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For Climate Action, Urban Finance

Climate-responsive Planning for Equitable Places & Communities

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59th ISOCARP World Planning Congress

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Julio Carrillo Madina Junussova

Climate Action, Urban Finance

Climate-responsive Planning for Equitable Places & Communities

Acknowledge, Decide, Invest and Interact

Cities are homes for over 50% of the world's population, consuming two-thirds of global energy and accounting for 70% of global emissions. Cities serve as financial centres and contribute up to 80% of the global GDP, but cities continue to face social, economic, and environmental development challenges. Many countries are urbanising rapidly without adequate urban governance, fiscal resources, urban policies, and integrated planning, preventing effective and efficient use of resources for sustainable development. There are also shrinking cities, mining and post-mining regions and towns where urban sustainability should be reinvented, considering just transitioning to the green economy and adapting innovative, nature-based solutions and adequate fiscal responses. Climate crises and financial constraints have become additional challenges for sustainable development in cities worldwide, requiring the rethink of policymaking, planning, investment, and development of integrated climate-responsive urban strategies. Therefore, there is a need for better policies, sustainable planning solutions and investments to facilitate the long-term prosperity of cities and support high-quality living conditions of people and stop financial flows historically supporting non-sustainable outcomes such as urban sprawl and real-estate development transactions leading to increased social and economic inequality.

The 27th session of the Conference of the Parties (COP 27) to the United Nations Framework Convention on Climate Change (UNFCCC) emphasised the critical role of cities in global climate change and called for finding enabling innovative solutions to merge policy making, planning and finance efforts for achieving urban sustainability and resilience. The UN-Habitat's Cities and Climate Change Initiative (CCCI) calls for supporting cities in low- and middle-income countries lacking policymaking, planning capacities and financial resources to respond to the negative impact of climate change. To create the foundations for a collaborative and participatory response to the climate crisis in cities and regions, the Urban Economy Forum (UEF) and the International Society of City and Regional Planners (ISOCARP) jointly organised the 5th Urban Economy Forum (UEF5) and 59th ISOCARP World Planning Congress (WPC59) as the integrated conference **"For Climate Action, Urban Finance, Climate Responsive Planning for Equitable Places & Communities".**

The joint UEF5+WPC59 event aimed to bring multiple stakeholders together, particularly professional planners, policymakers, city leaders, government, academia, financial institutions, entrepreneurs, and civil societies, to elaborate on the following four thematic areas and respective track of focus:

- Finding synergies and relevant solutions for attracting climate finance and transforming it into locally demanded social, economic, and environmental values for city residents not leaving anyone behind.
- Leveraging multi-disciplinary, multi-sector, and multi-level collaboration for better urban governance, balancing public and private, global, and local urban development needs.
- Investigating new ways of proactive planning and effective investment by combining the use of evidence with the foresight and visioning for transforming cities and communities into economically prosperous, healthy, environmentally friendly, socially just, inclusive, and resilient places.
- Exploring technologies, not historically linked to planning practice and urban finance, by exposing innovative linkages and synergistic opportunities of using big data, algorithms, and artificial in elligence.

Congress finding

The congress brought together more than 400 delegates from 100 countries, working in local and national governments, urban planning, and policy analysis. The congress comprised 70 thematic and special sessions, workshops, roundtables, debates, and networking events. The high-level and keynote sessions of the congress featured speakers from a diverse array of stakeholders, including global planners, policy makers, city leaders, academia, and community leaders. The congress assembly was essential in addressing crucial urban challenges and fostering productive discussions, creating the spirit of collaboration and discussion. Special Sessions at the congress were a dynamic and comprehensive platform for in-depth exploration of critical topics in the field of urban planning and sustainable development. These sessions delved into various themes, reflecting the diverse challenges and opportunities we face nowadays. Special sessions brought up the importance of decarbonization of multiple industries. Those perspectives provided valuable insights into how urban planning can drive the transition to a more sustainable and environmentally responsible future. Experts shared strategies and case studies, emphasizing the importance of reducing carbon emissions in our cities. UN SDG alignment and its practical support was another pivotal subject of the discussions, with participants examining how planning can play a vital role in advancing the United Nations Sustainable Development Goals. These sessions illuminated the significance of integrating SDGs into urban planning processes and leveraging them as a guiding framework for creating more equitable, prosperous, and environmentally friendly communities.

Congress Reflection

There are highlights from special sessions:

- Participants explored the Future of Planning and proposed practice of foresight that highlighted the importance of planning practice to anticipate future trends.
- The role of youth in shaping the future through technology, culture, and arts was also discussed, highlighting the innovative ideas and solutions that younger generations can contribute to the planning landscape.
- The Planning2050 initiative was an innovative topic, exploring its implications for the future of planning, particularly its integration with artificial intelligence to create more efficient and responsive planning systems.
- Discussions on the roles of private and public sector organizations in mitigating climate change by implementing green buildings, green infrastructure, and nature-based solutions showcased practical strategies for fostering a sustainable and resilient urban environment.
- Political roundtables aimed to inspire active citizen participation in all planning processes, particularly emphasizing historically underserved or underrepresented communities like indigenous groups, ensuring that everyone's voice is heard and accounted for in urban planning.

The special sessions served as a rich source of knowledge and inspiration for attendees, offering valuable insights into the complexities and possibilities of modern urban planning.

Indigenous values, knowledge and voices are critical to sustainable development.

Climate actions and urban planning could benefit from integrating indigenous knowledge like respecting land ownership, considering seven generations, and caring for personal and communal well-being. Unfortunately, current climate actions, planning and financing of urban development often ignore indigenous perspectives and cultural living values. However, achieving urban sustainability is only possible by embedding planning in local matters, understanding the past, and learning from indigenous people how to live harmoniously with the surrounding environment.

Cities need to be better prepared for financing strategic climate actions.

The national-level climate actions are not always adequately projected on the city level. There needs to be more knowledge and understanding of accumulating revenue for investing in climate actions. Climate finance is not yet an integral part of the public administration system or municipal finance. It is unclear how new policy approaches like land value capture or carbo pricing may help to enhance capital investment in urban infrastructure and bring cities long-term social, environmental, economic, and financial sustainability.

There is an urgent need to adapt and leverage intergovernmental and fiscal transfer systems to support and incentivize city-level climate action. National governments could better support low-carbon and climate-resilient urban planning at the municipal level.

City governments should play a key role in building urban resilience.

There was a clear message on paying attention to linking climate urban development projects with their potential for revenue generation. The congress participants agreed on the need to strengthen the role of local governments in leading climate actions. The financial sustainability of cities requires empowering city governments with better fiscal and political decision-making capacities for innovating and applying new planning and taxation approaches, exploring better policies for building urban resilience, attracting climate finance, and changing the behaviour of residents.

Investing in urban climate actions should start from the dialogue and adaptive capacities.

The city governments should invite private sector actors to dialogue and brainstorm together on how they can help the city address climate change-related challenges. It is crucial to develop innovative tools and instruments to incentivize businesses and other stakeholders to invest in more resilient and resource-efficient urban development. However, proactive, and engaging planning should include not only traditional stakeholders like businesses or adult residents but also youth. Building leadership capacities of children is a vital investment in the long-term sustainability of climate actions.

Underinvestment in technologies does not allow cities to benefit from their use.

Incorporating information technologies and artificial intelligence (AI) into the public sector is a crucial component of addressing climate challenges. These innovations enable data-driven decision-making, enhancing the efficiency and effectiveness of climate actions. Attracting funding for such initiatives can be challenging, especially in smaller communities with limited resources and expertise. It is imperative to highlight the immediate and long-term benefits of technology-driven climate solutions to cover the current gap. Investment in AI and other innovative technologies cannot only drive environmental sustainability but also boost economic development and resilience, ultimately making the case for securing funding in support of these vital initiatives.

Congress Reflection

TRACK 1: DECIDE jointly


Olusola Olufemi
Canada


Opeyemi Comfort Akintola
Nigeria


Rajendra Kumar
India


Sebnem Hoskara
Cyprus

The first track aimed to find synergies and relevant solutions for attracting climate finance and transforming it into locally demanded social, economic, and environmental values for city residents, not leaving anyone behind.

Finding synergies between climate-responsive planning, investment, and local needs, values, and aspirations on both city-regional (including metropolitan) and neighbourhood scales is critical for building sustainable, resilient, and inclusive cities that provide all residents with social, cultural, economic, and environmental values. The track sessions focused on acknowledging community and ecosystem values, strengthening recreational, cultural, and historical community values, including, and engaging urban planning, just transition and building resilient cities and communities.

The Virtual and Toronto Congress's track findings could be summarised as follows:

- Urban resilience requires practising a proactive and engaging approach to planning and comprehensive capacity building of local decision-makers and the community.
- The cultural heritage of tangible and intangible values is essential. Therefore, planners and policy decision-makers should respect local history and living customs.
- Urban transformation and transition through culture mapping and peer-to-peer mentoring is inclusive and promotes a strong connection with the community.
- Urban management at the micro level is crucial to alleviate the defects in regulatory planning controlling the urban landscape.
- Child-friendly neighbourhoods can help reduce greenhouse gas emissions, increase community resilience, and improve the health and well-being of children.
- Reuse organizations can facilitate employment opportunities for disadvantaged job seekers within and beyond circular work.
- Waste-to-wage enterprises contribute knowledge towards operationalizing institutional density concepts in circular city contexts.
- Smart cities and inclusive climate action in cities and building spaces are the most direct ways to regulate the climate.
- Spatial policies for carbon and urban heat reduction to realize carbon neutrality should focus on the development of green spaces and planting suitable trees species.
- In closing the financial gap for climate action for cities, securing funds within the city is achievable.

TRACK 2: DECIDE jointly


Gary Davidson
Canada


Hope Magidimishah-Chipungu
South-Africa


Jacob Adejare Babarinde
Canada


Renelle Sarjeant
Trinidad Tobago

The second track aimed to leverage multidisciplinary, multi-sector, multi-level collaboration, and cross-border planning for better urban governance, balancing public, private, global, and local urban development needs.

Collaboration between multiple disciplines, sectors, and levels is crucial for effective urban governance that balances public and private interests and global and local urban development needs. Recognising the importance of multidisciplinary, multi-sector, multi-level, and multi-scale approaches to urban governance is crucial for the proper planning and management of the city and the development of workable Climate Action Plans. It means breaking down traditional silos and bringing together actors from different sectors, levels of government, areas of expertise, and scales of planning. Moving beyond sectoral thinking and finding ways to merge economic development with land use, housing, transport, and infrastructure development in a climate-responsive and integrated manner is essential. The track sessions evaluated governance models, examined decarbonisation strategies, and explored ways to engage residents in climate actions and moving across disciplines, borders, and multi-modality.

The virtual track session findings allow to conclude that:

- National governments should not solve problems with new developments only, ignoring climate change realities, but run re-development by acting with local governments, communities, public and private sector representatives, and environmental and financial organisations.
- Planners can assist local communities and governments reach joint decision-making by studying people's needs and transforming collected information into reliable evidence for decision-making on development.
- Empowering young people could be a key to long-term sustainability. Therefore, it is vital to use new channels for dialogue, joint planning, and decision-making, such as social media and gamification.

The Toronto Congress second track sessions highlighted the role of education and knowledge, models of action, tools and technology, data and management that could be concluded as the following policy advice:

- Tailor planning programmes to regionally relevant climate change issues and communicate via multiple mediums.
- Move beyond traditional zoning and expert-led processes to co-evolutionary planning.
- Utilise mapping, technology, participatory budgeting, and nature-based solutions but with true collaboration and inclusion.
- Measure resilience and impact with technology and develop useable and relevant indicators.

Congress Reflection

TRACK 3: INVEST wisely


Adriano Bisello
Italy


Hadeel Abuzaid
Jordan


Nadine Bitar
UAE


Sabelo Goniwe-Mahlangu
South-Africa

The third track's main theme aims to investigate new ways of proactive planning and effective investment by combining evidence with the foresight and visioning for transforming cities and communities into economically prosperous, healthy, environmentally friendly, socially just, inclusive, and resilient places.

Transforming cities and communities into sustainable, healthy, and prosperous places requires proactive planning, practical investment, and particular effort to study and change people's behaviour and mindsets. Citizen-generated data can play a significant role in this process by providing insights into the needs and priorities of communities. Using this data can ensure that no one is left behind in transforming cities and communities. Combining evidence with foresight visioning is vital to transform cities and communities into economically prosperous, healthy, environmentally friendly, socially just, inclusive, and resilient places.

The virtual track sessions and Toronto sessions' findings highlight the following conclusions:

- Local and global challenges are different at scale, and the gap for investment is more prevalent when there is lack of leadership to connect opportunities for sustainable development at small scale.
- There is underinvestment in innovative solutions that are brought up by underrepresented communities, or demographic groups. Empowerment of the youth to support these initiatives and relevant solutions is important to highlight and amplify.
- Supporting links for investment in culture, technology, and arts must become a planning best-practice, so that solutions that bring up adequate rewards may be achieved.
- Climate action at root level, with participation from local citizens is an imperative practice of planning, which highlights the importance of planers as “activators” rather than “directors.” This type of participatory planning has been proven effective, but it is challenging to replicate due to lack of investment.

TRACK 4: INTERACT with tech


Hanna Obracht-Prondzyńska
Poland


Mohammed Ouerghi
Tunisia


Tijana Tufek-Memišević
US-BiH


Zhiyun Ling
China

The fourth track's main theme aims to explore technologies not historically linked to planning practice and urban finance by exposing innovative linkages and synergistic opportunities of using big data, algorithms, and artificial intelligence.

The digitalization of society has brought about a wealth of opportunities to improve planning practices and urban finance. With the rise of big data, algorithms, and artificial intelligence, planners can now access vast information to inform their decision-making processes. These technologies not historically linked to planning practice and urban finance have the potential to be applied by policymakers and planners to improve outcomes for cities are significant. Data is essential to reaffirm an approach to the circularity of economic practices. By using specific algorithms to analyse large amounts of data, policy makers, and planners can identify patterns and trends that may not be immediately apparent, better identify areas that require investment or intervention and predict future trends that may impact urban planning and finance.

Virtual sessions and in-person sessions findings allow to conclude the following:

- Planning today is at a paradigm shift: Urban planning is undergoing a transformative phase - a shift from traditional planning methods.
- AI can be a catalyst for understanding urban dynamics and interconnectedness of systems: Capturing complexities of urban processes, accommodating changing lifestyles, addressing climate change, and preparing for dynamic urban futures.
- Concerns about ethics, bias, and truthfulness: Ethical considerations and guidelines should be established to ensure the responsible use of AI in planning, addressing concerns related to disinformation and biases.
- Highlighting the role of technology incubators and investors: It is important to provide the links between financing mechanisms and entrepreneurs, supporting the need to scale and replicate relevant solutions in urban planning for meaningful and impactful outcomes.
- Generating databases through innovative platforms and technologies (i.e., Planning2050 initiative): Cities and Communities to track and report their progress towards advancement of UN SDGs (and beyond) to create healthy competition, connecting urban planning world with historically not linked industries.

Paper Index

TRACK 1:
ACKNOWLEDGE community values

Case Study Report

Pathways for a Just Transition in Prague's Built Environment

A Call for Vision and Leadership

Michaela PIXOVÁ, Charles University & UNYP, Czech Republic; BOKU, Austria

Abstract

Based on 21 interviews with built environment stakeholders, this research study sheds light on opportunities to strengthen the social dimension of built environment decarbonisation and resilience processes (BEDRPs) in Prague. The study focuses on social justice and inclusion in relation to housing and workers' rights, and on the role of governments, businesses and financiers in accomplishing these outcomes. Lack of climate leadership and vision, and of a national strategy with clearly defined milestones, hinders the scaling of BEDRPs by the Prague Climate Plan 2030. The risks and opportunities for construction workers and the right to housing are insufficiently addressed. Existing inequalities are deepening, especially housing and energy unaffordability. Policy-making in BEDRPs currently lacks transparency and clear communication, leading to residents' distrust in institutions and fear of the green transformation. BEDRPs are mainly driven by marketing, economic incentives, the availability of EU funds and rising energy costs due to Russia's war against Ukraine. The report makes a call for greater public sector leadership and private sector responsibility in addressing limited access to retrofitting and resilience funds for vulnerable residents, continued exploitation of migrant construction workers, and housing unaffordability.

Keywords

Built Environmentd, Decarbonisation, Resilience, Just Transition, Housing, Climate Leadership

1. Research process in Prague

Primary and secondary research was conducted in Prague between September and December 2022. The literature review included national decarbonisation plans and policies, the post-COVID-19 recovery and resilience plan, Prague's Metropolitan Plan, energy policies, housing and development reports, press releases, media articles and commentaries. Also, 21 semi-structured interviews were conducted with representatives of academia (3), business (4), government (6), NGOs (6), civil society organizations (1) and unions (1) (See appendix for interview list). The data were analysed using a framework of three contextual levels: (a) the decision-making dynamics, governance structure and policies at the national level; (b) risks and opportunities in the current city-level strategies for decarbonisation; and (c) specific observable initiatives at the neighbourhood level1. Furthermore, a visioning session was held on 19 January, 2023 with the Prague Innovation Institute to present the initial research findings and co-create a vision and pathways for a just transition of Prague's built environment.

1.1. Context: Building Decarbonisation and Resilience Processes in Prague

The main policy drivers for BEDRPs are the European Union's climate targets, the European Green Deal, Next Generation EU — the post-COVID-19 recovery package, and the REPowerEU Plan. Czechia has relatively low climate ambitions, an insufficient and poorly implemented climate policy (see Jungwirth 2020; Pixová 2020; Šipka 2020) and ministries that fail to comply with the Paris Agreement. BEDRPs

governance is fragmented, chronically understaffed and uncoordinated via four ministries: Industry and Trade (energy, construction, building materials), Environment (climate adaptation, just transition, energy modernisation, emission trading), Regional Development (building regulations, land-use planning, housing and social inclusion) and Labour and Social Affairs (housing allowances and employment). Social policies and BEDRPs are insufficiently connected, and awareness about measures envisioned by the EU Green Deal, such as the New European Bauhaus Initiative, is very low.

Prague, however, has tried to fill in for the lack of national climate leadership. In 2018, Prague joined the Covenant of Mayors. In 2019, pressured by climate activists, Prague adopted a "Climate Commitment", while two districts declared a "climate emergency". In 2020, Prague's Climate Plan was adopted, including the ambitious, but largely technocratic Sustainable Energy and Climate Action Plan, and Prague's Strategy for the Transition to a Circular Economy. However, these climate commitments have to date been hindered by existing regulations limiting energy communities, greening, retrofitting and building approval processes.

New built environment projects are required to meet high energy-efficiency standards; however, these new developments are often unaffordable for average residents. The decarbonisation of existing housing stock is voluntary. EU retrofitting and resilience funds are inaccessible to low-income disadvantaged residents due to financial and non-financial barriers—how to address these obstacles is currently under debate at the national level. Without timely and adequate measures, unequal access to BEDRPs will deepen tenure unaffordability and insecurity, as well as social inequalities.

2. Human Rights Risks and Opportunities

The primary social risk from Prague's BEDRPs is that they are not taking place at scale. Uncoordinated implementation risks being combined with other social problems, such as the deepening housing crisis, low wages, high numbers of people facing distressing proceedings, etc. If these issues are not tackled, BEDRPs may exacerbate existing inequalities, with only privileged social groups receiving benefits (García-Lamarca, Anguelovski and Venner 2022).

2.1. Participation and Decision-Making Processes

Societal awareness regarding BEDRPs policy-making and decision-making is generally low or superficial, as well as awareness of available measures and funding. These issues are poorly communicated, and relevant governance processes, especially EU funds allocation, are non-inclusive and non-transparent, leading to citizen distrust in decarbonisation:

"Large funds are spent without the participation of the public, which deepens the public's distrust in the state and institutions, which do not communicate with the people." (interview 19)

Currently, the Czech Building Act is being reformed to speed up currently long building approval processes. However, this means cutting corners in citizen participation in the process and giving less consideration for environmental impacts. Regarding policies, Czechia regularly updates its National Energy and Climate Plan and National Energy Efficiency Action Plan but does not have a clear, legislatively-supported roadmap to BEDRP. Associated political agendas at the national and city levels also lack interdepartmental bodies, and relevant ministries lack the professional and personal capacity to work on long-term strategies, visions, conceptions, and implementation.

