livingstone**	

		6 min Short Oral Presentations											
				Session Chair: YIWEN CUI			Session Chair: PIA KUUSINIEMI			Session Chair: ADNAN KAPLAN			Session Chair: PAMELA SARUNYA PAGANA
17:30	17:36	Break-out Session 15 (Üsküdar 2 Hall)	Sustaining Life: Protection, Mitigation & Management	Evaluation of cultural heritage protection benefits based on landscape perception - **Yu Cheng**, Huasong Mao, Changyu Zhang, Lingna Zhu	Break-out Session 16 (Üsküdar 1 Hall)	Engaging with the Digital: Innovation, Technology & Big Data	Revealing Landscape Preferences for Recreation Based on Social Media Data - **Jiaxuan Duan**, Haiyun Xu, Tian Qiu, Qiping Lu	Break-out Session 17 (Üsküdar 3 Hall)	Codifying Code Red: Eco-Emergency, Global Solidarity	A dynamic evaluation framework for ecological networks adapting to urbanization - **Hao Li**, Zhicheng Liu	Break-out Session 18 (Beylerbeyi 1 Hall)	Acting for All: Diversity, Equity & Inclusion	Landscape Progressive-action Design: Exploration based on 2 practices - **Liang Li**, Xiangrong Wang, Qing Lin
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
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
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

		6 min Short Oral Presentations									
				Session Chair:CEMRE KORKMAZ			Session Chair: NORMAN JUNE BRITO			Session Chair: STEFFI SCHUPPEL	
17:30	17:36	Break-out Session 19 (Beylerbeyi 2 Hall	Cultivating Resilience: Sustainable & Resilient Communities	Landscape Architects: Superheroes of the 21st Century - **Alper Çabuk**, Saye Nihan Çabuk	Break-out Session 20 (Yıldız-1 Hall)	Building Bridges, Breaking Barriers: Education & Practice	Exploring the A &T Center through the "Phenomenology of Perception" - **Kuan Chu Liao**, Chuang Hung Lin	Break-out Session 21 (Hamidiye Hall)	Sustaining Life: Protection, Mitigation & Management	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			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			"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			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**

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UCTEA CHAMBER OF LANDSCAPE ARCHITECTS

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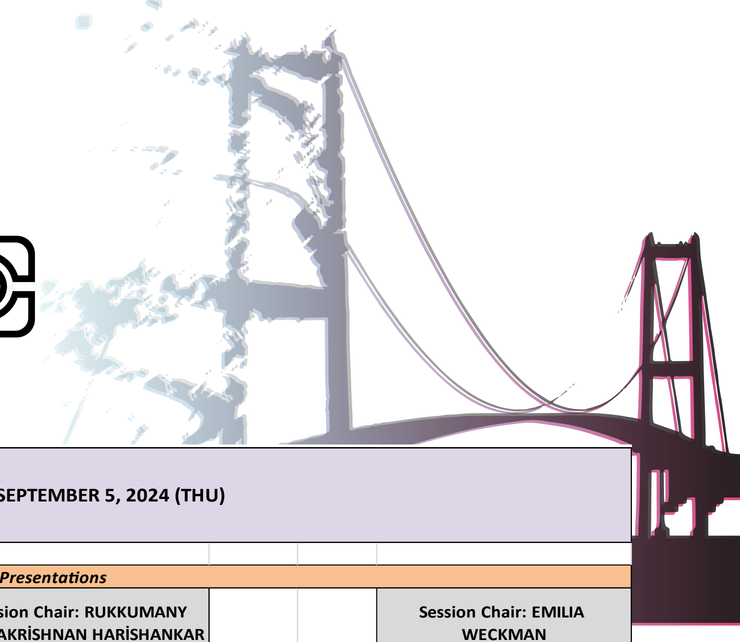