The government's performance is monitored by NGOs (e.g. Zelený kruh, Hnutí DUHA, Centrum pro dopravu a energetiku), industry associations (e.g. the Czech Green Building Council), universities (e.g. ČVUT's University Centre for Energy Efficient Buildings) and other nongovernmental stakeholders, which lobby for improvements and/or assist the state in establishing BEDRPs and associated agendas, such as land-use

planning and building regulations. Stakeholders with relevant expertise frequently have access to policymaking and decision-making processes, but power relations often determine the strength of these voices.

Surpassing the national government's low climate ambitions, in 2020, Prague joined other V4 capitals (Warsaw, Budapest, Bratislava) in calling for the EU to financially support their commitment to a green post-COVID-19 recovery. When the Prague Renewable Energy Community was established with the goal to install photovoltaic systems on 23,000 roofs, public interest was so strong that it overwhelmed the organizations' limited personal and technical capacities. Other proposed projects include a new biofuel station, and Energocentrum generating heat from Prague's central wastewater treatment plant. The Energocentrum would potentially heat the future Bubny-Zátory neighbourhood – one of several large built environment projects being developed on Prague's brownfield areas, and the first in Prague that aspires to be climate neutral.

Until June 2022, the climate plan's main promoter was the vice-mayor Petr Hlubuček, who was at that time accused of corruption and removed from office, negatively affecting the implementation of BEDRPs in Prague. Further uncertainty regarding the climate plan have arisen with Prague's current governance by SPOLU, led by the Civic Democratic Party (Občanská Demokratická Strana, ODS), which described the plan as "activist", "unrealistic" and "gambling with public money" (ODS 2021 May 10).

2.2. Socio-Spatial Inequality

Inequalities in accessing BEDRPs can also be perceived spatially by the concentration of certified green buildings in Prague's city centre (Figure 1). Energy efficiency certificates, such as BREEAM and LEED, are issued mainly to large developments in prime areas to ease project financing and to meet client requirements. This highlights the lack of energy-efficiency investments in peripheral areas.

Building in accordance with the highest environmental standards is seen as a default practice by the Prague Development Company, a municipality-funded organisation of the City of Prague established in 2020 to develop 6,000–8,000 public apartments on 400,000 m2 of municipal land by 2030:

"The highest standards have been in place for a long time. It is required by the market. Users want the most efficient buildings with certificates… We want the buildings to meet the standards also because they will be owned by the city of Prague, and we want to bring maximum efficiency to the owner and the users. We would be doing this even without the Climate Plan." (interview 5)

Carbon is complex to measure and, therefore, to reduce. Sustainable building certifications vary greatly in standards, partly due to the levels of complexity of carbon measurement and reduction. Certificates are in constant evolution and improvement e.g. moving from originally assessing only operational carbon (CO2 emissions by the use of buildings), to increasingly including embodied carbon (which considers all the environmental impacts of a building's lifecycle: emissions by construction, materials processing, and transportation).

Most interviewed stakeholders engaged in business perceive green building certificates as a sufficient solution to the decarbonisation of the built environment. Certificates are an important but only an initial step in the long journey to full lifecycle decarbonisation. One step further, is the recognition that these certificates and their benefits (to various degrees), currently have a very marked concentration in the centre of Prague. Unequal spatial distribution of green is evident in terms of investment flows, certifications, and other benefits across the city's neighbourhoods.

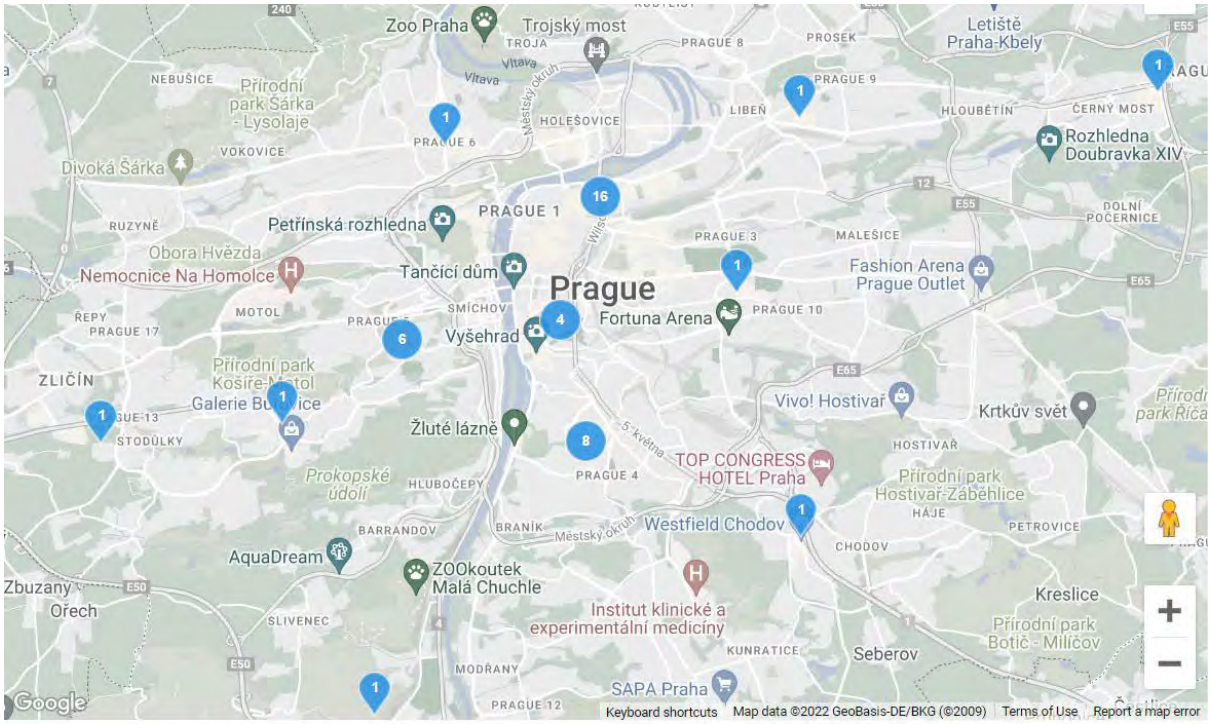

Figure 1. Certified green building concentration in central Prague. Source: http://www.gbig.org/places/26463

2.3. The Right to Housing

In Czechia, the privatisation of socialist housing stock resulted in 80% private homeownership, and the current lack of public housing and affordable housing policies. Only households which spend more than 30% (35% in Prague) of their monthly income on housing qualify for housing allowances.[1]

Business and government tend to believe that housing unaffordability will be alleviated through simplified building approval processes, to increase and accelerate housing supply. New housing, however, is increasingly sold to foreign real-estate companies and investors, who skyrocket prices interested in extracting high-rents, hence remaining unaffordable. According to interview 15, real-estate companies themselves provide tenants in new tenement projects with guidance in applying for the publicly-subsidised housing allowance to cover these high rents, which in turn feeds foreign private profit. This is a direct transfer of public funds to private hands, gambling with the citizens' right to housing.

Family houses and residential buildings can increase their energy efficiency using the New Green Savings programme, which also supports the integration of renewable energy resources, rainwater management technologies, ecological heating, ecological retrofitting, tree planting, etc. New Green Savings Light is aimed at households with financial barriers but is limited to a narrow group of recipients and offers only basic retrofitting. There are ongoing debates about adjusting subsidy programmes and accompanying assistance to a wider range of recipients to overcome these existing barriers.

Only 30% of Prague households live in tenement housing, which is inadequately regulated, insecure and tends to be seen as "emergency housing". Conflicts regarding rent are resolved by courts. Instead of decreasing tenants' energy costs, retrofitting may lead to rent increases and potential renovictions:

[1] Act no. 117/1995 Coll. on State Social Support. https://www.mpsv.cz/web/en/state-social-support

"There are tendencies to save costs, but people complain that landlords try to transfer the costs [of retrofitting] onto occupants. In Czechia, it is possible to chain contracts of one year. So, the tenant is protected only for a year. Then the landlord says, "I've done the insulation, I want more. Take it or leave it." The demand is higher than the offer." (interview 15)

Out of Prague's 1.3 million inhabitants, about 8,000– 12,000 are homeless, 10,500 live in substandard housing and about 160,000 are threatened by the loss of housing (Magistrát hl. m. Prahy 2022). In addition, extremely high energy bills and energy insecurity are some of the many challenges they face.

2.4. Construction workers

Representatives of the Czech Building and Construction Trade Union acknowledge the benefits of BEDRPs, but point to the gap in calculating and addressing the negative effects of the transition on workers:

"We are concerned about the impacts on the economy and people. If these [impacts] were more understandable and calculated, people would have a better attitude. Personally, I think that decarbonisation is a huge benefit; but it is hard to explain to people without more concrete information. Unions have been asking for impact assessments since 2020, and we still have nothing." (interview 21)

There are many opportunities that BEDRPs present for job creation in construction. However, the national government's poor communication, lack of vision and lack of transparency are keeping workers insecure regarding the future of their jobs. Furthermore, the Czech building and construction industry is kept afloat by foreign workers, primarily from Ukraine, Moldova and Bulgaria. Workers are hired through one of approximately 1,500 staffing agencies in Czechia. It is not uncommon for intermediaries to engage in clientelism, unfair commercial practices and unreported economic activity. Construction workers often work semi-legally in precarious, insecure, dangerous and exploitative conditions; live in substandard housing arrangements to save costs; and are unaware of their rights and employers' obligations. Uneducated and illiterate workers are particularly vulnerable.

The issue is also lack of accountability down the supply chain: from large development companies such as Metrostav and Skanska, to their sub-contracted construction companies, to the staffing agencies those companies use to supply workers.

"Employers [developers and construction companies] find the flexibility advantageous but they should be at least partially responsible for workers at their construction site and make sure that [staffing] agencies fulfil their legal obligations. Sometimes these agencies pay the workers only 50% of what they get from the company, or pay their health and social insurance only partially, or not at all. There have been several loopholes in the system over the long term, and there is no political will to change it." (interview 18)

3. Conclusions

BEDRPs in Prague are insufficient, uncoordinated and have superficial implementation due to weak climate leadership, at both national and municipal levels, and to a lack of vision and roadmap. There is also insufficient consideration of the social dimension and human rights in BEDRPs. So far, there are no adequate measures to prevent low-income residents from losing out, especially in housing, thus exacerbating existing urban inequalities. Only some partial measures have been introduced to improve access among all social groups to retrofitting and resilience funds. BEDRPs decision-making is non-transparent and non-inclusive, leading to citizen distrust in institutions and in the green transformation.

In Prague, BEDRPs are primarily pushed through strongly motivated individuals, at governments and companies. There is a huge opportunity for both sectors to harness these pockets of innovation to improve

BEDRPs. Building strong leadership is key to implement measures that ameliorate socio-economic issues and the human rights principles they enable: especially the right to housing, right to a clean and healthy environment, and workers' rights, among others.

New housing developments need to be examined with critical lens. Their core purpose, decision-making processes, and planned strategies should be based on evidence and aim to serve the needs of residents. This exercise can help prevent greenwashing and ensure that projects do in fact provide housing prices/rents aligned with average income, and follow the principles of transparency, accountability, non-discrimination, and participation, throughout the building's lifecycle (IHRB 2019).

For concrete recommendations see the full report (IHRB 2023).

4. References

García-Lamarca, M., Anguelovski, I., Venner, K. (2022) Challenging the financial capture of urban greening. *Nature Communications* 13, 7132. Available at: https://www.nature.com/articles/s41467-022-34942-x (Accessed: 16 December 2022)

IHRB (2019) Dignity by Design: Human Rights and the Built Environment Lifecycle. Available at: https://www.ihrb.org/focus-areas/builtenvironment/report-dignity-by-design-humanrights-and-the-built-environment-lifecycle (Accessed: 18 December 2022)

Jungwirth, T. (2020) *Politika ochrany klimatu v Česku: slova ztracená ve větru.* Klimatická koalice and Centrum pro dopravu a energetiku. Prague. Available at: https://klimatickakoalice.cz/images/200923_POK_final3.pdf (Accessed: 21 December 2022)

Magistrát hl. m. Prahy (2022) *Strategie prevence, snižování negativních dopadů a ukončování bezdomovectví v Praze do roku 2030.* Prague. Available at: https://www.praha.eu/file/3470837/Strategie___bezdomovectvi.pdf (Accessed: 19 December 2022)

ODS (2021 May 10) 'Pražská ODS: Klimatický plán Praha 2030 za 231 mld. rozvrátí pražský rozpočet na desetiletí a nepřinese potřebnou adaptaci města na klimatické změny.' Available at: https://www.ods.cz/region.prazsky/clanek/21073-prazska-ods-klimaticky-plan-praha-2030-za-231-mld-rozvrati-prazsky-rozpocet-na-desetileti-a-neprinese-potrebnouadaptaci-mesta-na-klimaticke-zmeny (Accessed: 19 December 2022)

Pixová, M. (2020) *Chaotic Czech climate politics are not bringing us closer to fulfilling the goals of the Paris Agreement; quite the opposite.* Social Watch & Klimatická koalice. Available at: https://www.socialwatch.org/node/18585 (Accessed: 20 December 2022)

IHRB (2023) Pathways for a Just Transition in Prague's Built Environment. Available at: https://www.ihrb.org/uploads/reports/Pathways_for_a_just_transition_in_the_built_environment_-_Prague.pdf (Accessed: 08 June 2023)

Rivera, A. (2021) 'Urban context's role in the emergence and development of social innovation' in Allegri, A. et al. (eds.) *Research Tracks in Urbanism: Dynamics, Planning and Design in Contemporary Urban Territories*. Taylor & Francis, pp. 42-50.

Šipka, M. (2020) *Politicians Hinder Solutions Offered by Civil Society and Experts.* Social Watch 2020 monitoring report. Available at: http://www.socialwatch.cz/?p=1132 (Accessed: 22 December 2022)

Appendix: List of interviews

1. Just Transition Officer, Ministry of Environment
2. Energy Efficiency and Savings Officer, Ministry of Industry and Trade
3. Social Inclusion Officer, Ministry of Regional Development
4. Municipal official, Department of Environmental Protection
5. Manager, Prague Development Company
6. Green infrastructure planner, The Prague Institute of Planning and Development (IPR)
7. Sustainable and affordable housing planner, Czech Technical University (ČVUT)
8. Civil engineer, University Centre for Energy Efficient Buildings (UCEEB)
9. Sociologist, Czech Academy of Science
10. Independent urban planner
11. Green buildings specialist
12. Architect, Czech Chamber of Architects
13. Former development project manager
14. Environmental activist
15. Representative of the Czech Tenement Association (SONČR)
16. Green building specialist
17. Social worker advising migrants (1)
18. Social worker advising migrants (2)
19. Community organiser and facilitator
20. Architect grassroots activist
21. Representative of the Czech building and construction trade union (Odborový svaz StavbaČR)

Acknowledgements and Partnerships

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Case Study Report

A Just Transition in Melbourne's Built Environment: A focus on housing

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Abstract

While owning your own home in Australia was once termed 'the great Australian dream,' it has never been a human right. Housing in Australia is in short supply, unaffordable, and not energy or resource efficient. This case study examines the extent to which built environment policies specific to housing and climate policies by government, business and NGOs intersect and consider a just transition and social equity. This study is part of a larger global study focused on eight major cities being undertaken by the Institute of Human Rights and Business. Applying action research incorporating a literature review, interviews and visioning workshop, this case study finds a range of risks and opportunities associated with current approaches to housing delivery and climate action in relation to a just transition. The study concludes that the most significant human rights risks for Greater Melbourne is the increasing deficit of access to adequate, affordable and appropriate housing, impacting significantly the most vulnerable members of the population.

Keywords

Just Transition, housing, climate-action, human rights

1. Introduction

At a time where the effects of climate change are being felt in many cities worldwide, Melbourne is no exception. Inclement weather in the form of rain, floods, and bushfires have put pressure on the existing built environment stock testing its quality, habitability, and resilience to these phenomena. Lower socio-economic classes, including homeless, are the most vulnerable to the effects of climate change. The social issue of housing provision and affordability, and the environmental issue of climate actions, including decarbonisation policy must be addressed in tandem. This case study facilitates to see the links between climate action and housing policy. It draws on the concept of a just transition which asserts the consideration of human rights in the policy process is key to achieving climate-responsive and equitable places and communities. This case study examines how built environment stakeholders, including local and state governments in Melbourne, Victoria, are responding to the housing challenge and whether they are seeking to advance the city's transition justly and sustainably. While the paper concludes by arguing that measures must be formalised, regulated and scaled. The paper ends by providing concrete recommendations on how Melbourne's built environment could advance its transition to be more sustainable and just for all its inhabitants.

2. Background

2.1 Housing in Melbourne

Greater Melbourne has 32 local government councils with an area of 10,000km (ABS 2016). It has 6.6 million residents and is projected to reach 7.5 million by 2027, and up to 12.2 million by 2066: the fastest growth rate of any Australian city (ABS 2018). Population growth drives rapid urbanisation, increasing housing demand (most in the renting scheme) and housing prices, impacting housing affordability (City of Melbourne 2020). Other major factors driving housing unaffordability include the financialisaton of the housing market and real estate speculation, and a complex landscape of land-use and taxation policies. The broader planning system encourages low densities, which often contributes further to unsustainable lifestyles. Those who are unable to afford a home rely on the private rental market or social housing[1]. Rental controls do not support permanent or longer-term tenure, disadvantaging renters who find rent increasingly unaffordable. The proportion of social housing in Australia sits well below the OECD average and the State of Victoria has the lowest proportion of secure and affordable social housing of all states.

In 2020 the Victorian State Government committed over AUD $90 billion to more than 165 major transport infrastructure projects under 'Victoria's Big Build' Plan and AUD $5.3 billion to investments in social and affordable housing under 'Victoria's Big Housing Build' Program (Victorian Government 2020), proposing to build 12,000 homes by 2024. The program funds large-scale projects which are aligned with the emissions target agenda by providing energy efficient new homes that meet 7-star energy efficiency standards, although it should be noted that the policy also involves demolishing a proportion of existing social and affordable housing blocks.

2.2 Carbon Emissions and Climate Action

The residential sector is responsible for 30% of the carbon emissions in Victoria, ahead of commercial services and manufacturing (both 17%) (Victorian Government 2022). These emissions are associated with electricity usage (from predominantly coal-fired generation) and gas (fossil-fuel) usage in homes, as well as vehicle emissions. The type, location and construction of housing further contributes to energy inefficiency. In terms of housing type, 68% of people in Greater Melbourne live in detached houses, and 46.5% drive to work (ABS 2021). Many of these houses are in planned suburbs which typify so-called 'urban sprawl', which produces further emissions through their patterns of living and working. Housing across Australia has not adopted circular economy materials and existing housing stock is not well built. For example, in relation to insulation most houses have poor airtightness and single-glazing is the norm.

Climate action policies for Greater Melbourne are part of a multilevel governance structure that stems from the national response to climate change. Australia's national government has committed to achieving net zero carbon emissions by 2050, notwithstanding a significant population increase. The Victorian State Government (2023) aims to better these targets by working towards net zero emissions by 2045. Climate action is a thread that has been woven into many social, cultural, and economic plans at the local government level, such as City of Melbourne's Economic Development Strategy 2031 and Zero Carbon Merri-Bek Climate Emergency Action Plan.

3. Methodology

Action research was engaged to deliver this pilot case study that received ethics approval from The University of Melbourne Ethics Committee. Three qualitative methods were engaged. First, a literature review was conducted of Federal, State and Local Government documents relating to housing and climate

[1] Social housing is social housing provided by not-for-profit social housing association or public housing provided by government.

action policies, as well as grey and academic literature focused on housing and climate action. Second, a total of 13 semi-structured interviews with representatives from local and state government, researchers, property developers, academics, trade unions, architects, financiers, energy rating organisation were conducted during the period March-May 2023. Interviews were recorded and transcribed with the permission of participants. Finally, a visioning workshop was held on 29 May 2023, bringing together the perspectives of representatives from governments, academia and private sector including developers, architects, urban planning and engineering firms, non-governmental organizations (NGO's), financial institutions, and civil society representatives. The data collected from interviews and field notes from the visioning workshop was thematically analysed according to established and emerging themes.

4. Findings and Discussion

In the context of human rights risks and opportunities, we found that housing delivery mechanisms and climate action within Greater Melbourne were in the most part disconnected.