Days / Hours		HALL	THEME	DAY 2 - SEPTEMBER 5, 2024 (THU)						
		6 min Short Oral Presentations								
				Session Chair: BENNI YU-LING PONG			Session Chair: NİKOLA WATTé			Session Chair:BENJAMIN STOCKWIN
08:30	08:36	Break-out Session 22 (Üsküdar 2 Hall)	Projecting the Process: Monitoring, Assessment & Applications	Revealing Relationship between Environmental Features Combinations and Cultural Ecosystem Benefits - **Mengyun Chen**, Guangsi Lin	Break-out Session 23 (Üsküdar 1 Hall)	Codifying Code Red: Eco-Emergency, Global Solidarity	How does blue-green space mitigate water hazards in shallow mountains - **Siyao Liu**, Xuanying Li, Yue Lai, Huiyi Sun, Xiaoyu Ge	Break-out Session 24 (Üsküdar 3 Hall)	Cultivating Resilience: Sustainable & Resilient Communities	The resilient landscape of a community - **Marilena Baggio**
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
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**
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**
09:00	09:30	Main Hall (Üsküdar 2 Hall)	AWARDS	**IFLA Student Competition Awards**						
09:30	10:00		KEYNOTE SPEAKER	**Ceylan Belek Ombregt**						
10:00	10:30		KEYNOTE SPEAKER	**Christophe Girot**						
10:30	**11:00**	*Foyer*		*Break*						

Days / Hours		HALL	THEME	DAY 2 - SEPTEMBER 5, 2024 (THU)						
		6 min Short Oral Presentations								
				Session Chair: REEM ALISSA			Session Chair: RUKKUMANY RAMAKRİSHNAN HARİSHANKAR			Session Chair: EMILIA WECKMAN
08:30	08:36	Break-out Session 25 (Beylerbeyi 1 Hall)	Sustaining Life: Protection, Mitigation & Management	"{" From biodiversity to heterogeneity as landscape development factor "}" - **Carmen Angelillo**	Break-out Session 26 (Beylerbeyi 2 Hall	Acting for All: Diversity, Equity & Inclusion	Assessing recreational-services in Post-COVID Beijing via social media camping data - **Haiyun Xu**, Guohan Zhao, Tianzi Xie, Meng Miao	Break-out Session 27 (Yıldız-1 Hall)	Cultivating Resilience: Sustainable & Resilient Communities	Landscape Approach: Cultivating Landscape Literacy through New Models of Practice - **Sonja Vangjeli**, Maria Catalina Picon, Cristina Contreras Casado
08:37	08:43			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			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			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**

				Moderator: Dr. Jala Makzoumi *IFLA Vice-President and IFLA Middle-East President*			**Moderator:** Marina Cervera Alonso de Medina, *IFLA Special Envoy*
11:00 - 12:30		Special Session 1 (Üsküdar 1 Hall)	BRIDGING THE DIVIDE: COLLABORATIVE DESIGN FOR A PLANET IN CRISIS Interdisciplinary Collaboration	**Pietro Elisei** ISOCARP President (International Society of City and Regional Planners)	Special Session 2 (Üsküdar 3 Hall)	REDEFINING PRACTICE: INNOVATIVE APPROACHES TO LANDSCAPE ARCHITECTURE FOR A CHANGING WORLD Professional Practice and Standards	**Torey Carter-Conneen** ASLA CEO (American Society of Landscape Architects)
				José Luís Cortes UIA Immediate Past President (International Union of Architects)			**Matt Miller** CLARB CEO (Council of Landscape Architectural Registration Boards)
				James Hayter IFLA Immediate Past President (International Federation of Landscape Architects)			**Yuko Nagamura** Director (TabbyCat Japan) and Member (Japan Landscape Architects Union)
				Mona Rady Chairperson (UN-Habitat Professional Forum)			**Indra Purs** IFLA Professional Practice and Policy (PPP) Chair
				Barış Işık CTLA President (Turkish Chamber of Landscape Architects)			**Carey Duncan** Past-President (IFLA Africa)
				Debbie Tikao NZILA President (New Zealand Institute of Landscape Architects)			**Henri Bava** President (French Federation of Landscape Architects)
				Emilia Weckman Head of Programme (Aalto University, Finland)			**Yasin Otuzoğlu** CTLA Past-President (Turkish Chamber of Landscape Architects)
12:30	**13:30**	*Foyer*		***Lunch + Poster Sessions***			
13:30	14:00	Üsküdar 2 Hall	INVITED SPEAKER	**Gareth Doherty**	Üsküdar 1 Hall	INVITED SPEAKER	**Ahmet Oktan Nalbantoğlu**

				Moderator: Katerina Gkoltsiou, *IFLA Europe President*			**Moderator:** Chris Tidswell, *IFLA Asia-Pacific President*
11:00 - 12:30		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	**Giselle Sebag** Executive Director, International Society of Urban Health (ISUH)	Special Session 4 (Beylerbeyi 2 Hall)	INDUSTRY IN TRANSITION: EMBRACING SUSTAINABILITY IN LANDSCAPE ARCHITECTURE Industry and Outreach	**Mike Wood** Director of Landscape Architecture, ARUP
				Elisabeth Belpaire ISOCARP President-Elect (International Society of City and Regional Planners)			**Mikko Partanen** Head of Design, Lappset Group Ltd
				Nathalie Laure Roebbel WHO Urban Health Leader (via Zoom)			**Audrey Timm** AIPH (International Association of Horticultural Producers)
				Jane Welsh IFLA Special Envoy for AIPH			**Selim Bayraktar** WGIN (World Green Infrastructure Network) and Researcher (İstanbul University-Cerrahpaşa)
				Pia Kuusiniemi President of the Finnish Association of Landscape Architects			**Maria Ignatieva** President of URBIO (Urban Biodiversity and Design Network) and Professor of Landscape Architecture (University of Western Australia)
				Helen Andreae Interaction e-Health Designer, Victoria University of Wellington			**Lea Ann Macknally** President (Council of Landscape Architecture Registration Boards)
				Gül Sayan Atanur European Healthy Cities Network Scientific Committee Member			**Peta-Maree Ashford** Immediate Past President (Australian Institute of Landscape Architects) and Director (Emerge Associates)
12:30	**13:30**	*Foyer*		***Lunch + Poster Sessions***			
13:30	14:00	Üsküdar 3 Hall	INVITED SPEAKER	**Alexandra Steed**			

				15 min Oral Presentations						
				Session Chair: MONICA PALLERES			Session Chair: AYŞEGÜL İBİCİ ORUÇKAPTAN			Session Chair: INDRA PURS
14:00	14:15	Break-out Session 28 (Üsküdar 2 Hall)	Projecting the Process: Monitoring, Assessment & Applications	The Effectiveness of Indices in Measuring The Naturalness of Cities - **Nurdan Erdoğan**, Betül Çavdar, Ilgaz Ekşi, Ayşenur Kaylı	Break-out Session 29 (Üsküdar 1 Hall)	Acting for All: Diversity, Equity & Inclusion	Comparing Performances across State-led, Co-managed, and Community-based Conservation in China - **Ying Lou**, Yin Zhang	Break-out Session 30 (Üsküdar 3 Hall)	Codifying Code Red: Eco-Emergency, Global Solidarity	Light Rail Vs. Highway: Influence on land-use & habitat fragmentation - **Behnoud Aghapour**
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
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
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
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
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
15:30	**16:00**	*Foyer*		*Break*						
				15 min Oral Presentations						
				Session Chair: ROBERT DALTON			Session Chair: EMRAH YALÇINALP			Session Chair: EMRAH YALÇINALP
16:00	16:15	Break-out Session 34 (Üsküdar 2 Hall)	Acting for All: Diversity, Equity & Inclusion	The ASLA Legacy Project for career discovery in landscape architecture - **Ebru Ozer**, Emily O'mahoney, Sulin Kotowicz	Break-out Session 35 (Üsküdar 1 Hall)	Codifying Code Red: Eco-Emergency, Global Solidarity	Human impact on ecosystems: Human-based landscape vulnerability codes in Istanbul - **Sevgi Gormus**, Serhat Cengiz	Break-out Session 36 (Üsküdar 3 Hall)	Sustaining Life: Protection, Mitigation & Management	Is urban park a carbon sink or a carbon source? - **Mingzhu Yang**, Shangcen Luo, Yangyang Yuan
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
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
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
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
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**
17:30	18:00	*Extra time, if needed*								
19:30	22:30	KHALKEDON	EVENING EVENT	**GALA DINNER & PARTY**						