4.1 Human Rights Risks

Unlike other similar liberal democracies, Australia does not have a Bill of Rights, leaving protections for human rights to be found in the Constitution and in legislation passed by the Commonwealth Parliament or State or Territory Parliaments. Participants interviewed explained that the absence of a bill of rights in Australian, contributed to the government's patchy commitment to fulfil the right to adequate, affordable and appropriate housing. While home ownership has been the *Australian Tradition,* it has not been treated by government as a human right. As two participants explained, "*Australia doesn't have a bill of rights. There is no legal right to housing [in Australia]." (Researcher)*

Government policy focused on affordable, safe and sustainable housing in the form of the National Housing and Homeless Agreement has been assessed as ineffective by the Productivity Commission (2022)[2]. Despite a strong research and evidence base on housing existing in Australia, translation to housing policy and government action has been patchy. Participants drew attention to the politicisation of housing and infrastructure including election cycles, pork barrelling and powerful development lobby groups which together act against delivery of affordable, safe and sustainable housing. As one participant observed, "The development lobby is incredibly small, but well organised and powerful. The community sector is incredibly large, disorganised, fragmented and not very powerful." (Affordable housing developer).

Although Victoria has recently made a commitment to enhance its social housing stock, after falling behind the rest of the country in investment on social housing per person, via the Big House Build program, participants suggested that this approach leans heavily on the use of government land to reduce the cost of housing and private developer partnerships tend to prioritize commercial over social outcomes (Raynor 2020). The government is operating like a market actor playing within the rules, rather than like the regulatory and policy-making body that it is.

There are some signs for optimism, for example the Victoria government's improved environmental design standards and inclusive social procurement practices that provide opportunities for Victorian Aboriginal people, Victorians with disability, social housing residents or people on the register, and consider women's equity and safety.

[2] The Productivity Commission is the Australian Government's independent research and advice to the Australian Government on economic, social and environmental issues affecting the welfare of Australians.

4.2 Rights to Energy Efficient Housing

Climate action policies by government have stood largely in isolation to housing policy. Incentive schemes have largely driven energy efficiency responses to housing in Melbourne and these regulations have mainly focused on new builds, not existing buildings; for homeowners, not renters; and for high-income, not low-income residents. There are certainly exceptions and variances, but the general trend is that climate action policies on housing largely perpetuate the inequalities of the housing market.

Incentives rather than regulation has been the mechanism policy makers have used to drive energy efficiency in housing, except for the National Construction Code discussed below. The lack of regulation across the building lifecycle – on financiers, including private equity, real estate investment trusts, developers, builders and the supply chain – is a factor in the slow pace of transition towards energy efficient homes, justly distributed in the territory. As a participant noted, "Currently, the built environment will not change without a stick (policy regulations and frameworks for example emissions caps, planning policy, public disclosure, etc.). Incentives for example tax cuts, are important and might work for the top tier but not for the bulk [of the city]" (local council representative).

The main roadblock seems to be the debate about who bears the cost of energy efficiency improvements. Critically, existing regulations do not apply to all buildings leaving vast amounts of housing stock energy inefficient. For interviewees, the National Construction Code (NCC) is the central mechanism to drive energy efficiency in new builds. It is Australia's primary set of technical design and construction provisions for buildings, setting minimum standards for their safety, health, amenity, accessibility and sustainability. However, interviewees said the NCC is slow to introduce mandatory requirements for environmental performance in buildings and lags global standards, and it needs to be constantly updated.

Encouragingly, energy rating systems such as the Nationwide House Energy Rating Scheme (NatHERS) and Green Star – founded by the Green Building Council of Australia continue to push for change. While initially aimed at new dwellings, the 2023-2024 federal budget allocated AUD $36.7 million for NatHERS to apply to existing houses. While these are positive steps, their application remains limited to certain sectors of the market, privileged population groups and, in the case of Green Star, to voluntary nature.

5. Conclusion and recommendations

While climate action and the delivery of housing may be viewed as unrelated issues, Australia has committed to achieving zero net carbon emissions by 2050, whilst at the same time, Greater Melbourne's population is projected to exceed 8 million people. To achieve these milestones, housing delivery must intersect with climate action. Examples where housing and climate action can intersect, include; densifying within existing infrastructure on a metropolitan scale, retrofitting old building stock, ensuring green measurement tools are accompanied by consideration for building life cycles, and embedding meaningful and impactful changes in the National Construction Code.

As Australia works towards net zero carbon emissions, all our households, including the most vulnerable, must not be further disadvantaged by inadequate access to clean energy, transport and green public space, resource-efficient, healthy, and well-made sustainable dwellings that support and encourage fulfilling and sustainable lifestyles. Housing, planning and infrastructure policies and climate action needs to be examined with a human rights lens, as well as the rights of the environment, following the principles of transparency, accountability, non-discrimination, adaptation, and participation across the entire building lifecycle (IHRB 2020). Decision-making processes and cultures, and inventive and participative policy development should be based on evidence and citizen engagement, to avoid politicization and prevent greenwashing, and aim to provide housing for all people, including renters and people on low incomes. We can no longer allow our housing policy to remain detached from our social policy and climate policy.

We make the following recommendations:

1. Victorian State Government planning reforms: Inclusionary Zoning

The mandatory inclusion of units for social housing is common in many places worldwide, where the amount of social housing included in new developments generally ranges from 5 – 20%. Melbourne has significant demand for social housing that is projected to increase as the population grows. Mandatory inclusionary zoning of a percentage of social housing in new developments would help to meet the needs of housing Australia's most vulnerable people.

2. Victorian State Government planning reforms: Diversity of Tenure Models

At the intersection of the 'missing middle' of housing typologies and the projected demand for affordable housing is an opportunity to introduce a wider variety of tenure models, filling the gap between government-funded social housing and developer-led housing for the private housing market. Owning a variety of mixed-income housing typologies is one way that community housing providers or state housing providers can leverage middle-to-high income earners' rents to support more vulnerable and lower-income earners.

3. Victorian State Government planning reforms: Density and a Right to Development Along Transport Corridors

Greater Melbourne's density is low by global standards, and most new dwellings are built at a low density near the fringe of the urban growth boundary. However, to meet sustainable lifestyle goals, new dwellings should be built in established suburbs that already have infrastructure for public transport, schools, hospitals, and employment. Policymakers should consider introducing a right to development for projects that increase density along transport corridors providing they meet predetermined requirements and urban design criteria. This right to development would likely incentivise developments in these areas by minimising time and cost risks relating to the planning process.

4. Federal, State and local governments: Energy Justice

Given the advantage that high-income socio-economic groups typically have in the climate action process, distributive justice should be a key consideration. It is important as the transition takes place towards net-zero carbon emissions that the most vulnerable households are not disadvantaged further.[3] Policymakers should form a richer understanding of the vulnerable cohorts at risk of energy stress when aiming to achieve a just transition.[4] Considering sustainable lifestyles beyond the dwelling is required, including the cost and accessibility to electric vehicles, as cars are often needed to access employment.[5]

5. Federal Government: Changes need to be in the National Construction Code (NCC)

The NCC must be updated to meet the energy standards required for a zero-carbon future. Most buildings constructed today will need to meet net zero emissions in 2050. As the primary set of technical design and construction provisions for buildings, the NCC sets minimum standards for various criteria, including sustainability.

6. Lenders, financiers and superannuation/pension funds:

Financial incentives for retrofitting or mitigation of demolition to account for embodied energy[6] produced in the demolition of existing housing stock (known as the whole life cycle (WLC) of construction projects which includes energy use in the manufacturing, transport, and construction stages of buildings).

[3] https://www.acoss.org.au/wp-content/uploads/2017/03/Consultation-Paper-Empowering-Vulnerable-Households-and-Decarbonisation.pdf

[4] https://www.acoss.org.au/wp-content/uploads/2017/07/ACOSS_BSL_TCI_Empowering-households.pdf

[5] https://www.melbourne.vic.gov.au/sitecollectiondocuments/climate-change-mitigation-strategy-2050.pdf

[6] the carbon dioxide emissions associated with materials and construction process throughout the whole lifecycle of a building

7. Building owners: Retrofit Existing Housing Stock

Green measurement tools such as NaTHERs and Green Star tend to have the most significance in relation to new housing and infrastructure. However, the whole life cycle of a building must be taken into consideration, including the embodied energy in an existing structure. Given that new dwellings account for less than 2% of new housing stock each year, we need to pay more attention to the other 98% of houses that are existing, a significant amount of which were built before the year 1990 and have an estimated NatHERS rating of less than 3-stars[7]. By 2050 this old housing stock must meet the Federal Government's zero net carbon emissions commitment.

4. References

ABS (2016), 2071.0 - *Census of Population and Housing: Reflecting Australia - Stories from the Census,* Australian Bureau of Statistics. Canberra. 12 July. https://www.abs.gov.au/ausstats/abs@.nsf/Lookup/2071.0main+features1132016

ABS (2021), *Greater Melbourne: 2021 Census All Person QuickStats.* Australian Bureau of Statistics. Canberra. https://www.abs.gov.au/census/find-census-data/quickstats/2021/2GMEL

ABS (2018), *Population Projections, Australia.* Australian Bureau of Statistics. Canberra. 22 November. https://www.abs.gov.au/statistics/people/population/population-projections-australia/latest-release

ABS (2017) *Population Projects, Australia*. Australia Bureau of Statistics. Canberra. 22 November. https://www.abs.gov.au/statistics/people/population/population-projections-australia/latest-release

City of Melbourne (2020). *Affordable Housing Strategy 2020-2030.* City of Melbourne. https://www.melbourne.vic.gov.au/sitecollectiondocuments/affordable-housing-strategy.pdf

IHRB (2020). *Framework for Dignity in the Built Environment*

Productivity Commission (2022), *In need of repair: The National Housing and Homelessness Agreement, Study Report*, Canberra. https://www.pc.gov.au/inquiries/completed/housing-homelessness/report/housing-homelessness-overview.pdf

Raynor, Katrina (2020), "Victoria's $5.4bn Big Housing Build: it is big, but the social housing challenge is even bigger," The Conversation. 18 November. https://theconversation.com/victorias-5-4bn-big-housing-build-it-is-big-but-the-social-housing-challenge-is-even-bigger-150161

Victorian Government (2023), *Climate Action Targets*. Melbourne. https://www.climatechange.vic.gov.au/climate-action-targets

Victorian Government (2022), *Greenhouse Gas Emissions.* Melbourne. https://www.climatechange.vic.gov.au/victorias-greenhouse-gas-emissions-and-targets

Victorian Government (2020), *Social housing developments: A streamlined approval and permit process for social housing developments, including Victoria's Big Housing Build.* Melbourne. https://www.planning.vic.gov.au/guides-and-resources/guides/all-guides/social-housing-developments

[7] https://theconversation.com/budgets-energy-bill-relief-and-home-retrofit-funding-is-a-good-start-but-dwarfed-by-the-scale-of-the-task-205380

case study report

Preserving historical value according the water and tourism in Iranian urban planning (The case study: Yazd city)

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Abstract

Water is always a permanent challenge in middle east and also in Iran. Iranians in the past survived their settlement with an intelligent technology in harvesting underground water which is called "Qanat".

Qanat is a technique which lead underground water by an underground corridor to the earth. This system has been used in most of Iranian cities. In addition, Qanat has been used in other countries like China and Spain.

Yazd city is an Iranian historical city which its historical urban fabric has been registered in UNESCO in 2018. In this area there are some traditional hydraulic structures which has been preserved for tourism.

For the best result for tourism a track has been identified in this area which seven points (different hydraulic structures) has been modified in it. These structured include water reservoirs, Payab, watermill, traditional bath, wash house and water mill.

All of these hydraulic structures were irrigated by water of Qanats which were flowed underground. So, these structures were built underground to be able to reach the water of Qanat. Architectural features of these building are intellectual. For example, the water flows in corridor of Qanat gently but there is an intellectual design to use the power of this water to turn the wheel of water mill.

A track has been identified to link these points and lead a visitor with the minimum time to visit all the seven points.

In addition of visiting the seven points people can see the traditional urban fabric of Yazd which have individual urban planning features.

City of Yazd is a great sample to show traditional architecture and urban planning of Iran. Defining these kinds of tracks for tourists will help the economy of tourism very much. In the other word improvement of the economy of tourism a main target of Iran and it is a one of the ways to achieve it.

This paper is about this track and its points which will present the historical area and its features for visitors.

Keywords

Qanat , historical hydraulic structures , traditional water infrastructure , urban planning

1. Introduction

Is it possible to discover the history of a UNESCO World Heritage Site in the middle of a desert through an underground water distribution route in two hours? A city that has never been deurbanized as a result of its harsh dry climate but instead has developed a special culture of social participation to transfer water through underground tunnels for many kilometers; the city of Yazd.

Located in the middle of the central plateau of Iran and surrounded by one of the desert, Yazd, has survived millenniums. In order to become more familiar with this great city, the history of Yazd will be discussed, followed by a brief description of its most prominent water structures. Then the related culture and the concept of "Karez[1] Civilization" will be looked at.

Revival of the features of karez civilization through an entertaining tour of water in Yazd reminds us of what our diligent ancestors did to preserve a culture. This historical review can cast light on the future paths to take, in order to preserve water for the generations to come.

2. History of Yazd

The history of Yazd, an astonishing civilization in the center of a desert, is mixed with myths. Yazd is located in the central part of the Iranian Plateau. Yazd has been the subject of contemplation of historians, a city situated both by the edge of the desert and near a humid mountainous area.

3. Most significant Water Structures of Yazd

The geographical and the climatological condition of Yazd, has led people to create and construct special hydraulic structures in order to adapt with their surrounding environment. These structures that will be discussed below had a significant role in supplying, transferring and storing water for multiple use, mainly drinking and irrigation. The most important structure providing water is qanat system, other water structures were related to this system.

3.1. Qanats

Qanat or Kariz is an underground canal with a gentle slope. It consists of an almost horizontal tunnel with some shaft wells, which conveys groundwater to the earth surface (Semsar Yazdi & Labbaf Khaneiki, 2017).

[1] Karez is the Persian name of Qanat

3.2. Water Reservoirs

In addition to thinking of ways of transferring water, which was made possible by the construction of Qanats, storing water has also been on the minds of people living in arid regions. To this end, water reservoirs were built. It consisted of a storage tank, the roof of storage tank, wind tower, stairway and portal. Water reservoirs were filled in the wet season with the water of nearby shallow qanat and in the dry season could provide people with cool fresh water (Semsar Yazdi & Labbaf Khaneiki, 2017). The stored water was disinfected with salt stone that produced chlorine gas after dissolving in water and as a result this water could be used for drinking and cooking.

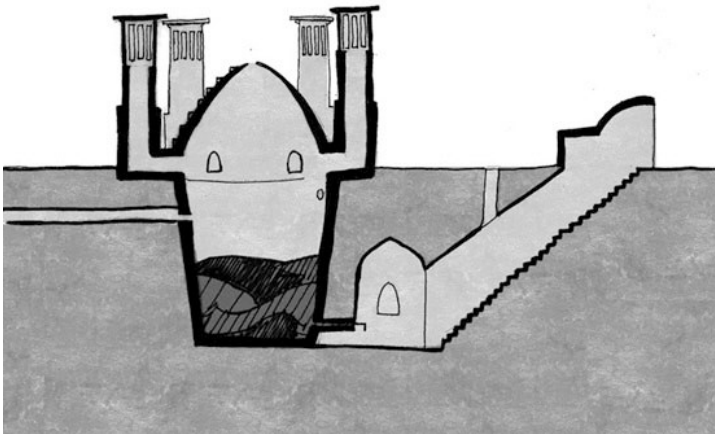

Fig 1- Typical water reserviors (Semsar Yazdi- p 149)

3.3. Payab

Payabs are structures that give easy access to the Qanat water through Qanat gallery. The underground passage can be reached by going down the stairway. The payab was built perpendicular to the direction of the qanat gallery in order to prevent the probable collapse of the gallery (Semsar Yazdi & Labbaf Khaneiki, 2017). At the bottom there is a space, usually rectangular or octagonal in shape where there is a pool through which Qanat water passes. Some payabs were public, situated near mosques, bazars, and caravansaries, but also there were private ones designed to reach people's houses. Water from public payabs was mainly used for sanitary purposes.

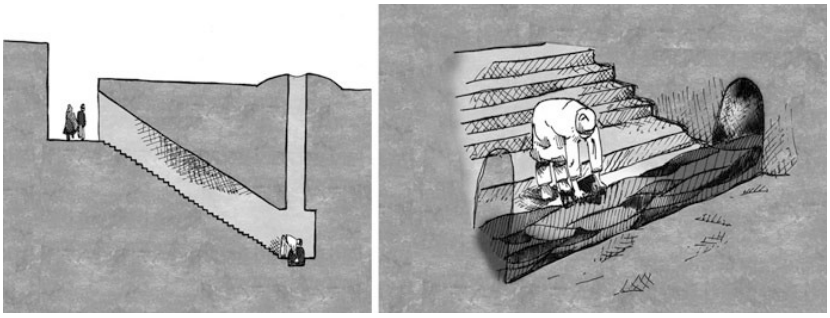

Fig 2 - Payab (Semsar Yazdi - p 147)

3.4. Watermills

Watermills are structures that use hydropower. The watermills of Yazd were built along Qanats. It consists of a water house, two millstones, rotor blades and an axis vertically connecting the blades and the upper millstone. The water house is a reservoir dug in the ground and located below the Qanat where water is received and stored. When Qanat water reaches the water house, it fills up the water house and then gushes out from a tiny nozzle at the bottom and hits the rotor blades, making the blades rotate, and imparting energy to the rotor which then turns the upper millstone (Semsar Yazdi & Labbaf Khaneiki, 2017). The lower millstone is stationary, and wheat turns into flour due to the friction created between the two millstones.

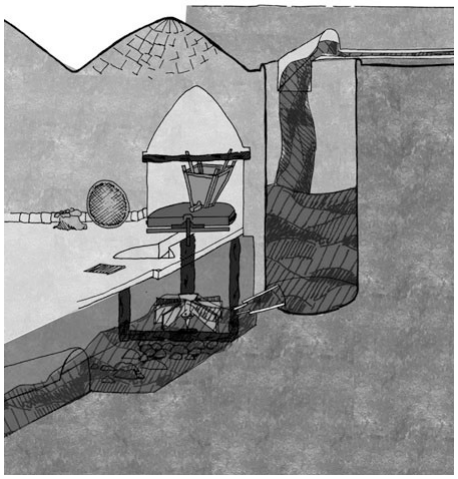

Fig 3 – watermill(Semsar Yazdi – p 6)

4. The Route

This route will take us back in history, to a time when Yazd was represented by its Kariz Civilization. The route will be crossed both above and under the ground so that we learn about the ways in which our ancestors founded such a civilization along this route and in the desert.

The route starts from Amirchakhmagh square from its water reservoir. The next point is the water museum where a Sradab can be visited. Then the Darvazeh Mehriz (Mehriz Gate) Water Reservoir will be visited. From that point the Payab of Jame' mosque, and the Shah Kamalieh Hammam can be visited. Then visitors can move to the Rakhtshooy Khane and finally the Vazir watermill.

It should be noted that Kariz Civilization is formed around water, but not around surface water and instead around underground water; water that was methodically directed from mountain skirts in long distances to reach farmlands and the city (Semsar Yazdi & Labbaf Khaneiki ,2017). This created a social responsibility for all the citizens to consider using the water free of charge in a way that would not affect farming negatively. Also, farming processes were in total harmony with the nature. There were farming products equivalent to the amount of water that could be used in the lands. On

the other hand, other Qanats may have passed through farmlands to reach another city, no instances of misuse of the passing water was seen. There were no conflicts over water; this is yet another manifestation of Kariz Civilization.

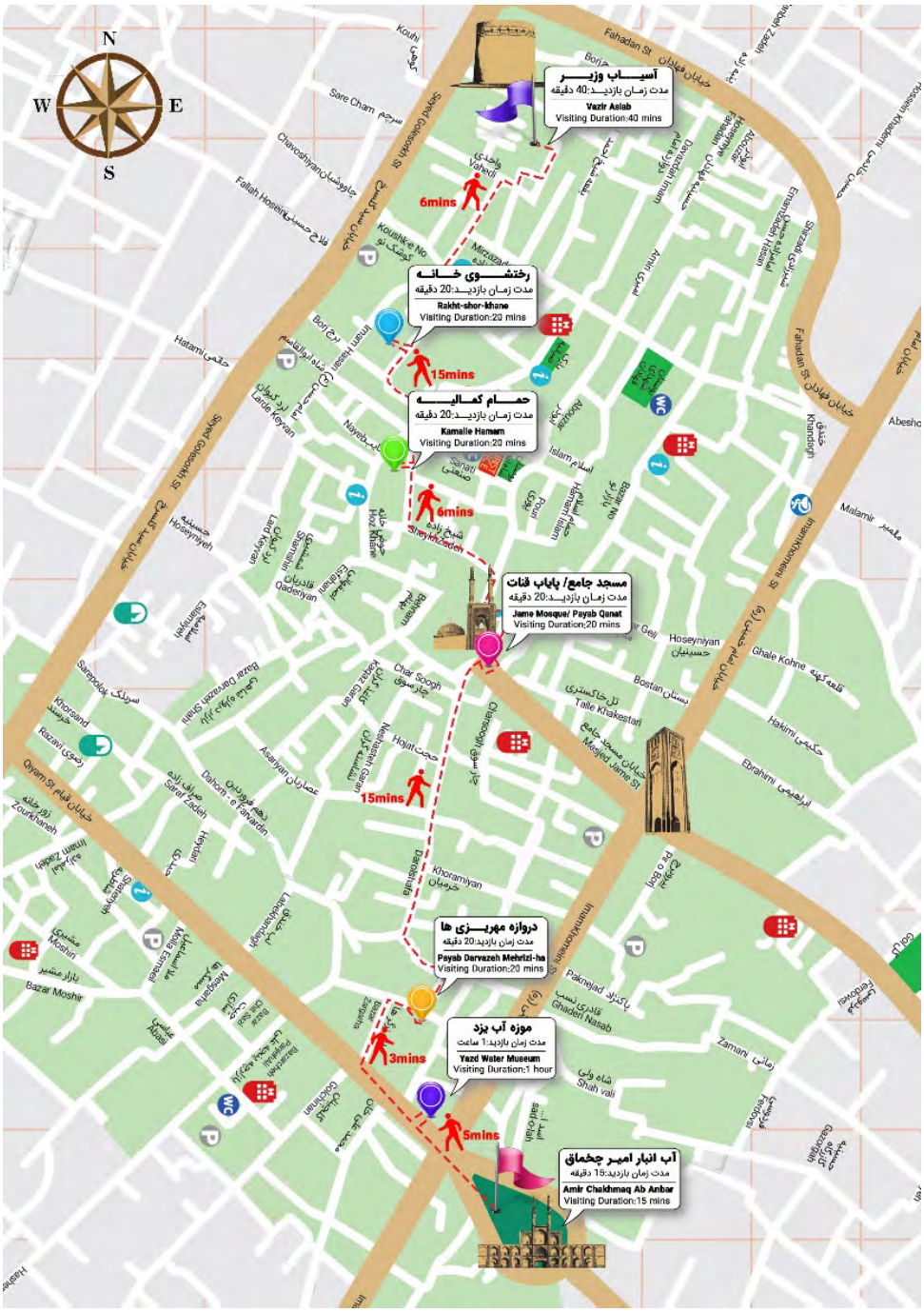

Fig 4 - Water Tourism Route

Points of the Route

1- Tekiyeh Water Reservoir (Amirchakhmagh Square)

The whole area of Yazd is poorly watered and lacks adequate rainfall.
In the historical complex of Amirchakhmagh Square, there were three water reservoirs as follows (two of which now remain as historical monuments).
1- Panj Badgiri Water Reservoir (Seti Fatemeh): It can be seen on the northern side of the square at the beginning of the old fabric.
2- Meydan Water Reservoir: This water reservoir existed on the south side of Amirchakhmagh Square and was destroyed during the construction of the street.
3- Tekiyeh Water Reservoir: It is located under Amirchakhmagh's Tekiyeh (or Hosseinieh) and now it is a part of the Water Museum.
The only entrance to the reservoir is located in the second northern alcove of Tekiyeh, and 52 steps must be taken to reach Pashir, where water is collected. In the past, the water of the water reservoir reached the reservoir through a space called the hose (Khortoom). But recently, an access way (a corridor-like passage with a width of 130 cm was cut) was created from Pashir to the reservoir for tourists to visit the mentioned place.
There are three exclusive features for this reservoir that show the intelligence, mastery, and skill of its builders:

1- The whole structure of the water reservoir is buried under the ground but the dome rises above the surface.
2- the structure of the wind catcher is invisible inside the walls of Haji Ghanbar Bazaar.
3- Stairs of water reservoirs in most cases reach the middle of the storage tank, but in this water reservoir, the stairs are constructed on the side. If the stairs were built as usual (in the middle) the space under the minaret needed to be excavated and this could impact the minaret's stability.

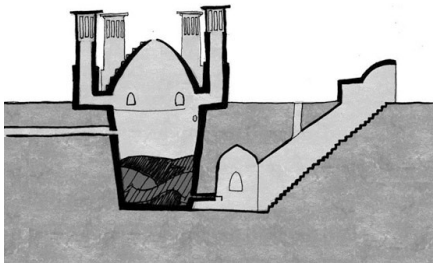

Fig 5 – Water resevior section (Semsar Yazdi – p 6)

These three characteristics show that the water reservoir and bazaar were simultaneously established around 1683 A.D (masarat, 2010).
The storage tank is 14 meters down in the ground and enjoys a diameter of 9 meters. One of the four wind catchers of water the reservoir is ruined and the other three ones

are some 1.5 meters higher than the roof of the bazaar. The other wind catcher leads to a slime chamber and includes a spool for lifting the slime in buckets to clean the water reservoir (Mollazade & Mohammadi, 2000).

Fig 6 - Tekyeh Water Reservoir (UNESCO-ICQHS – p 28)

2- Yazd Water Museum and its Sardab

The Kolahdoozan house dates back to about 110 years ago. Two Qanats named Rahimabad and Zarch passed under this building and the house is intertwined with water due to the passage of two Qanats under it; and today it has become a water museum. Water plays a fundamental role in the overall organization of the home's spaces. The harshness of Yazd's climate has led traditional architects to use groundwater and Qanats in order to alleviate climatic problems.

One of these elements is Sardab in traditional houses of Yazd. In different climates, different meanings are derived from the word Sardab (Koohsari et al., 2011). In this report, it is a space in the basement that is a few meters deep in the ground, and provides a pleasant atmosphere in summer and is protected from extreme heat and drought due to its closeness to water. In the houses of Yazd, two kinds of Sardabs can be seen, Quadrilateral and octagonal Sardabs (Pirnia, 1990).

Fig 7 - Sardab of Yazd Water Museum ((UNESCO-ICQHS – p 30)

The Sardab of the Kolahdoozan house is different from other Sardabs in terms of height. The basement is 9.5 meters below ground level. This octagonal Sardab with an octagonal pool in the center is located in the lower part of the yard and receives light from above. The location of the Sardab's location in the heart of the house and the use of materials of high heat capacity that delay heat transfer to the basement, also the proper orientation of the Sardab in the house, allowing the entrance of cool air and moisture through a canal to the lower part of the Sardab, are all solutions of the past desert dwellers to improve their living conditions (Kazemi &Ayatollahi, 2012).
The Sardab, in addition to the functions mentioned, was an excuse for family members to gather and, in addition to meeting human physical needs, it provided a gentle and soothing light. As can be seen, Sardabs are genuinely worthy heritage.

3- Mehriz Gate Water Reservoir

In ancient times, when the city of Yazd was surrounded by its historical fence, to reach Mehriz, you had to pass through a place in the southern part of Shahzadeh Fazel Bazaar called Mehrijard (Mehriz) Gate. Next to this gate, a reservoir was built to irrigate the road travellers around Yazd, such as Akbarabad, Naeem Abad, Ahrestan, Qasem Ayad, Rahmat Ayad, and Najafabad.
The features of this water reservoir have caused it to be one of the most prominent water reservoirs in Yazd:

- Beautiful brick designs and tile designs decorated with the names of Allah, Mohammad, and Ali in Kufic script.
- Having a significant place called a tea house in the stairs landing that fits very well with the space. This building, which is located at the entrance gate of Yazd, is located in front of Bayaq Khan Mosque and next to Khan, Afshar, Sadri, and Shahzadeh Fazel bazaars. Caravans and merchants came to this place after long journeys, looking for a place to relax and relieve hunger, thirst, and fatigue. This very good practical space is not seen in any of the reservoirs of Yazd, not even the reservoirs next to the caravanserais, and this

was due to the amazing planning of Amir Moazeddin Qannadi Bani and other constructor. All the components of the building were dug into the ground and then the structure were decorated with bricks. The water storage tank is circular and made of brick and mortar materials. In the Pashir (where water was collected by the public) part, the words Allah, Muhammad, and Ali are written in Kufic script on three sides. In the middle of the stairs is a corridor that leads to a building with a cruciform design. The cross-shaped building seems to have been a tea house where people spent some time relaxing and drinking tea. In addition to water supply services, this reservoir has two excellent and beautiful skylights on the stairs landing. It has a long staircase to access Pashir, and this requires a skylight. Right at the top of the stairs landing, there is an octagonal skylight about 7-8 meters high. Going down the stairs, there is a space on the left, and it has a similar skylight just like the one in the middle. This space is designed and built at the same time of the reservoir and is an integrated complex with the reservoir. It is a beautiful tea house which is completely compatible with the climate of Yazd.

The space is very precious due to its harmony and its proximity to the old Gate of Mehriz. In the old times, there was a small mosque in front of the water reservoir which has been destroyed, solely its altar is still standing. So, the three coordinated units: water reservoir, mosque, and tea house were skillfully put together at the point where exactly the tired travelers entered the city (Masaret, 2010).

Fig 8 -Mehriz Gate Water Reservoir (UNESCO-ICQHS – p 28)

4- Jame' Mosque Payab

The entrance of this Payab is located near the north of Jame' Mosque and next to one of Soffeh of the mosque. This Payab existed before the construction of the mosque and was repaired and rebuilt after the construction of the mosque. The Payab of the Jame' Mosque starts with 9 brick steps with a width of 1.3 meters facing Qibla, and after passing the footpath with a 90-degree turn, it ends with 54 steps with a width of 1.9

meters to the Payab. On the nineteenth step, there is a room to the left of the passage that was once used to hold the dead until burial. On the fiftieth step, on the left side is a room and on the right side is a ledge with a height of one meter from the floor (Semsar Yazdi, 2014).

The plan of the Payab is octagonal and in each wall there is a ledge with a height of 1 meter from the floor. In the middle and at the bottom of the Payab is a circular pool with a diameter of 2.5 and a depth of one meter. This footstool has been used for ablution and Ghusl. The old roof of Payab is domed and made of soil, and the shaft well connected to the courtyard of the mosque provided light for the Payab. This skylight was blocked about 50 years ago during the restoration of the Jame' Mosque (Ettinghausen and Grabar, 2017).

Fig 9 - Jame' Mosque Payab (UNESCO-ICQHS – p 34)

5- Shah Kamaliyeh Hammam

Shah Kamalieh bathroom is the oldest bath in Yazd and belongs to the eighth century. It is located in the south of the Shah Kamalieh school and has many historical values. In the history book of Yazd written by Jafar bin Mohammad bin Hassan Jafari and Jame Mofidi written by Mohammad Mofid Mostofi Bafghi, brief explanations have been written about a person named Abu al-Ma'ali and his endowments.

The bathroom consists of two parts for men and women and has two separate entrances. Each part has a dressing room and a warm house and is located below ground level. The women's bathroom is smaller than the men's bathroom, and the dressing room and the Garmkhaneh are lined up opposite each other. The arch of the roof of the porches is truncated and is hemispherical with a skylight in the middle. The Garmkhaneh space of the men's section has four octagonal columns, with arches between them. The building is made of brick and mortar, as well as mosaic and cement mortar for the platforms.

Fig 10 - Shah Kamaliyeh Hammam (UNESCO-ICQHS – p 35)

6- Rakhtshooykhane Payab (Haji Abbas Payab)

This Payab is located at the intersection of the alley behind Ab-e-Anbar and Samei alley and has two entrances, one in Haji Abbas's house and the other in the ruins located in Kushkeno. Both entrances, have about 75 brick steps, and lead directly to the Qanat gallery.

The floor plan is circular, with a pool in the middle. The area around the pool is lined with bricks for sitting and washing clothes. The walls and ceiling are made of mud. This Payab has been used for the public use of local residents and residents of Haji Abbas house. In recent years, due to lack of use, it had fallen into a ruin and had become a space for pigeons to live, and hence it is also known as "Jooye Kaftar" which means “Pigeon’s Payab” (Semsar Yazdi, 2014). Recently Recently, Payab was restored by the Cultural Heritage, Handicrafts and Tourism Organization and can be visited by the visitors.

Fig 11- Rakhtshooykhane Payab (Haji Abbas Payab) (UNESCO-ICQHS – p 36)

This Payab has been widely used in the past and one of its uses has been washing clothes. Washing clothes was done in a large dish that was placed next to the pool. In

this way, the clothes were poured into a big dish and water and Oshnan (Oshnu in the local dialect of Yazd) or Chubak were poured on it, and they soaked for a while so that it would be easier to wash them. Then they squeezed the clothes with sticks called Kotak so that they get clean (Besharat, 2007).

7- Vazir Watermill

This watermill is located in the area of a large square known as the Lard of the Mill. Alongside of the Lard yard, there is an entrance to the watermill. Elsewhere, there are stables for keeping and unloading animals, as well as a place for a person who sifted grain before milling. The entrance corridor to the mill with a width of 3 to 4 meters is sloping (for ease of passage of animals) and after a distance of about 350 meters, it reaches the mill yard.

The walls and ceiling of the corridor are made of baked clay (old brick) with white Khorasani cladding and its height from the ceiling is about 4 meters. The plan of the courtyard of the mill is square shapes and is approximately 15×15 meters and the height from the floor of the courtyard to the ground level is about 30 meters. On the side of the courtyard, a shallow well has been built on the Qanat gallery, which has been used in the past for the use of travelers and watering their animals. On the sides of the yard, rooms have been built for millers, workers, and travelers. Next to the mill courtyard, there is a staircase with about 20 steps for the millers to go to the second floor (roof of the courtyard).

The water of the saline branch of the Zarch Qanat, after leaving Jooy Asiab (Abbas Goli) and walking the waterway with a length of approximately 15 meters, reaches the place of the Tanoore. The Tanoore is a cylindrical well made of brick, lime, and ash with a diameter and approximate height of 3 and 6 meters, respectively.

The water of the Qanat enters Noucheng after falling from the Tanoore. Noucheng is a small-diameter pipe made of cooked mud that directs water from the Tanoore to the mill blades at high speed. In fact, here the conversion of potential energy into kinetic energy happens and thus water hits the blades of the mill very quickly and moves them, and subsequently, the lower stone of the mill rotates. The upper stone is fixed and therefore, with the friction that occurs between the surface of these two rocks, the necessary energy is provided to crush the grains poured between the two stones of the mill (Samsar Yazdi, 2014).

Fig 12- Vazir Watermill (UNESCO-ICQHS – p 38)

Conclusion

There is a sociological connection between the stops of the route. Imagine that we are standing in the large square of the city. This is the beginning of the historical site of Yazd. At the end, there is the largest mosque of the city. From the square to the mosque, we cross the bazaar. Along the way, historic houses have been built. The tangible concept of social organism can be perceived from this route. The minarets of the square and the mosque respectively symbolize the beginning and the end of the city. The former is place for the ruler of the city for the purpose of communication with people and the latter is the place for the ruler of Sharia. In the midst of politics and religion, economy is present. So it seems that politics can be seen as the head and religion the heart and the bazaar's economy and agriculture the hands and feet of this organism. Going a little further, people are blood in the veins of this organism. What will guarantee the social life of such organism? Yes, water indeed!

Water is the basis of social cohesion and development. The force of Qanat water turns the wheels of the water mill. Wheat is an agricultural product from outside of the city, from where we call it Qanat outlet. The water governance system is designed to store water as soon as it reaches the city and before passing under the city. Thus, it is possible for desert people to have access to water in all seasons, even when water does not flow from the springs to the city through Qanats. The Water Museum, located close to the main square, where the Sardab can be visited, is a historic aristocratic house. A house under which Qanat passed.

Basically, building a house under which a Qanat passed meant easier access to water. Therefore, social class can also be indicated by the ease of access to water. Water has determined social class. All the public facilities that were available in the city can be found in one aristocratic house. When visiting the water museum, apart from the Sardab, a Payab, a water reservoir and even a private bathroom can be seen. There were public baths, Payabs and Rakhstshooy Khane in the city for the use of other social classes to which all people have equal access.

Another social consideration is the participation of women in social life. Women are not confined to their brick houses as some people may think. They are water stakeholders. They are responsible for bringing water for cooking and washing. They are sometimes stronger than the men who try to bring water to the city through Qanats! They go down the stairs for at least 40 meters, in a dark and wet space to take water, wash their dishes and clothes in it and then with a heavier load they climb the same stairs to come to the surface. Women are also included in water governance, they are the ones who decide which time of the day to use water for washing and cooking, so that downstream water do not get contaminated. Participatory water management can also be seen in the pictures of this report.
In a new definition of water tourism, we will go deeper into the earth to discover history and learn great lessons from it such as adaptation with nature, for our today's world. We are going to know again why the historic city of Yazd is a UNESCO World Heritage Site and how it can be used as a model for developing desert cities nowadays. What is integrated water resource management and how can women, along with men, play an effective role in water governance. At the end of this route, we are going to think differently about water and treat such millions-of-years old groundwater heritage with more care.
We showed the possibility of portraying the theme of World Water Day 2022 in this project: Groundwater: Making the Invisible Visible. In the water tourism, from the perspective defined, calls on the people of developing countries, including the people of our land, to reconsider the history of water transfer through Qanat and the social aspects of the Kariz civilization, in order to celebrate the theme of World Water Day, which coincides with Spring season and the ancient ritual of Nowruz (Persian new year). Groundwater is a concern for all the people of the world. We made it visible centuries ago. Let's find it again. Recognize the value of water; the source of life. Let's reconsider groundwater, about making the invisible visible!

5. References

1-Javadian Zadeh , Mohammad Mehdi / Mehrdadi, Mehrasa / Faghih Khorasani, Abbas /Raee, Elham /Semsar Yazdi, Soudeh , (2021) , Design and Description of the WaterTourism Route in the Ancient Area of the UNESCO World Heritage Centre of Yazd – Iran . Yazd : UNESCO-ICQHS

2-Semsar Yazdi , Ali Asghar / Labbaf Khaneiki , Majid (2017) Qanat Knowledge construction and maintenance , Springer . DOI 10.1007/978-94-024-0957-4

3-Labbaf Khaneiki , Majid (2020) Cultural dynamics of water in Iranian civilization , Springer .https://doi.org/10.1007/978-3-030-58900-4

4-Alkarji , Abobakr Moahamad al hasan al Haseb. (1994). Harvesting of hidden water. T: Hosien Khadive Jam. Tehran, UNESCO publication

5-Bonine, Micheal .(2003). Qanat, Kariz and Kattara . London: The Middle East Center, school of oriental and African studies

6-Roaf, S .(2003) .settlement form and qanat routs in the Yazd province , Qanat, Kariz and Kattara . London: The Middle East Center, school of oriental and African studies

Case Study Report

Making schools into the booster for community resilience:

An experimental retrofit plan of *Yuyuantan* middle school in the inner-city Beijing

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Abstract

This report demonstrates the latent and critical roles schools play in promoting community resilience from physical and social aspects, with an experimental retrofit plan of Yuyuantan Middle School in Yangfangdian Sub-district in the inner Beijing, specifically in several ways: information and resources sharing, ordinary and contingency services distribution, energy support and food reserve, caring and providing development opportunities for the youth, the elderly and the migrants, stabilizing employment and enhancing school-community collaborative networks. Yet long-term institutional fragmentation in schools and communities administration in China's municipalities, along with the predicament of public finance at grass-root level, make it extremely difficult for schools to perform these roles. Accordingly, this report propose a school-centred reform model to restore local capabilities of catalyzing resilience.

Keywords

School-community collaboration, Community resilience, Values seeking, Age-responsive planning

1. Introduction

1.1. The aging work-unit neighbourhoods in the inner-city Beijing

During the past few years, the climate change and the global pandemic have exposed many vulnerabilities of communities in decaying old neighbourhoods, where significant infrastructure aging, population aging, economic decline, ineffective use and waste of resources were witnessed. This is especially the case in the inner city of Beijing between the Second and Third Rings, where cellular work-unit structure in the Maoist era dominates, planned and developed with central ministries and commitees, state-owned enterprises and national lifeblood headquarters over half a century.