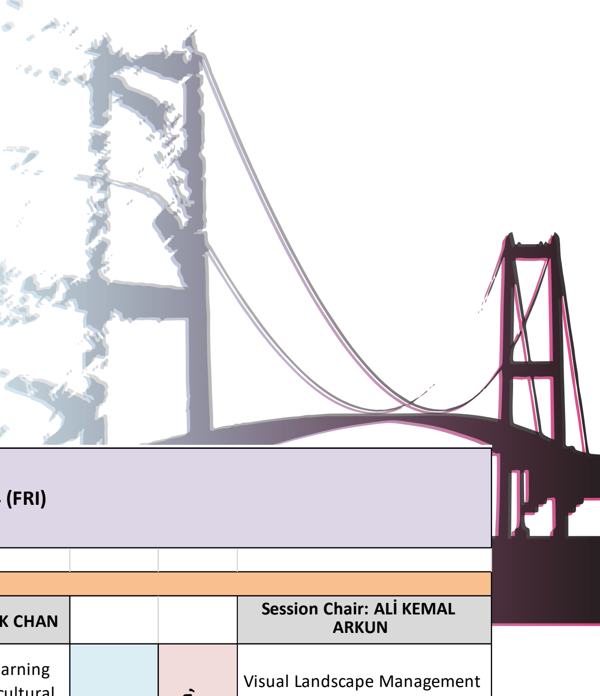
				15 min Oral Presentations						
				Session Chair: LEA ANN MACKNALLY			Session Chair: BAHAR BAŞER KALYONCUOĞLU			Session Chair: STEFFI SCHUPPEL
14:00	14:15	Break-out Session 31 (Beylerbeyi 1 Hall)	Cultivating Resilience: Sustainable & Resilient Communities	Water Consumption for Irrigation in the Case of Adanalıoğlu, Çukurova - **Fırat Fırat,** Beyza Sat	Break-out Session 32 (Beylerbeyi 2 Hall)	Engaging with the Digital: Innovation, Technology & Big Data	Intergrating VGI and SVI data in designing exercise-friendly blue spaces - **Haoxiang Zhang**, Steffen Nijhuis, Caroline Newton	Break-out Session 33 (Yıldız-1 Hall)	Sustaining Life: Protection, Mitigation & Management	Urban afforestation against biodiversity loss: integrating design in science experimentation - **Thomas Cabai**, Chiara Geroldi, Matteo Umberto Poli
14:15	14:30			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			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			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			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			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			*Break*						
				15 min Oral Presentations						
				Session Chair: CATHE DESIREE NADAL			Session Chair: NESRİN KARAOĞLU OTUZOĞLU			Session Chair: ALPER CABUK
16:00	16:15	Break-out Session 37 (Beylerbeyi 1 Hall)	Cultivating Resilience: Sustainable & Resilient Communities	Code Red for Disaster Risk Reduction and Resilience - **Syed Nil Ainuddin**, Chamawong Suriyachan, Ariya Aruninta	Break-out Session 38 (Beylerbeyi 2 Hall)	Sustaining Life: Protection, Mitigation & Management	'Suitable Mechanization Transformantion' Effects on Farmland Ecosystems in China's Hills - **Jie Ren**, Xiaohui Xu	Break-out Session 39 (Yıldız-1 Hall)	Engaging with the Digital: Innovation, Technology & Big Data	LA-GPT: Supermodel Forged by Training on Billion-Scale Landscape Architects Corpus - **Xueqi Yao**, Ran Chen, Xiaomin Luo, Jing Zhao
16:15	16:30			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			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			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 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			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*						
19:30	22:30			**GALA DINNER & PARTY**						

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	SEPTEMBER 6, 2024 (FRI)
				6 min Short Oral Presentations
				Session Chair: RUTH WANJIKU MWAI
08:30	08:36	**Break-out Session 40 (Üsküdar 2 Hall)**	**Sustaining Life: Protection, Mitigation & Management**	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			*
				Session Chair: SAYE NİHAN ÇABUK
08:30	08:36	**Break-out Session 41 (Üsküdar 1 Hall)**	**Acting for All: Diversity, Equity & Inclusion**	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
				Session Chair: VARPU MIKOLA
08:30	08:36	**Break-out Session 42 (Üsküdar 3 Hall)**	**Cultivating Resilience: Sustainable & Resilient Communities**	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
				Session Chair: CHINGWEN CHENG
08:30	08:36	**Break-out Session 43 (Beylerbeyi 1 Hall)**	**Codifying Code Red: Eco-Emergency, Global Solidarity**	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
				Session Chair: PAUL Y K CHAN
08:30	08:36	**Break-out Session 44 (Beylerbeyi 2 Hall)**	**Building Bridges, Breaking Barriers: Education & Practice**	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**
				Session Chair: ALİ KEMAL ARKUN
08:30	08:36	**Break-out Session 45 (Yıldız-1 Hall)**	**Engaging with the Digital: Innovation, Technology & Big Data**	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**

09:00	09:30	**Main Hall (Üsküdar 2 Hall)**	**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***