Under the marketization transition since 1980s, the middle/high-density compounds affiliated to work units have been commodified and disintegrated from the original work-unit welfare system (Wu, 2005), but not completely due to the special status in the inner-city Beijing case. And due to the regulations to secure government functions and to maintain the Capital landscape features, they have hardly ever experienced any large-scale and thorough renovation. Hence the aging post-work unit neighbourhoods in the inner city have gradually lost their appeal to young settlers, only leaving retired employees, some empty-nesters, migrant tenants and families with school children there, with limited reinvestment into residential districts and a lack of economic vitality from the bottom. This is manifested by the inefficient use of service facilities and along-street space, as well as the waste of multiple resources.

Corresponding to the institutional legacy, it is mainly depending on up-down mass movements rather than grass-root supports that post-work unit communities are capable to respond to sudden disasters, such as rainstorms hits and epidemic outbreaks, e.g. collective rescue and relief work, nucleic acid testing for all personnel, etc., requiring a large amount of emergency funds which could be unsustainable. Meanwhile, such typical residential enclaves are usually isolated from each other and disconnected with public service sectors, which further weakens the local capabilities in building resilience to increased climate variability and unprecedented uncertainties. Would there be a proper existing resource to be used as catalyst to enhance community resilience, and to offer a breakthrough for the fiscal system reform?

1.2. The potential role of schools and multiple values lying in them

As an inextricable physical part and an essential source of social capital of the community, schools have a great potential to serve as the booster in building community resilience against various disasters through their centred sites for information and resources sharing, broad stakeholder networks and collaboration, mandates for education and disaster preparation (Oktari, et al., 2017), as well as property appreciation, which should be taken as a key source of multiple values of community. For the case of inner-city Beijing, despite the physical decay and stagnancy of living quarters, historical schools with good quality established to serve state cadres and employers' offspring maintain a good reputation and promising prospects to the neighbourhoods. Yet their potentials to support community resilience has not been fully realized.

With a full awareness of the potentials in making schools the booster for community resilience and a magnet for attracting climate finance, we combine planning with policy making and fiscal issues and propose a school-community collaboration model with place-based strategies to catalyze the bottom-up capacities to cope with climate threats, by seeking values and enhancing supports from schools, as an innovative path for climate-responsive community planning. In line with the purposes of age-responsive planning, this retrofit process is also targeted at promoting inclusiveness among population subgroups by connecting quality education with decaying neighbourhoods in several ways and providing equitable access for everyone to opportunities to participate and contribute to local development.

2. The retrofit plan of *Yuyuantan* middle school in *Yangfangdian* Sub-district

2.1. The context of the case study area

Located in *Yangfangdian* Sub-district, the southernmost tip of *Haidian* District, the case study area is 6 km west away from the Capital's centre, *Tiananmen* Square, extending from the Third Ring in the west to the West Moat in the east, from *Fuxing* Rd. in the north to *Lianhuachi* E. Rd. in the south, with an area of 2.42 km^2. Set as an area to secure central government functions, the administrative and commercial buildings are densely concentrated along the north road and the south corners of the site, around major landmarks like the Military Museum, Beijing West Railway Station and the transportation hubs (Figure 1). Residential buildings are slab-type or high-rise apartments, and some of them are mixed-used along the main roads or the edges of blocks with shop fronts and up-floor dwelling units. Since the buildings in forms of post-soviet or new Chinese style have large volumes and long facades, street public space for activities is scarce.

The population of the area is about 44,000 people (nearly 20% of them aged 60 or above according to the 7^{th} National Census in 2020), served by 10 school sites and 32 communities, which were built within 1950-2010 or even earlier, and most of them have been built for more than 20 years. It is getting harder for the aging facilities, lack of necessary renewal planning, to meet the changing needs of the population. The vulnerable households are mainly those retired employees from government agencies or research institutes, migrant workers with relatively high level of education, but they have little connections with the surrounding school enclaves unless they have schooling offspring there. One of the school enclaves in the centre of the site is *Yuyuantan* Middle School, a reputable key school established in 1964 with junior and senior high departments, accommodating about 150 staff and faculty and 1300 students (Figure 1).

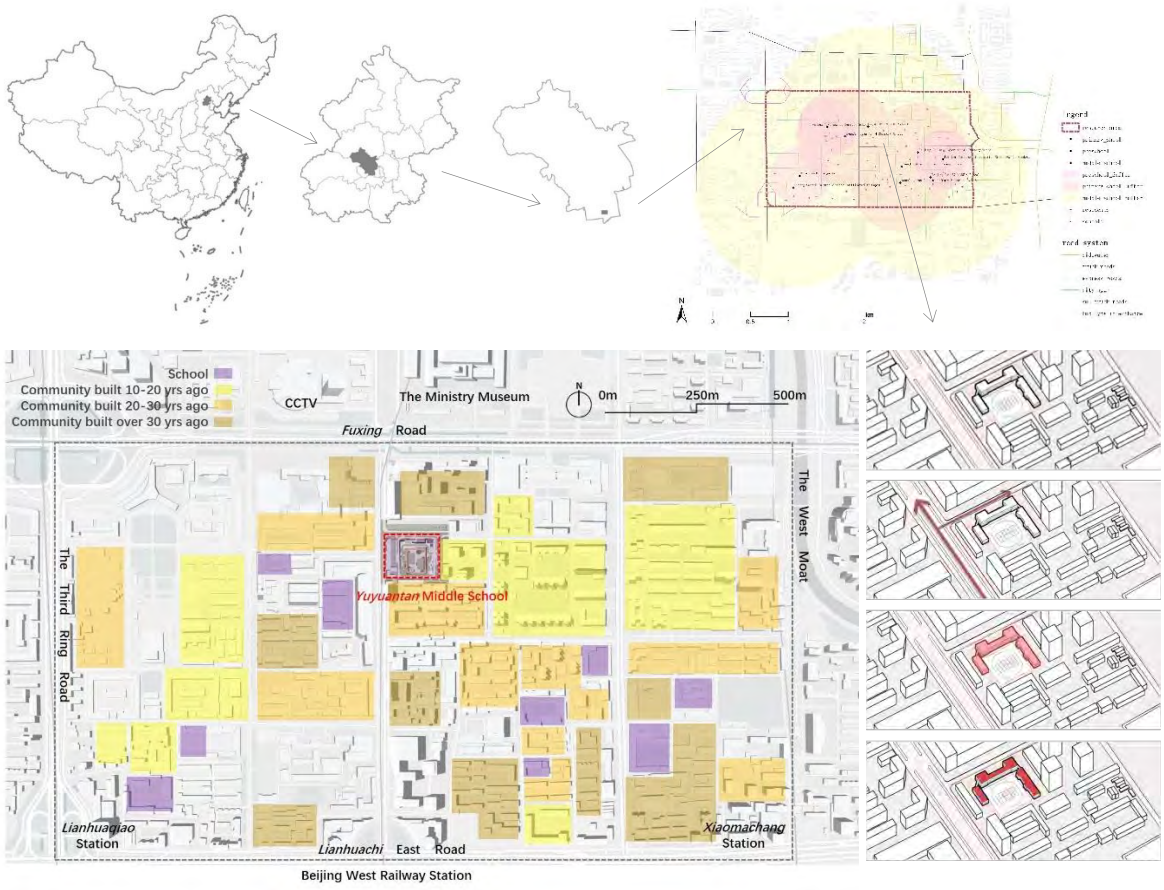

Figure 1. The location of the case study area and *Yuyuantan* middle school. Source: Authors.

Under the working framework of responsible planners in *Yangfangdian* Sub-district, this area is faced with three main problems of urban renovation after physical examination and socio-economic analysis, which may considerably weaken the capabilities for resilience. First, the post-work unit institutions and forms are increasingly unsuitable to meet the development demands in market backgrounds, not only the service industry for state economy has encountered bottlenecks, but also a civil foundation in building community wealth is lacking. Second, local vitality is insufficient, accompanied with population ageing and young talents loss, and facility resources, potential public spaces have not been fully utilized. Third, the buildings themselves have structure wear out, outmoded surfaces and poor conditions, requiring for cost-effective retrofits for green and low-carbon operation. Hence we take the experimental retrofit plan of *Yuyuantan* Middle School, combined with factual demands, as a pilot exercise to kick off an overall renovation and to explore the latent roles schools play in promoting community resilience from physical and social aspects.

2.2. Retrofit approaches to enhance community resilience

From the practical level, there just required engineering measures to renewal the campus in high-density built environment, such as reopening the entrance and exit on the north branch road to improve flow directivity from the west secondary road, renovating the side buildings while retaining the main building in the north and expanding the limited campus space for activities. As the project progresses, awareness for school-community relationships emerged to form innovative approaches to solve the existing problems for both sides. And based on this idea, several roles were proposed to give rise to schools to boost resilience: information and resources sharing, ordinary and contingency services distribution, energy support and food reserve, caring and providing development opportunities for the youth, the elderly and the immigrants, stabilizing employment and enhancing school-community collaborative networks (Figure 2).

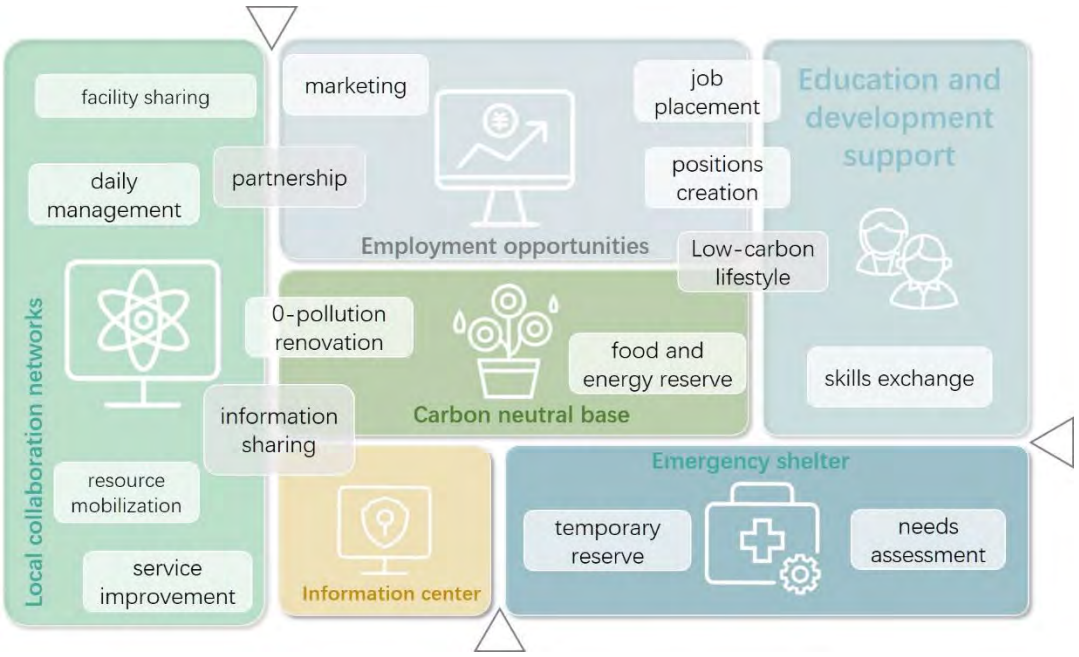

Figure 2. The potential roles of schools to enhance community resilience. Source: Authors.

- **Making schools the centre to share necessary information and resources by improving the infrastructure qualities and renovating the connections between schools and communities;**

To improve the environment quality including the guard room, canteen, library and other service facilities through low-cost zero-pollution renovation, residents and other stakeholders are involved and motivated to participate in the retrofit work and a synergic relationship is set up for information and resources sharing.

- **Sparing warehouse and shelter spaces within schools for communities and clarifying the services available for ordinary and contingency scenarios;**

Formulating a service delivery list between school and community to meet the needs of staff, teachers, students and residents in normal times and in contingency scenarios, arranging elastic spaces like indoor sports ground to make school a warehouse to provide medical and health supplies for communities.

- **Retrofitting schools into a carbon neutral base to draw funds with distributed energy sources and green food reserves;**

Supplying small-scale distributed energy support to communities by collecting solar energy, exploiting heat from municipal sewage and increasing carbon sinks in vertical planting. By opening a semi-public canteen, integrating marketability and public welfare (also as a food reserve) and promoting low-carbon lifestyles, funds for school renewal and healthy development are supposed to be raised.

- **Providing diverse education and development programs for the disadvantaged;**

By providing development programs like job training, skills exchange, marketing activities to increase job opportunities for the elderly, and the immigrant population, an age-responsive planning strategy is fulfilled.

- **Stabilizing employment combining welfare positions with competitive positions;**

Providing welfare positions and competitive positions under necessary regulations to attract community members, including the elderly, the migrant and other disadvantaged to contribute to school services and to stabilize employment; allowing students to participate in service positions and internship opportunities in communities to increase the social connections between school and community.

- **Building local collaboration networks through school affairs.**

Through admission, daily operation and management affairs, building a cooperative network between the school and the community based on the communications among city leaders, citizens, parents and students.

With regard to the various roles of schools to enhance community resilience above, such as to respond to sudden threats, to revitalize the local economy, to improve the lives of local residents and to form a green and low-carbon demonstration, etc., a detailed school-centred retrofit plan is proposed, making *Yuyuantan* Middle School as a multifunctional resilience infrastructure and a community centre. The core idea is to accommodate necessary functions, services and activities to deal with climate impacts by expanding space, breaking boundaries and activating flows, without increase in resources or energy wastes (Figure 3).

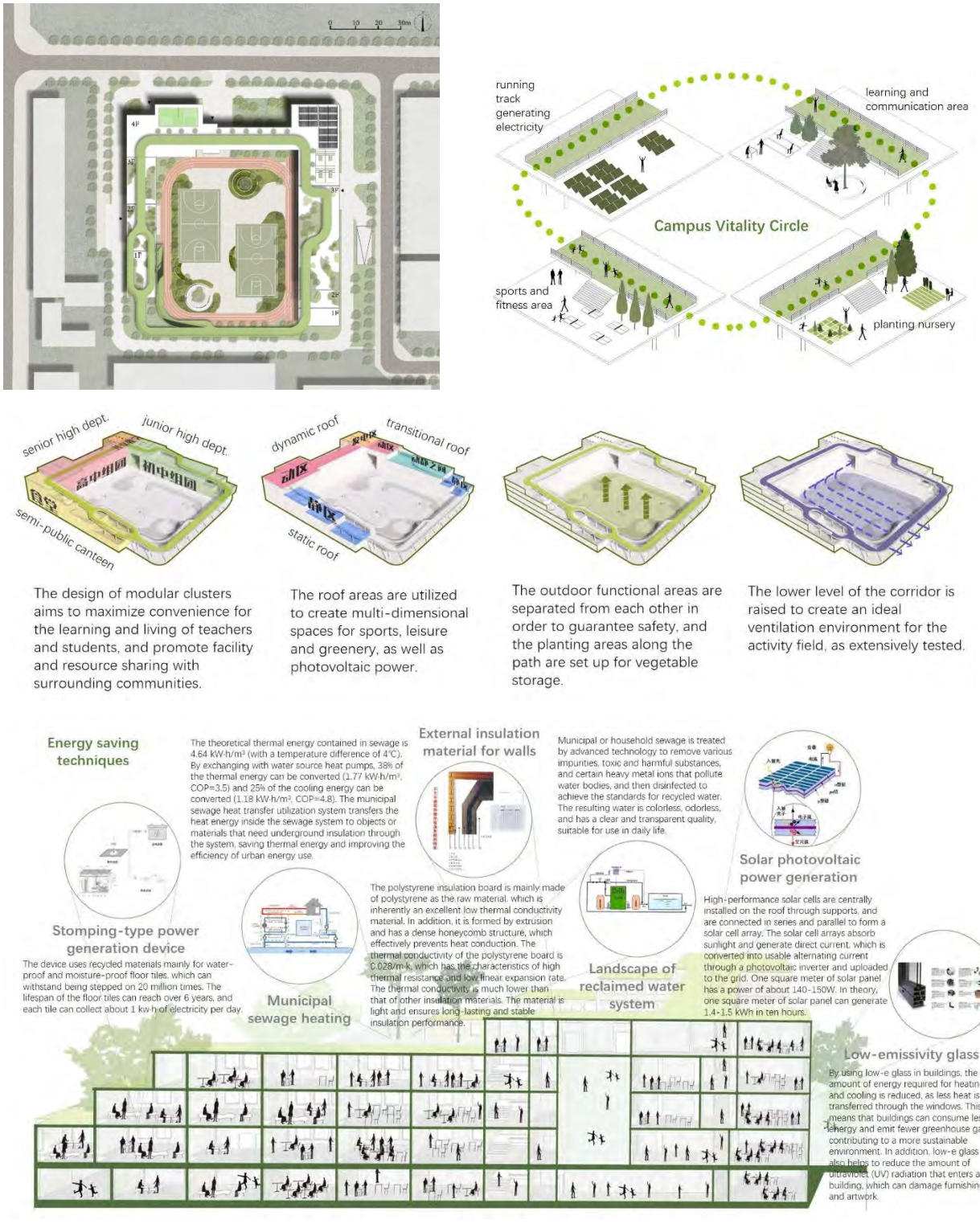

Figure 3. The main ideas of *Yuyuantan* middle school retrofit plan. Source: Authors.

The project mainly retrofits the west side building as a multifunctional canteen and combines the current modules while retaining the original teaching building in the north. The entire building roof and the ground are connected by a campus vitality ring, which links various systems and is extensible to the public spaces around in the future. By optimizing the overall wind, sound and heat environment and adopting energy-saving techniques, the whole school is created into a green, low-carbon and energy-saving campus, compact with diverse and variable functions and friendly to community partnership (Figure 3). With space exploitation and greening building measures, it is supposed to achieve a low-carbon and resilient transformation of a typical school in the dense and declining urban environment.

2.3. The planning results and broader impacts

Upon physical renovation, the project is targeted at closer cooperation between the school, communities and grass-root government departments, and seeking values from schools as community wealth to drive the local economy (Figure 4). At the physical level, schools provide routine and special education (aging education, physical education, disaster prevention education and job training, etc.) for surrounding residents of all ages, with classrooms, instructional equipment and sports grounds, which are critical resources to form a good learning environment to meet local educational needs. By formulating time-sharing schedules, the campus can also be a venue for various community events, e.g. cultural displays, sports competitions, creative markets, etc. to promote community communications and interactions, thus being integrated into the system of public facilities like parks, libraries, gymnasiums, etc. to enrich people's lives by providing places for reading, lecturing, exercising and playing. For emergency scenarios, schools can provide shelters, infirmaries and test services, making it easier for evacuees to have basic treatment.

At the social level, teachers and students from schools are able to have sufficient supports and resources from communities to take social practices through cooperation, and there would be considerable service activities generating new job positions or temporary works, such as extracurricular tutorials, nutrition chefs, security administrators and various volunteers, etc. for residents. As the current staff-student ration in public schools is very low (about 1:10) due to the financial shortage, it is expected to develop mentors and helpers from aging residents to provide better service to students and the flexible jobs that school can provide are estimated to solve the employment of 1/8 elderly residents in the case area, thus improving the integration and development of communities. This model under implementation is worth promoting.

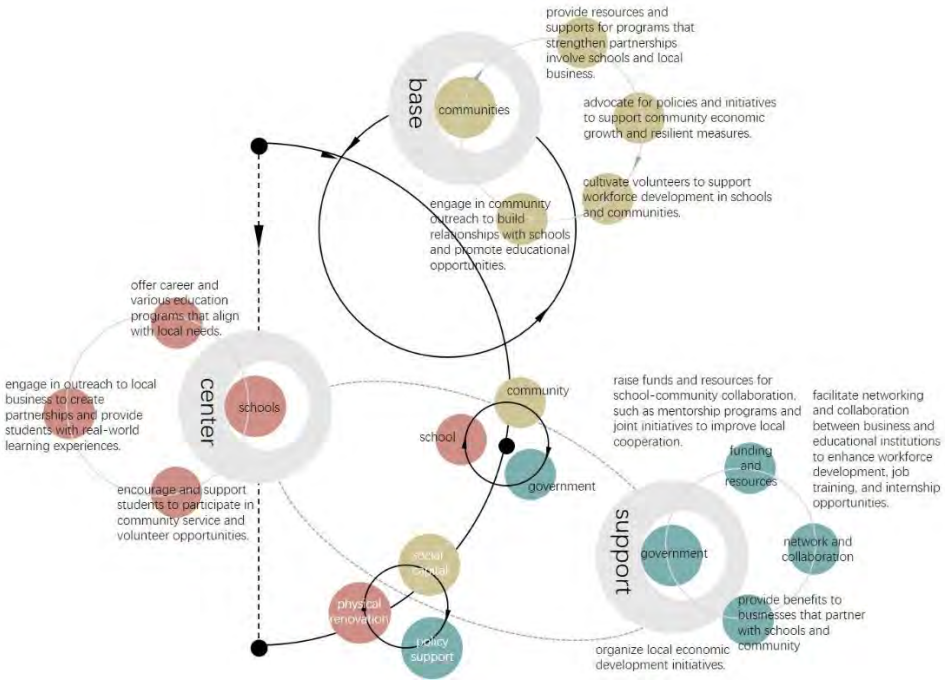

Figure 4. The school-community collaboration model to enhance community resilience. Source: Authors.

3. Institutional innovations to re-incorporate schools into communities

As is mentioned, under the marketization transition, along with the tax-sharing system reform, work-unit compounds that used to be multifunctional with a close relationship with affiliated schools have been disintegrated partially into commodified housing estates, designated as the counterpart catchment areas of particular schools but the boundaries vary. Despite the spatial proximity, schools are administered by the upper committee of education at the District level, while communities belong to the neighbourhood committees (*Juweihui*) at the Sub-district level (*Jiedao*). The long-term institutional fragmentation in the schools' and communities' administration, as well as the predicament of public finance at grass-root level in Chinese municipalities, makes it very difficult for schools to be integrated into community development, not to mention performing the roles as the booster for community resilience. Correspondingly, we propose a school-centred model to promote the fiscal system reform at different levels to restore local capabilities of catalyzing resilience, as recommendations for policy decision makers.

3.1. School districting optimization

First, at the District level, the Committee of Education should optimize the school districting system to straighten the networks between schools and surrounding communities, work units and other stakeholders. As schools provide vital physical, mental and emotional social welfare services to children and families, official concerns for schools should not be limited to academic outcomes or cost benefits (Fay, et al., 2020). Building and maintaining links between schools and surrounding neighbourhoods through renovation projects and other normalized activities contribute to bonding local social capital among diverse stakeholders and a sense of "belonging to a place", which is crucial to the enhancement of social resilience (Aldrich and Meyer, 2015). A relatively stable school district system making schools correspond to communities can provide an institutional guarantee for multiple school-community collaborations.

3.2. Community engagement

Second, at the school level, the decision-making board should develop mechanisms to engage as many partnerships as possible to invest in resilience measures, including the neighbourhood committee, the owners' committee, parent and resident delegates, relevant business and NGO, etc.. In terms of the Beijing case, public schools are mostly relying on supports from upper departments or associate work units, but for many transactions in daily teaching and emergency management, informal resources are required. The knowledge resource of the communities, especially from the elderly citizens, can be utilized to organize extracurricular activities for the second classroom. On the other hand, community engagement provides a base for students to reflect on others' needs, engage with their community, and act as responsible citizens. The opportunities of mutual aids across generations between schools and surrounding communities will benefit students and residents of all ages.

3.3. School as a magnet to attract climate funds

Finally, at District or Municipal level, a special fund in the education and redevelopment part of finance, should be established to support schools, especially those in disadvantaged areas and in high needs for resilience. And it would also be reasonable for the government to reach out and seek cooperation in the crossing field of education and climate actions. But at present, not only the physical sources of resilience in schools, such as facilitating residents' activities, providing emergency shelter, forming a carbon-neutral base and so on have not been seen very well, but also the generalized roles in education like raising public acknowledgement, improving disaster prevention awareness, enhancing employment and mutual aid skills, etc. have not been realized. More viabilities than the listed above can be detailed and schools as the centre of communities should be justified as a magnet for raising climate funds.

4. Conclusion

The relationships between schools and communities can be experienced and exploited through everyday life in an urban setting, both tangible and intangible, which can provide active and needed supports for communities to combat climate change while also giving mutual benefits to schools and other stakeholders. Where community engagement makes an essential part of school development already, like in some developed democratic countries with decentralized systems, raising funds for the greening and low-carbon retrofit of school facilities can produce multiplier effects on improving community resilience and generate environmental and health benefits for the whole place. While schools made isolated from communities or even enclaves is the case, like the case in our plan, it is imperative to rationalize the relationships and build up an effective collaboration network to implement place-based strategies smoothly. The experimental retrofit plan of a middle school in our report is to serve as the beginning of a discussion

Moreover, a school-centred community planning approach may offer a breakthrough for policy decision makers to tackle institutional and financial barriers in grassroots governance in a developing country with increasing centralization like China, where a vertical structure from the top to the bottom could undermine community sense and resilience in a deep extent by atomizing individuals, isolating communities and schools and fragmentizing self-organized efforts. A network built upon awareness, commitment, effective communication and mutual trust among different groups and stakeholders horizontally from the bottom can be a significant contributor to communities to withstand and recover from various adversities. The school-community collaboration model is expected to give planners new roles to coordinate relationships and to be referred by other developing countries with relatively rigid centralized systems.

In a disconnected world of the post-pandemic era, it matters more than ever that school and community cooperate with each other to prepare for local solutions to global changes. And there lies a variety of roles in school to come into play. The core concept in our plan is to activate vulnerable communities through school renovation, to restore the natural relationship between schools and communities as a key source of resilience, and a sound plan is one that takes financial feasibility into account. School expands capacities of community to withstand and recover from adversities while community promotes inclusiveness and equity through school involvement. This idea of putting new wine into old bottles is worthy of being put into multiple practices today.

Acknowledgement

Thanks to the responsible planner project in *Yangfangdian* Sub-district for the opportunities. Supported by National Natural Science Foundation of China (No.52008024) and Beijing Social Science Foundation (20JYC013).

5. References

Aldrich, D. P., & Meyer, M. A. (2015). Social capital and community resilience. *American Behavioral Scientist*, 59(2), 254-269.

Fay, J., Levinson, M., Stevens, A., Brighouse, H., Geron, T., & Fellow, P. (2020). Schools during the COVID-19 pandemic: Sites and sources of community resilience. *Edmond J. Safra Center for Ethics | COVID-19 White Paper*, 20.

Fulong, W. (2005). Rediscovering the 'Gate' Under Market Transition: From Work-unit Compounds to Commodity Housing Enclaves, *Housing Studies*, 20:2, 235-254.

Oktari, R. S., Shiwaku, K., Munadi, K., Syamsidik, & Shaw, R. (2017). Enhancing community resilience towards disaster: the contributing factors of school-community collaborative network in the tsunami affected area in Aceh. *International Journal of Disaster Risk Reduction*, S2212420917301851.

Research Paper

Study on the spatial self-organization characteristics and mechanism of traditional villages based on climate response

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Abstract

In the face of the current global climate crisis and sustainable development demands, traditional villages have attracted widespread attention due to their green construction wisdom of "harmony between nature and human". This study firstly divided traditional villages in the China's Yangtze River Delta region into three types based on the landscape elements: plain water network type, mountain valley type, and mountain dock and lake bay type. On this basis, one representative case was selected from each of the three types. Taking the village as a whole as the research unit, the self-organizing characteristics of its spatial morphology and the driving mechanism behind it were analyzed from the perspective of climate response. It is found that the spatial self-organization of traditional villages in the Yangtze River Delta generally exists in three development stages: settlement location for safety and faith, layout of streets and buildings to meet production and life needs, and construction of vegetation and green space in pursuit of life quality. Through the study on the climate adaptability of traditional villages, it is expected to provide enlightenment for the contemporary urban and rural construction.

Keywords

Traditional villages, Climate response, Ecological wisdom, Spatial form, Yangtze River Delta region

1. Introduction

Traditional villages, as a product of the common role of the natural environment and social context, are livable and low -cost spatial form organization containing the green construction wisdom of the unity of heaven and man. Especially in the current trend of global climate deterioration, it has become the only way to become unique in people's eyes. However, with the acceleration of the urban construction process, due to the lack of the awareness of the inherent mechanism of the overall space response to the overall space response, the blind expansion of the construction land has caused the space field of traditional villages to be continuously occupied. Instead, the average building made of reinforced concrete, the deterioration of the ecological environment, the regional characteristics of the regional characteristics, the livability is greatly reduced, which seriously restricts the sustainable development of human society(Zhou et al., 2019; Wang et al., 2019)**.**

Related research on climate change and material space covers the levels of multiple spaces, including the improvement of the heat island effect of the macro scale, the impact of the shape of the middle viewing scale on the comfort of the human body, and the correlation between building height, density, intensity and energy consumption at microscopic scale (Shi et al., 2022; Banerjee et al., 2022; Thomas et al., 2023). For example, Rashid et al.(2022) through Urban Thermal Field Variance Index (UTFVI)

to prove that land use and vegetation coverage will affect the fluctuations of the surface temperature. Xiong & Jin (2017) took classical gardens in the South of the Yangtze River as an example to study the layout strategy of urban open space in microclimate construction. Gholami & Abbasi (2023) proposed to build dynamic buildings that adapt to changes in temperature and solar radiation to achieve climate adaptability. In addition to being affected by macro climate conditions, microclimate and comfort level are closely related to the surface characteristics formed by the spatial form of urban and rural areas (Oke et al., 2017). As the boundary between urban and rural areas becomes increasingly blurred, rural areas also play the important role in climate issues (Alberto et al., 2019). However, existing studies mainly focus on the mutual regulatory relationship between urban built space and climate environment, little attention has been paid to the creation of microclimate in rural areas(Xiong et al., 2022).

Traditional villages have been living in harmony with nature for more than 100 years, and their traditional green construction wisdom is still of reference significance for the construction and sustainable development of livable environment today(Akbar et al., 2020). In recent years, experts and scholars have increasingly studied rural areas. In the face of severe climate crisis, the construction wisdom of traditional villages in regulating local microclimate has become a new research hotspot. Cheng et al. (2022) studied the influence of vegetation water environment on climate in Dai traditional villages with high temperature and high humidity through Kriging analysis and UTCI. Zeng et al. (2017) measured the creation of comfortable wind environment by the layout of traditional residential houses in Lingnan through numerical simulation. In general, the research on climate response of traditional villages has gone through the stage from extensive qualitative description to quantitative measurement and simulation. However, the research content focuses on macro-regional scale and building monomer scale, paying less attention to the overall spatial form organization of villages at mesoscale, and mostly focuses on surface research on the current layout characteristics. There is a lack of in-depth research on its spatial morphogenesis mechanism under climate response(Ma & Tong, 2021).

Therefore, from the perspective of climate response, this study takes different types of typical traditional villages in China's Yangtze River Delta as objects, and uses PHOENICS software simulation methods to analyze the self-organizing characteristics of the overall spatial forms of different types of villages at mesoscale and the driving mechanism behind them. It is expected to help planners master climate response methods with regional characteristics, and play a positive role in the protection and inheritance of traditional villages, the construction of new rural areas, and even the shaping of livable urban environment with the help of modern application of traditional methods.

2. Methodology

2.1. Research object

A total of 1,074 traditional villages in China's Yangtze River Delta (including Shanghai, Zhejiang Province, Jiangsu Province and Anhui Province) are listed in the national traditional Village Protection list. These traditional villages have developed over the past hundred years, creating a sustainable development path of human-land symbiosis under different climatic conditions(R Pang & Z Shen, 2021). With numerous lakes and dense paddy fields, the diverse natural environment gives birth to different village forms (see Figure. 1).

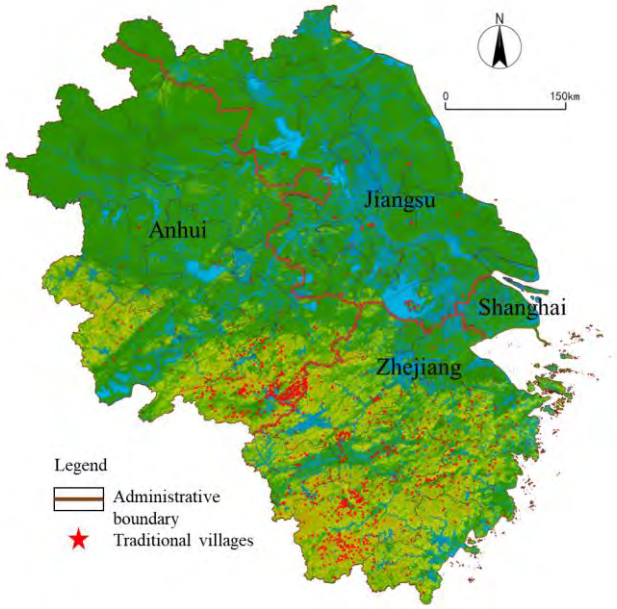

Figure 1. Distribution of traditional villages in the Yangtze River Delta region. Source: Self-draw.

In the Yangtze River Delta region, southeast wind prevails in summer, with high air humidity and low wind speed at night, while northwest wind prevails in winter and is cold and dry, especially hot in summer and cold in winter. Longer summer and winter put forward higher requirements for the comfort of living environment. It is worth noting that under specific geographical conditions, traditional villages will adopt targeted spatial strategies to adapt to or improve local microclimate, which is reflected in differentiated spatial forms (Fu et al, 2021). Therefore, in order to compare the interaction characteristics between different natural environments and village forms, this study divides traditional villages into three types: plain water network type, mountain valley type and mountain dock lake bay type according to the relationship between terrain characteristics and water (see Figure. 2). Among them, the plain water network villages are mostly located in the northern region of the Yangtze River Delta, the terrain is not large fluctuation, and the traditional villages are close to the water layout. The settlement space of Qiqiao Village in Nanjing is surrounded by many ponds, which is a typical representative of the plain water network. Mountain valley villages are mostly distributed between hills, suitable for construction of low and gentle slope area, Yuyuan village is located in the valley, is a typical representative of mountain valley. One side of mountain dock and lake bay village is adjacent to the mountain, the other side is close to the water, pay attention to the “fengshui” pattern. Luxiang village is located in the mountain dock facing Taihu lake, is a typical representative of mountain dock and lake bay village. Through the specific case analysis of Qiqiao village, Yuyuan village and Luxiang village, the action mechanism of different types of traditional village spatial forms based on climate response is compared.

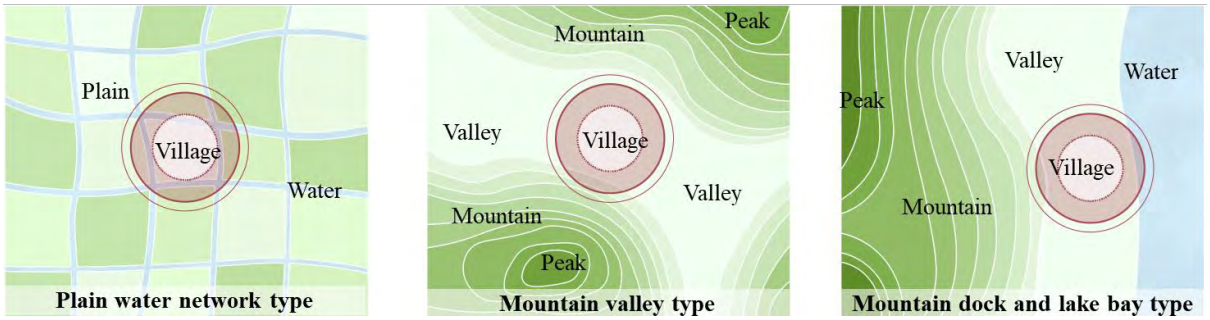

Figure 2. Three typical villages. Source: Self-draw.

2.2. Research method

(1) Field observation

Firstly, the vector data of the buildings of Qiqiao village, Yuyuan village and Luxiang village were obtained from the local planning department, and the 3D model was initially drawn by combining the elevation information. On this basis, through field investigation, the building layout, building orientation, and street network information of the three villages are carefully checked to obtain more accurate material space information, thus providing an analysis base for subsequent software simulation.

(2) PHOENICS microclimate simulation

PHNENICS software was used to simulate the outdoor wind environment of different villages in summer. According to the relevant provisions of the simulation calculation in the Green Performance Calculation Standards for Civil Buildings and the Technical Regulations for Numerical Simulation of the Built Environment, the regional scope of the environmental simulation of each village was set, and the grid was divided. The wind direction was based on the dominant summer wind direction in the recent three years calculated by the local meteorological station, and the average wind speed was 3m/s. In the same period, the wind speed and direction distribution of different villages 1.5 meters above the ground were simulated, and the causes of wind and heat environment were further analyzed in combination with building groups and street system.

3. Analysis of the correlation between spatial form and climate

3.1. Settlement site: near the water and mountains

Through the analysis of natural topography, it can be found that traditional villages tend to build villages in the flat terrain near water sources and at the foot of mountains.

On the one hand, the heat capacity of the water is large, the reflection of solar radiation is small, and the heat absorbed can be stored, thereby reducing the temperature. Qiqiao village is located in the northeast of the low hills to the southwest valley plain transition slope, The Qiqiao river flows through the village to the Gucheng lake. The built area of the village are high and flat, with low lying polders and crab ponds surrounded by water. The village is arranged in the middle of the pond, just like an island on the water surface. The historical river and pond system have a good effect on the regulation of the thermal environment of the settlement (see Figure. 3-1).

On the other hand, the mountains around the topography such as mountain dock and valley form a natural ground barrier, which can shield the influence of external adverse environmental conditions on the settlement and maintain the ecological stability of the micro-environment of the settlement. Yuyuan village is located on a low mountain and gentle slope suitable for construction, and the main body of the settlement is located on a slope facing east and southeast. Such site selection is conducive to the

settlement receiving sunlight and making full use of solar radiation energy (see Figure 3-2). Luxiang village, located in the East hill of Taihu lake, is located in a mountain dock surrounded by mountains on three sides and only opens on one side facing the water surface of Taihu lake, which can not only use the mountain to shield the winter wind, but also achieve cooling through Taihu Lake in summer (see Figure 3-3).

Figure 3-1. Location of Qiqiao Village.

Figure 3-2. Location of Yuyuan village.

Figure 3-3. Location of Luxiang village.

Figure 3. The location of three villages. Source: Self-draw.

3.2. Street space: serve as wind corridors to cool down

The streets and alleys of the settlements in the Yangtze River Delta are generally narrow, and the cooling is achieved through self-shading, wall cold storage and night ventilation. The height to width ratio of streets and alleyways is mostly between 1.0:1.5 and 1.0:2.5. As a buffer space for buildings, it can form a large shadow area, play a sunshade effect in summer, and accumulate cold amount at night to form air convection and strengthen ventilation.

Among them, due to the influence of the ancient trade road traffic, the narrow and long terrain conditions, Qiqiao village runs through the whole village with a core main street, and other alleys intersect with it. The core main street is the most important street for sacrificial and commercial activities, which is the basis for the development of the whole village (see Fig 4-1). The main street of Yuyuan village divides the village into north and south along the water. Perpendicular to the main street, a number of alleys extend to the deep mountains, and the spring water on the mountain flows into the Yinhe river through the laneway (see Fig 4-2). A main road in Luxiang village is arranged roughly parallel to the shore of the lake, and the branch road extends vertically to the left and right sides of the main road. The overall road network structure is roughly fishbone, forming a street pattern of "one street, six lanes and three rivers" (see Fig 4-3).

Figure 4-1. Streets of Qiqiao Village.

Figure 4-2. Streets of Yuyuan village.

Figure 4-3. Streets of Luxiang village.

Figure 4. The street space of three villages. Source: Self-draw.

In general, the spatial hierarchy of streets and alleys in the Yangtze River Delta can be divided into three systems according to the pattern: First, the core street passing through the village, as the main channel of transit people and logistics transportation in the village and outside the village, is the commercial activities and public service space in the village; As the connection between the street and the courtyard, the secondary branch lane forms the transition space. Level three is the inner workings of the house. The main street conforms to the terrain as a ventilation corridor to introduce the wind into the settlement, and the branches crisscross to enhance the air flow, while weakening the wind pressure in the main street to avoid the generation of convection wind.