				Moderator: Ahmet Cemil Tepe, *İstanbul Büyükşehir Belediyesi Park ve Bahçeler Dairesi Müdür Yardımcısı*
11:00 - 12:30		**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)	**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
				*
				*
				Moderator: Graham Young, *IFLA Africa President*
11:00 - 12:30		**Special Session 6 (Üsküdar 1 Hall)**	**SPCLIMATE ACTION NOW: LANDSCAPE ARCHITECTS DESIGNING FOR A RESILIENT TOMORROW** Climate, Environment, Sustainability	**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
				*
				Moderator: Alessandro Martinelli, *IFLA Education and Academic Affairs (EAA)*
11:00 - 12:30		**Special Session 7 (Üsküdar 3 Hall)**	**FROM CRISIS TO CURRICULUM: REIMAGINING EDUCATION FOR THE ANTHROPOCENE** *Education*	**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)
				Moderator: Maria Gabriella Trovato, *IFLA Landscape Architects Without Borders (LAWB) and Norwegian Life Sciences University (NMBU)*
11:00 - 12:30		**Special Session 8 (Beylerbeyi 1 Hall)**	**LANDSCAPES OF HOPE: DESIGNING FOR RESILIENCE IN THE FACE OF CRISIS AND CONFLICT** Crisis and Conflict	**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
				*
				Moderator: Hermann Georg Gunnlauggson, *IFLA Thresurer*
11:00 - 12:30		**Special Session 9 (Beylerbeyi 2 Hall)**	**WEAVING CULTURAL THREADS INTO A SUSTAINABLE TAPESTRY: CULTURAL LANDSCAPES, NATURAL HERITAGE AND PLANETARY RIGHTS** Culture and Cultural Landscapes	**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)
				*
				*
12:30	**13:30**	**Foyer**		***Lunch + Poster Sessions***
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
				Session Chair: EBRU OZER
14:00	14:15	**Break-out Session 46 (Üsküdar 2 Hall)**	**Sustaining Life: Protection, Mitigation & Management**	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**
				Session Chair: MONICA KUO
14:00	14:15	**Break-out Session 47 (Üsküdar 1 Hall)**	**Projecting the Process: Monitoring, Assessment & Applications**	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
				Session Chair: HERMANN GEORG GUNNLAUGGSON
14:00	14:15	**Break-out Session 48 (Üsküdar 3 Hall)**	**Acting for All: Diversity, Equity & Inclusion**	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
				Session Chair: ANA INES BAJCURA
14:00	14:15	**Break-out Session 49 (Beylerbeyi 1 Hall)**	**Sustaining Life: Protection, Mitigation & Management**	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
				Session Chair: NAPPY NAVARRA
14:00	14:15	**Break-out Session 50 (Beylerbeyi 2 Hall)**	**Cultivating Resilience: Sustainable & Resilient Communities**	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**
				Session Chair: SAYE NİHAN ÇABUK
14:00	14:15	**Break-out Session 51 (Yıldız-1 Hall)**	**Engaging with the Digital: Innovation, Technology & Big Data**	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			*
15:30	**16:00**	***Foyer***		***Break***

https://ifla2024.com/theme/upload/IFLA-2024-Program.pdf

				15 min Oral Presentations
				Session Chair: AYŞEGÜL İBİCİ ORUÇKAPTAN
16:00	16:15	**Break-out Session 52 (Üsküdar 2 Hall)**	**Codifying Code Red: Eco-Emergency, Global Solidarity**	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
				Session Chair: ALİ KEMAL ARKUN
16:00	16:15	**Break-out Session 53 (Üsküdar 1 Hall)**	**Sustaining Life: Protection, Mitigation & Management**	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
				Session Chair: JAMES HAYTER
16:00	16:15	**Break-out Session 54 (Üsküdar 3 Hall)**	**Cultivating Resilience: Sustainable & Resilient Communities**	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			*
				Session Chair:NİLÜFER KART
16:00	16:15	**Break-out Session 55 (Beylerbeyi 1 Hall)**	**Acting for All: Diversity, Equity & Inclusion**	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**
				Session Chair: XIAODI ZHENG
16:00	16:15	**Break-out Session 56 (Beylerbeyi-2 Hall)**	**Sustaining Life: Protection, Mitigation & Management**	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			*
				Session Chair: ALPER ÇABUK
16:00	16:15	**Break-out Session 57 (Yıldız-1 Hall)**	**Projecting the Process: Monitoring, Assessment & Applications**	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
17:30	17:45	**Main Hall (Üsküdar 2 Hall)**	**CLOSING**	**Closing Ceremony & Flag Hand-Over**
17:45	18:00			