3.3. Building group: compact and flexible

3.3.1. Compact building layout

Because of the dense population and the shortage of land resources, the compact building layout can effectively improve the capacity of the limited land resources. A simplified building model ignoring water bodies and green spaces is established, and the wind speed and direction under the existing building layout are simulated by PHOENICS software. It can be seen that under the influence of southeast wind in summer, the three villages have achieved good ventilation and cooling effect on the whole, and at the same time, there are certain differences in different terrain and climate conditions. Specifically, the wind speed inside the dense building cluster in the center of Qiqiao village is lower than the regional average wind speed, while the wind speed of the cluster distributed outside the pond is higher, and the wind speed in the open water and green areas reaches more than 3.5m/s (see Fig 5-1, Fig 5-2). Yuyuan village is located in the wind corridor of the three mountains, and the wind speed is maintained between 0.4-1.5m/s through the layout of close proximity between the buildings, which is equivalent to a temperature reduction of 1.9-3.9℃ (see Fig 5-3, Fig 5-4). The architectural community of Luxiang village is flexibly arranged according to the mountain situation, and several tuyere are formed in the area where the architectural group meets the mountain water body (see Fig 5-5, Fig 5-6).

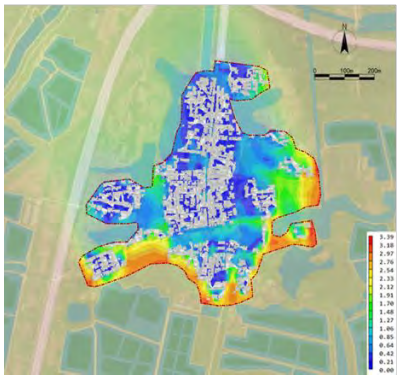

Figure 5-1. Wind speed of Qiqiao Village.

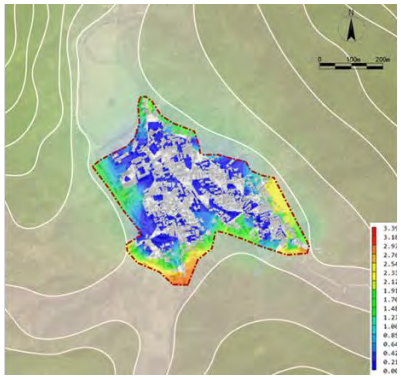

Figure 5-3. Wind speed of Yuyuan village.

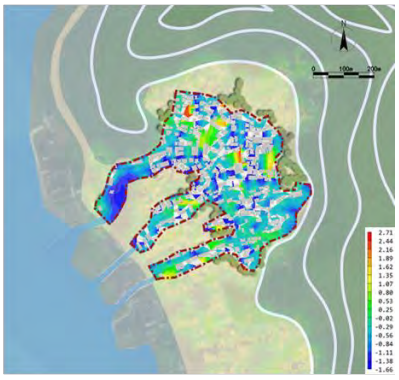

Figure 5-5. Wind speed of Luxiang village.

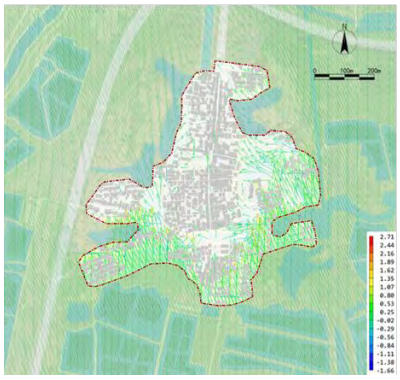

Figure 5-2. Wind direction of Qiqiao Village.

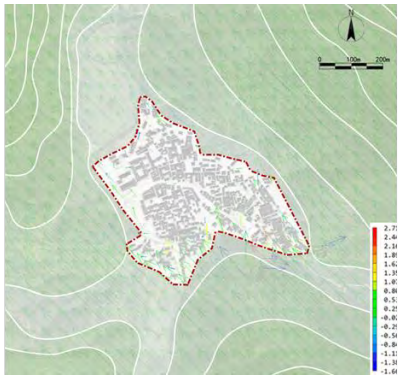

Figure 5-4. Wind direction of Yuyuan village.

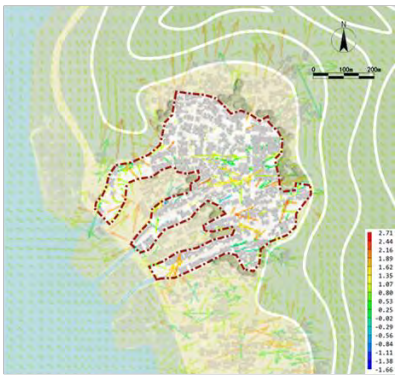

Figure 5-6. Wind direction of Luxiang village.

Figure 5. The wind environment of three villages. Source: Self-draw.

Combined with the compact layout of the natural environment, on the one hand, the buildings shield each other in summer to avoid the direct sunlight on the underside and achieve the cooling effect. On the other hand, the formation of hot pressing to keep warm in winter. It is not only an efficient use of land resources, but also a wise way to deal with the climate characteristics of the Yangtze River Delta region.

3.3.2. Flexible building orientation

The climate in the Yangtze River Delta region is warm and hot, and the orientation of buildings pays more attention to avoiding the hot summer sun, and the interval combination of water, road and house has a particularly significant cooling effect. Therefore, the orientation of traditional village buildings in the Yangtze River Delta is often closely related to the direction of the road. The larger the street-facing interface, the better the ventilation effect and the more obvious the cooling effect.

Specifically, among the 707 buildings in Qiqiao village, the main street buildings and the roundabout island buildings have obvious differences in orientation. The main street buildings tend to follow the trend of the street layout for ventilation needs, so the proportion of east-west buildings reaches 63%, while the surrounding island buildings are not restricted by the main street, and the south-north buildings account for 75%, thus achieving a good lighting effect (see Fig 6-1). The buildings in Yuyuan village are affected by the valley topography and streams, and the orientation distribution is relatively free, and the height are scattered to reduce the shade, so as to obtain sufficient sunshine (see Fig 6-2). Hanshan Port, Luxiang Port and Jiangwan Port three water systems introduce the water of Taihu lake into the Luxiang village, forming three external communication channels, and most of the buildings along the road face east-west. The long side of the building along the street is conducive to expanding the commercial street interface and improving economic benefits; meanwhile, the increase of the contact surface is conducive to introducing street wind into the interior. The orientation of buildings near the mountain is more free, and under the condition of conforming to the distribution of roads, the buildings are mostly oriented to the north and south, and try to strive for the land facing south (see Fig 6-3).

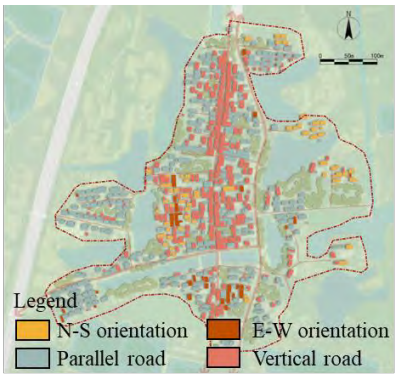

Figure 6-1. Orientation of Qiqiao Village.

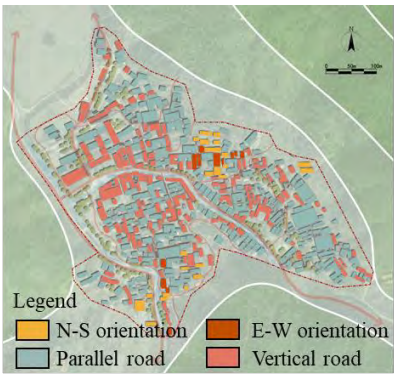

Figure 6-2. Orientation of Yuyuan village.

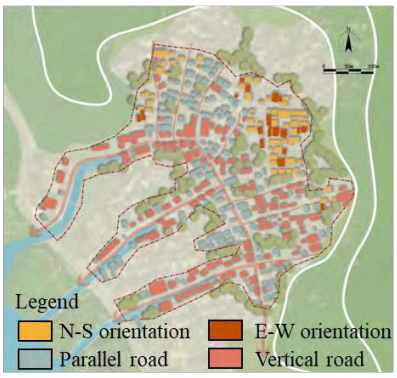

Figure 6-3. Orientation of Luxiang village.

Figure 6. The building orientation of three villages. Source: Self-draw.

Different from modern urban housing, traditional buildings do not adhere to the north-south orientation, but more consider the terrain environment, street trends and clan etiquette concept. Even if the orientation of the building is not good, the villagers can also adjust the internal microclimate by changing the layout, patio, cornice, doors and windows and other components of the building.

4. Climate adaptation and regulation mechanism

4.1. Basic function stage: security defense - facilitate production and life - environment construction

Through the specific analysis of the above typical cases, it can be found that in the face of different natural geographical conditions and climate environment, traditional villages generally have three development stages of security defense, production and life, and environmental construction, from the initial individual small-scale settlement point to a stable settlement group with a certain scale that is compatible with climate characteristics (see Fig. 7).

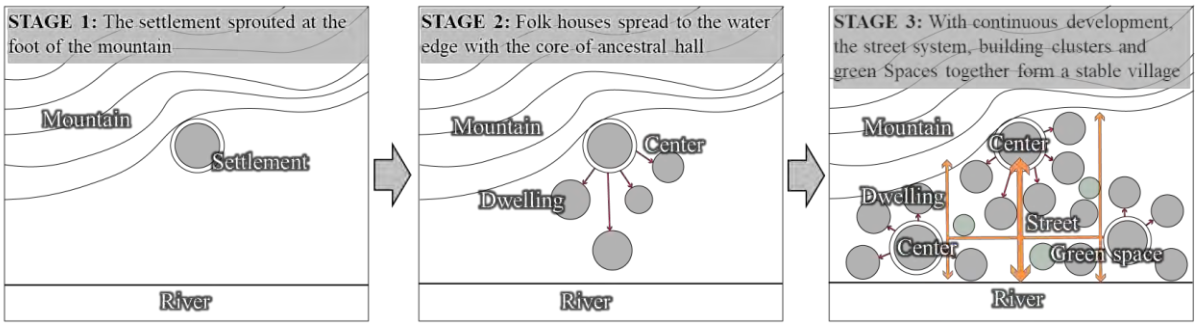

Figure 7. Climate response phase of traditional villages. Source: Self-draw.

First of all, in the early stage of site selection, the village center is usually laid out in the flat terrain area at the foot of the mountain from the perspective of security defense. On the one hand, the relatively independent and closed environment is conducive to resisting foreign invasion during the war period; on the other hand, the mountain can be used as a barrier to withstand wind when building a residence at the foot of the mountain. By using the valley trend to guide the wind direction to create a good wind environment, the site selection by water can achieve the role of cooling and humidifying in summer through the specific heat capacity of the water, so as to maintain the safety of the natural environment. On this basis, residential houses began to expand outward from the settlement center. In order to facilitate production and living, villages often developed in the direction of water sources and arranged building groups in accordance with the terrain. Street spaces naturally formed in the blank areas, and ventilation corridors formed along the water streets and vertical streets. Finally, when the village expands to the limit of environmental capacity, a relatively stable settlement organization is formed. The local microclimate is further optimized through vegetation planting, small green spaces in front and back of the house, and internal courtyards and patios of the building, which gradually develops into an organism integrated with the natural environment.

4.2. Climate regulation of plain water network villages

The Yangtze River Delta is the most developed area of water network system in China. The water network is dense, and the layout of settlement groups is closely related to the trend of water. The building community is built around the water, to meet the daily water needs and use the water to regulate the microclimate of the settlement. There is no building shielding above the river course, which plays a role in guiding the wind direction and forming the water and land wind. During the day, the solar radiation is strong, and the water surface absorbs a lot of heat but the temperature increases little, while the temperature over the land increases significantly. A temperature difference is formed between the two, which promotes the effect of hot pressure ventilation blowing from the water surface to the land, thus relying on the evaporation of the water body to absorb heat and reduce the ambient temperature. At night, there is no solar radiation, the ground specific heat capacity is small, heat dissipation is fast,

resulting in the ground temperature is lower than the water surface, and the wind blows from the land to the water surface.

Under the principle of climate regulation, the spatial form of the plain water network is mainly characterized by high-density centralized buildings and grid narrow streets. The building is built along the river and opens to the side facing the water body to introduce as much water draught as possible and take away the hot and humid environment inside the building.

4.3. Climate regulation of mountain valley villages

Mountain valley villages are located in a certain area suitable for construction in the gentle slope, the mountain occluded to form a relatively hidden introverted settlement, build a natural protection border, in ancient war is easy to defend but difficult to attack the military. In addition to safety and defense, mountain valley villages often choose areas with stable mountains and gentle slopes to reduce the impact of natural disasters such as landslides. In terms of climate regulation, the enclosure of the mountain can not only resist the influence of large wind pressure on the settlement, avoid the infiltration heat loss caused by strong winds, but also use the trend of the valley to form a natural wind channel, so as to achieve good ventilation and heat dissipation effect for the settlement.

Under the common influence of natural environment and social development, the spatial form of mountain valley villages is mainly characterized by free layout of buildings along contour lines and semi-natural streets depending on the mountain. In order to reduce the damage to the natural mountain environment, the dwellings were built according to the terrain and the height difference formed between them, which can reduce the occlusion, obtain ventilation and sufficient sunshine. In addition, vertical streets perpendicular to the contour line, as the height increases, the wind speed and temperature increase, then there is often a dense forest between the mountain and the building community, forming a multi-level transition system of mountain - forest - building - street, providing an effective buffer space for climate change.

4.4. Climate regulation of mountain dock and lake bay villages

The slope of mountain dock and lake bay is gentle, and the settlement "back mountain and face water" get the proper orientation at the same time, with reasonable layout, is conducive to the formation of a good microenvironment. The village is located on the south side of the mountain, which will not be blocked by the mountain, but also can use the mountain to resist the winter wind from the north. At the same time, conforming to the dominant wind direction in summer, the layout is between large water bodies and mountains, and the cooling effect is enhanced by the circulation effect of water, land and valley winds according to the local situation, which is an excellent treasure in the Chinese traditional "Fengshui" science.

The spatial form of mountain dock and lake bay villages is mainly characterized by the group distribution of buildings behind the mountain and the water on the surface, and the infiltration street along the river to the mountain. Many large water bodies and streams between the mountain not only serve as drains for the mountains and forests in the rainy season, but also provide convenient places for residents to collect water and dock boats. In addition, the streets, squares and other public spaces of the settlement are also arranged along the water, reflecting strong hydrophilic characteristics.

5. Conclusion

In the Yangtze River Delta region of China, where summer is hot and winter is cold, year-round high humidity and land resources are extremely scarce, traditional villages combine the natural environment, adapt to local conditions in terms of site selection and spatial form organization, and use various wisdom

to create a livable and sustainable living environment. This paper takes three typical traditional villages of plain water network type, mountain valley type and mountain dock and lake bay type as the research object, conducts a comparative study on the climate suitability of settlement siting at the macro level, street space and building group layout at the meso level, and summarizes the self-organization stage of traditional villages based on climate response and the organizational characteristics of the three types of villages.

It is found that the traditional villages in the Yangtze River Delta region generally have a role stage of safety defense, convenience of production and life, and environmental construction in terms of climate response. The streets and alleys of the water network village in the plain are grid, and the building groups present a high-density centralized layout; the valley village buildings in the mountain are arranged along the contour line; the village buildings in the mountain dock and lake bay face the water surface, and the streets and alleys penetrate deep into the mountain from the water.

The three typical traditional villages adopt a variety of spatial means to adjust the climate under different natural environments, and the green wisdom contained in them brings enlightenment to the current new rural construction and the improvement of living environment. When building a comfortable microclimate, the natural environment should be fully respected, the scientific wisdom of traditional village construction should be flexibly applied, the actual social resource conditions should be comprehensively considered, and the excellent cultural genes should be inherited while creating a comfortable and livable settlement environment, so as to realize the dual sustainable development of traditional culture and green habitat.

6. References

Alberto Martilli,E. Scott Krayenhoff & Negin Nazarian. (2020) 'Is the Urban Heat Island intensity relevant for heat mitigation studies?', *Urban Climate(C)*, Volume 31, 100541.

Akbar Naji,Abubakar Ismaila Rimi & Bouregh Adel Saleh. (2020) 'Fostering Urban Sustainability through the Ecological Wisdom of Traditional Settlements', *Sustainability*, 12(23), 10033.

Banerjee Shreya,Ching N. Y Graces,Yik Sin Kang,Dzyuban Yuliya,Crank Peter J.,Pek Xin Yi Rachel & Chow Winston T.L.. (2022) 'Analysing impacts of urban morphological variables and density on outdoor microclimate for tropical cities: A review and a framework proposal for future research directions', *Building and Environment*, Volume 225, 109646.

Cheng Haifan,Chen Peng & Hu Rong. (2022) ' Study on the Climate Adaptation of Traditional Dai Villages: Taking Manyuan Village as an Example', *China City Planning Review(04)*, 38-47.

C Zhou,S Wang,J Wang. (2019) 'Examining the influences of urbanization on carbon dioxide emissions in the Yangtze RiverDelta,China:Kuznets curve relationship', *Science of the Total Environment*, 675:472-482.

Dougherty Thomas R. & Jain Rishee K.. (2023) 'Invisible walls: Exploration of microclimate effects on building energy consumption in New York City', *Sustainable Cities and Society*, Volume 90, 104364.

Fu, J. , Zhou, J. , & Deng, Y. . (2021). *Heritage values of ancient vernacular residences in traditional villages in western hunan, china: spatial patterns and influencing factors*. Buildenv [online]. Available at: DOI 10.1016/j.buildenv.2020.107473

Gholami Rostam Mehdi & Abbasi Alireza. (2023) 'Dynamic climate-adaptive design: A key to realizing future-proof energy efficiency in building sector', *Applied Energy*, Volume 341, 121146.

Ma HeDan & Tong Yuquan. (2022) 'Spatial differentiation of traditional villages using ArcGIS and GeoDa: A case study of Southwest China', *Ecological Informatics*, Volume 68, 101416.

Oke, T.R., et al., (2017) *Urban Climates*. Cambridge University Press, Cambridge

Rashid Najiba,Alam J A M Mostahidul,Chowdhury Md. Arif & Islam Syed Labib Ul. (2022) 'Impact of landuse change and urbanization on urban heat island effect in Narayanganj city, Bangladesh: A remote sensing-based estimation', *Environmental Challenges*, Volume 8, 100571.

Xiong, Y., & Jin, M. L. (2017) 'A brief analysis of the microclimate construction of the classical garden space in the south of the Yangtze River: Taking the garden as an example', *Chinese Landscape Architecture*, 33(04), 35–39 (in Chinese).

Xiong Yao,Zhang Jianping,Yan Yan,Sun Shibo,Xu Xiyan & Higueras Ester. (2022) 'Effect of the spatial form of Jiangnan traditional villages on microclimate and human comfort', *Sustainable Cities and Society*, Volume 87, 104136.

Yin Shi,Hua Junyi,Ren Chao,Liu Sheng,Lin Hankun,Huang Songyi. & Xiao Yiqiang. (2023) 'Impact of synoptic condition on urban microclimate variation: A measurement study in a humid subtropical city during summer season', *Urban Climate*, Volume 47, 101350.

Z Wang,C Cui,S Peng. (2019) 'How do urbanization and consumption patterns affect carbon emissions in China?Adecomposition analysis', *Journal of Cleaner Production*, 211:1201-1208.

Zhiwei Zeng,Li Li & Yue Pang. (2017) 'Analysis on climate adaptability of traditional villages in Lingnan, China--World Cultural Heritage Site of Majianglong Villages as example', *Procedia Engineering*, Volume 205, 2011-2018.

Research Paper

A Comparative Study of the Indigenous Adaptation Mechanisms to Climate Change in Informal Settlements

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Abstract

More than half of the world's population now lives in urban areas. Out of every ten urban residents, more than seven are in low and middle-income nations and approximately 60–70% of the urban population lives in informal settlements. These settlements are built outside the "formal" system of laws, and regulations meant to ensure resilient structures, settlements, and systems. These sites are chosen by the residents because they are less likely to be evicted as the land is unattractive to developers. Most housing structures in these settlements are of poor quality, making them high-risk areas, Also the inhabitants are the most vulnerable and marginal section of the urban population. Informal settlements are located on lands that are not only unattractive but also at high risk of flooding and landslides. There has been a little critical review of the indigenous measures for coping with climate change in informal and slum settlements in Nigeria. This research explores the indigenous measures for adapting to climate change in informal settlements. The study examines how inhabitants of informal settlements cope with climate change and presents a comparative study of the indigenous adaptation mechanisms across some informal settlements in Nigeria, thereby determining the effectiveness of these mechanisms and how they can be incorporated into urban management policies. Reviews of literature and conceptual examples were used to gather information on climate resilience in informal communities, adaptation, mitigation strategies for climate change, etc. Findings revealed that; inhabitants of informal communities employ a combination of strategies to cope with the impacts of climate change; their capacity to respond is not equally distributed across informal settlements in Nigeria because of the socio-cultural differences, and the prevailing economic and political constraints. It was therefore recommended that; economic and political constraints should be reduced through government policies and programs to minimize the consequences of global climate change; adaptation strategies should be more inclusive, among others. Also, achieving resilience, inclusiveness, and low-carbon development in informal settlements can be made possible by upgrading such communities which will reduce the risks associated with climate change and provide multiple economic and social benefits.

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Keywords

Inclusion, adaptation, vulnerable, indigenous, policy, informal settlement

1. Introduction

The greatest threat to our planet's existential is climate change primarily caused by human activities. Climate change has become one of the cutting edges of several environmental debates globally. Yet, for many poorer regions especially in developing countries including Nigeria, the effects of climate change

are a daily reality (Singh et al. 2014). In Nigeria, vulnerability to climate change is becoming more intense because urbanization continues to push people into cities in different regions of the country and gradually expands these towns and cities to flood plains and coastal strips where they are further exposed to more coastal flood risks (Ekoh S. 2021). The effects of climate change are local and different across social groups, Also, adaptation strategies may vary from one location to another, between economic and cultural backgrounds among other factors.

Urbanization often leads to the growth of informal settlements thereby creating new climate-vulnerable areas because of housing being built in high-risk areas, poor quality structures, and limited access to basic facilities and services among other things. The vulnerability assessment of the urban poor has shown that they display weak adaptive capacity due to their already vulnerable state (Olotuah, 2007). Informal settlement communities are at the forefront of the impacts of climate change: already located in areas prone to flooding, climate change-induced extreme weather events and sea level rise are disproportionately impacting these vulnerable communities by exacerbating the adverse conditions. Researchers are beginning to gauge the precise impacts of climate challenges on the human experience in these vulnerable communities. According to the Intergovernmental Panel 6th Assessment Report (IPA) on climate change, the growth of vulnerabilities is at its peak in urban settlements, and gains in well-being in such areas can be achieved by prioritizing investments to reduce climate risks for low-income and marginalized residents and targeting informal settlements (Adesina, et.al 2014).

According to Un-Habitat (2013), informal or marginal settlements are spread and located in vulnerable areas such as swamps, canal setbacks, rail line setbacks, and marginal land among others, deprived of basic infrastructural services which are mostly inhabited by the urban poor. These settlements are at higher risk of the effects of climate change (UNISDR, 2013). Some of the challenges of such settlements across Nigeria as identified by the Population Reference Bureau (PBF) in 2004 include vulnerability to environmental hazards, natural disasters, public and reproductive health, and poverty.

Informal settlements are mostly concentrated in urban areas of low- and middle-income nations. They are built outside the 'formal' system of laws and regulations that are meant to ensure resilient structures, settlements, and systems since the residents of such settlements cannot afford 'formal' housing, (Singh et al. 2014). The low economic status, inadequate facilities and services, and limited voice representation in governance make the inhabitants of informal settlements more vulnerable and hence often lack the capacity to cope with the effects of climate change. This is also coupled with the inhomogeneity nature of the residents which makes policy interventions highly expedient. The 'extent of risk depends on the level of vulnerability and the effectiveness of adaptation for the settlement or region. Addressing the risks associated with climate change in informal settlements will foster resilience, livability, and social inclusion in such settlements. Identifying and assessing the indigenous adaptation measures to climate change in various communities will further help in specific policy interventions and at the same time holistic.

Adaptation, especially in cities and developing countries, has increasingly become a focus of international organizations and academia, which has resulted in the production of recommendations, guidelines, and priority areas for action, African Adaptation Initiative (2018). This study focuses on the local and indigenous measures of adapting to flooding in informal settlements.

2. Methodology

The social vulnerability and adaptation approach views disaster as a natural hazard and human action as espoused by Wisner et al. (2003) and Cannon (2000), This approach was used for this study to explain climate change coping mechanisms among residents of informal settlements. The approach suggests that the risks involved in disasters must be critically analyzed from the aspects of connections between the risks people face and the reasons for their vulnerability to such risks. The principal methodology involved a scoping bibliographic review of literature and conceptual examples to collect and analyze information on climate change, vulnerability, climate resilience in informal communities, indigenous adaptation, and mitigation strategies for coping with climate change, general and global practices on adaptation, and other published research on climate change impacts in Nigeria. The effectiveness, efficiency, and sustainability of the Indigenous adaptation mechanisms for climate change were also reviewed. Eligibility criteria for selecting existing literature were all types of peer-reviewed publications reporting on climate change or related extreme weather events (as defined by the United Nations Framework Convention on Climate Change), informal settlements (as defined by UN-Habitat), low- and middle-income countries (as defined by the World Bank) and impacts on informal settlements. Also, one city was selected from each geographical region vulnerable to flooding among which are Port Harcourt (Rivers State – South), Lokoja (Kogi State – North-Central), and Lagos (Lagos State South-West).

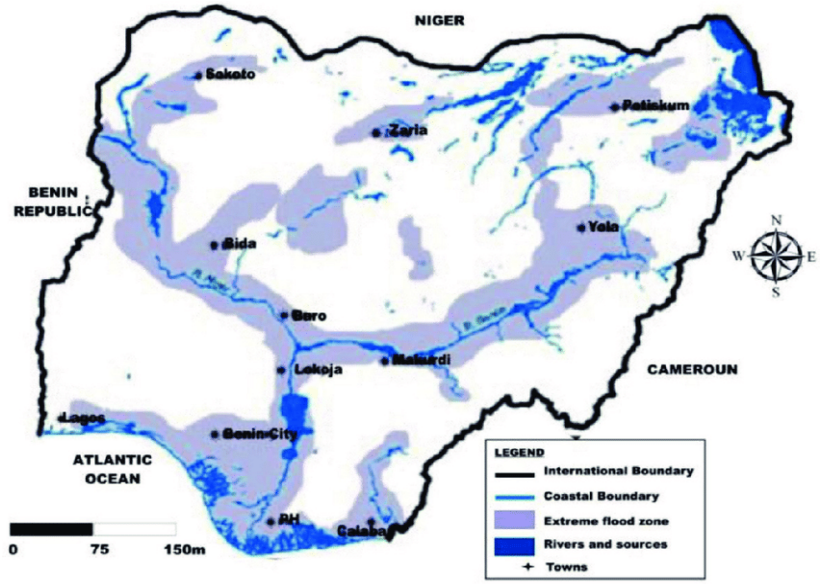
2.1 Why Nigeria?

Nigeria is located on the western coast of Africa with a climate ranging from arid to humid equatorial. The country is majorly drained by River Niger from the northwest and River Benue from the northeast of the country draining into the Niger Delta (see Fig1). The drainage basin of the country occupies about 20% of the nation's landmass, Wright (1985).

Globally, areas along the coast or sea level elevation below 200m above sea level are always at risk of flooding as seen in the place along the course of River Niger and River Benue, (Multiple Media Report, 2022; Schraven et.al., 2019). According to (Mark, 2015), people who are less economically powerful are more likely to reside in the most high-risk areas where land costs are low, they are outside the "formal" system of laws, and regulations meant to ensure resilient structures, settlements, and systems are absent. Therefore, Nigeria is recognized to be vulnerable to climate change and variability, (Aizebeokhai 2011).

Furthermore, most cities in Nigeria are currently experiencing climate change impacts and face development challenges, thereby increasing risks and vulnerability.

Figure 1. Hotspots of Flooding in Nigeria



Source: Nkwunonwo et al. Hotspots of flooding in Nigeria.

3. Review

3.1. Informal Settlements, Vulnerability, and Adaptation to Climate Change

A study conducted on vulnerable spaces by Ekoh, S & Teron, L (2023) proved that physical vulnerabilities occur across various income groups, but wealthy people invest in more resilient structures and other strategies to minimize the impact. The extent to which a person's life and livelihood, property, and other assets are vulnerable to hazards is influenced by socio-economic status, ethnicity, gender, health and immigration status, age, and the nature and extent of social networks. Wisner et al (2003) also acknowledge that disaster victims do possess the capacity to anticipate, cope with, resist, and recover from the harmful effects of natural hazards. Cannon (2000) arguing from the same vein, identifies five components of vulnerability that influence an individual's coping capacity. The inhabitants of informal and slum settlements are highly vulnerable to hazards posed by climate change due to the settlement conditions characterized by poor and clustered houses, poor sanitation, infrastructure deficit, etc. They are also economically marginal lacking social and societal protection, (Elshiet, 2022). On the other hand, Adger, (2006) defined vulnerability as "a state of susceptibility to harm, in other words, it is a state where people are unable to cope with harmful conditions, which is always influenced by socio-economic factors, (Wisner et al. 2004).

Climate change adaptation involves any activity or a combination of activities that reduce the negative impacts of climate change and/or takes advantage of new opportunities that may be presented, (Wang

et.al. 2009). Adaptation is a critical and useful tool in fighting the dangers of climate change which includes an adjustment to ecological, social, or economic systems which is a two-step process involving awareness of changes and adaptation strategies, (Nneka 2015).

Most informal settlements are located on lands that are at high risk from flooding and landslides; these sites are chosen by the residents because they are less likely to be evicted as the land is unattractive to developers (UN-Habitat 2013). Most housing structures in informal settlements are of poor quality making them high levels of risk areas. Thus, the conditions of life in informal settlements elevate risks from most climate change impacts (UNISDR, 2013). Informal settlements are defined based on contraventions of specific laws, rules, and regulations. These include settlements on land acquired from the owner (and thus not illegally occupied) but that were illegally subdivided (Rojas 2018).

According to Watson (2009); and Porter (2011), with the continuous increase in hazards and disasters related to climate change, substantial damage to residential and commercial structures is inevitable and flooding is one of the most costly and destructive natural hazards, buildings can be washed away due to forceful impact of the water under high velocity.

Thus far, the vulnerability to climate change falls within the lines of income which in turn affect one's ability to cope and recover from its effect. Poor housing conditions, lack of or inadequate provision of infrastructure and services, unregulated land use, etc. increase vulnerability to the effects of climate change in informal settlements, (Mark 2015).

3.2. Climate Change Adaptation in Informal Settlements – A Comparative Study

Throughout history, communities have come up with measures to adapt to life in a changing climate that involves a lot of adjustments to actual or expected future climate to reduce vulnerability to harmful effects. While climate change is global, it is felt on a local scale therefore cities and municipalities are at the frontline of adaptation, (Shemdoeb, R 2018 et al.).

Adaptation to actual and expected impacts of climate change in the context of interacting non-climatic changes involves changes in socio-ecological systems in response (Moser and Ekstrom, 2010), this can range from short-term coping to longer-term, deeper transformation, etc. People employ adaptation strategies to reduce adverse environmental effects and enhance opportunities for well-being. Liana, Pietro, Silvia, and Cerbara (2012) observed that low-income or poor people whose livelihoods depend on natural resources are likely to choose to adjust or diversify their livelihood as compared to people who are less dependent on these resources tend to migrate to less vulnerable areas. The adaption action to the effect of climate change can be seen in three major ways; adjustment; diversification; and substitution which also constitute a locally relevant sub-set of eight universal human adaptation processes, namely: mobility, exchange, rationing, pooling, diversification, intensification, innovation, and revitalisation (Thornton & Manasfi, 2010).

3.3. Climate Change Adaptation in Lagos State

According to Eshiet (2022), residents of Ilaje-Bariga and Makoko communities of Lagos have become ingenious and resilient to flooding and have devised strategies to mitigate its impacts on their livelihoods and environments by building high walls around their houses, the use of containers to evacuate floodwater from inside the rooms, filling rooms with sand/sawdust /stone bags to reduce and absorb the water in the room, taking all my valuable clothes and other properties to my relatives' houses until the rainy season is over, relocating to live with friends and relatives in other communities that do not flood until the rains are over. Lawanson, et al. (2023).

Similarly, indiscriminate waste disposal contributes significantly to flooding in Lagos (Gandy, 2006), and due to the failure of the government to come up with essential municipal services, most households, neighborhoods, and/or individuals come up with their waste management practices which include neighborhood community-policing strategies to monitor indiscriminate waste disposal (Ekoh & Teron 2023).

Flood events usually leave the environment dirty and clogged with all manner of solid waste. To cope with the after-flood sanitation, community members engage in cleaning and clearing the surroundings and drainages. Community members also engage in filling the streets with sandbags, sawdust, and concrete stones, putting wooden shavings/planks on the streets, constructing wooden bridges, and the use of canoes as a means of moving around. Some other adaptation mechanisms by the inhabitants of informal settlements in Lagos include creating public awareness of the impact as a measure of preparedness for future occurrence, (Musa and Narsiah 2015). A study by Akinsorotan and Olujide (2007) revealed that communities with functioning Community Development Association (CBA) have successfully implemented both structural and non-structural disaster management strategies in Lagos State.

3.4 Lokoja – The Confluence Flood Plain

Lokoja the capital of Kogi state is a confluence town therefore highly contiguous to many water bodies and wetlands. Communities along single-river floodplains normally experience single-riparian flooding. Still, in the case of Lokoja being a confluence point between the two major Rivers Niger and Benue, the situation is exacerbated by the double riparian generated by the two large water bodies (Anunobi, 2000). These areas are characterized by minimal or low urban planning, poor environmental conditions, insufficient urban management, design materials, and technology of buildings that are rudimentary with shallow foundations, mud walls, thatched roofs that could hardly withstand flooding, etc., and are mostly occupied by low-income or middle-class households. Satherthwaite et al.2007).

According to Opaluwa et al. (2020), some of the effects of climate change in Lokoja as attested by residents include excessive flooding and erosion which always result in the destruction of houses,

properties, and lives, increase in rainfall which increases diseases and pests' infestation, increase in temperatures etc. However, in agreement with Coster and Adeoti (2015), residents claim they use more than one adaptation strategy to cope with the effects of climate change because a single strategy is not always adequate. Among these strategies are early preparedness by clearing the drainages where they exist, the elevation of buildings with high foundations, communal flood alert system, relocation, and adjusting dates for crop planting in terms of agriculture among others. Other interventions by the government are creating awareness, early alerts, and improving channels by widening, deepening, dredging, and removing obstructions.

Figure 2. Flooding in Lokoja, Kogi State

Source: Premium Times October 12, 2022

3.4 Climate Change Adaptation in Port Harcourt

As the effects of the climate crisis intensify, residents of Port Harcourt have deployed different coping techniques for them. Results from a study conducted by Greenwalt et al. (2021) on climate change adaptation and community development in Port Harcourt showed the most common impact of climate change noticeable by residents based on the knowledge and awareness include increasing intensity and frequency of rainfall, temperatures, and flooding which align with the current popular scientific research on the impact of climate change. Furthermore, some adaptive mechanisms adopted by residents are the construction of high tables for storage of personal belongings to avoid being flooded, raising floors, doorsteps, and beds to prevent water ingress, improving waste management by designating more dumpsites, clearing, and cleaning drainages and gutters, etc. (Greenwalt et.al. 2021). While these coping strategies are at individual or household levels, there are some coordinated measures by the communities which include tree planting, construction of gutters, berms, and nets, and improving environmental standards with little or no participation of authorities. However, beyond all the listed measures are finance, knowledge (warning), and awareness of climate change which ranked high among all.

3.4 Global Recommendations for Adaptation in cities and developing countries.

The "Adapt Now" report calls for a revolution in understanding the risks, solutions, and awareness of climate change by building climate resilience by upgrading living conditions in vulnerable communities, strengthening the local capacity, drawing on community knowledge, and increasing climate-resilient investments and capture value from adaptation benefits (GCA 2019).

Also, according to Filho et al. (2019), cities should focus on prioritizing actions, proper planning, integrated approach that considers structural and development issues more on vulnerable communities.

The World Resources Institute (WRI) (2018) highlighted that cities thrive better when they invest in climate-resilient infrastructure, information management systems, and risk-reduction programs hence government should demand that homeowners and landlords invest in bringing their existing and new buildings up to official standards while they help with the cost for connecting these buildings to infrastructure and services. Access to ''formal'' housing by increasing the supply and reducing the cost should be key components and developing policies or programs of government. Complimentary strategies to first reduce climate change-related risks should be developed through upgrading informal settlements as an entry point to promote inclusive urban development because successful interventions require local catalysts rather than top-down approaches that make inhabitants of informal residents feel marginalized and excluded.

4. Conclusion

Throughout history, interest in the resilience of cities and communities to climate change impacts has continued to grow and people have continuously devised means of coping with such impacts the vulnerability to climate change falls within the lines of income which in turn affects one's ability to cope and recover from its effect.

Most responses to climate change in Nigeria are largely reactive rather than proactive this is expected from people who live in structurally compounded inequality and marginalized. Generally, adaptation is undertaken by different actors of the community ranging from individual households, community, and in some cases the government even though these communities are mostly built outside the formal system. This study revealed that; Residents of informal settlements adopt more than one strategy as a way of coping with the impact of climate change because a single strategy is hardly adequate, sustainable, or even effective, some of which include;

Early preparedness by clearing drainages where they exist, the elevation of buildings with high foundations, communal flood alert system, relocating/migrating, and adjusting dates for crop planting in terms of agriculture among others.

The low economic status, inadequate facilities and services, and limited voice representation in governance make the inhabitants of informal settlements more vulnerable and hence often lack the capacity to cope with the effects of climate change this is also coupled with the inhomogeneity nature of

the residents which makes policy interventions highly expedient. The 'extent of risk depends on the level of vulnerability and the effectiveness of adaptation for the settlement or region. Addressing the risks associated with climate change in informal settlements will foster resilience, livability, and social inclusion in such settlements. Identifying and assessing the indigenous adaptation measures to climate change in various communities will further help in specific policy interventions and at the same time holistic.

4.1. Recommendations

Findings from reviewed literature proved that to improve the adaptation to climate change in informal settlements, the following must be considered.

1. Marginal communities must be included in the wider and structured plan for the country rather than the indigenous measures adopted by the residents which are hardly adequate or effective,
2. To achieve more positive results, the Climate Change Act must be implemented by the Nigeria Climate Change Commission at the national level while the state and non-state actors must ensure that the commission adequately provides support for the country's fast-growing population,
3. Stakeholders at all levels must prioritize the planning and implementation of green infrastructure to enhance the sustainability of the environment,
4. Also, climate activists, urban planners, policymakers, and goodwill-hearted individuals must intensify debates on a timely response to climate change-related disasters rather than allowing households to devise ways of coping with the impacts,
5. The government must also ensure an upward review of financing urban infrastructure projects to address the survival of its citizens during such disasters.
6. There should be communication and collaboration between communities and officials to ensure housing solutions are responsive to the needs of residents.
7. The presence of community 'disaster committees' at the local level to prepare for, and respond to, emergencies and long-term recovery is also critical in this regard.

5. References

Adesina, F. A., Odekunle, T. O. (2014). *Climate change and adaptation in Nigeria: Some background to Nigeria's response*-III. International conference on environmental and agricultural engineering. Retrieved from https://www.researchgate.net/publication/228839655

Adger, W. N. (2006). Vulnerability. *Global environmental change*. 16, 268–281.

Agrawal, A. (2010). *Local institutions and adaptation to climate change*. In R. Mearns, & A. Norton (Eds.). Social dimensions of climate change: Equity and vulnerability in a warming world (pp. 173–197). Washington DC USA: The World Bank.

Adger, W. N. (2006). Vulnerability. *Global environmental change*. 16, 268–281.

African Adaptation Initiative (2018) *Enhancing action on adaptation in Africa.* Discussion paper for Africa State of Adaptation Report

Akinsorotan, A., and Olujide, M. (2007). *Community development associations' contributions to self-help projects in the Lagos State of Nigeria*. *J. Central Eur. Agric.* 7, 609–618. doi: 10.5513/jcea.v7i4.402

Alzebeokhai, A,P (2011). *Potential Impact of Climate Change and Variability on Groundwater Resources in Nigeria.* African Journal of Environmental Science and Tech. Vol, 15(10) pp 760-768 ISSN 1996-0768

Anunobi, A.I. (2014). *Informal Riverine Settlements and Flood Risk Management: A Study of Lokoja, Nigeria*. Journal of Environment and Earth Science www.iiste.org ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online) Vol.4, No.12, 2014

Artur, L. and D Hilhorst (2012), "*Everyday realities in climate change adaptation in Mozambique*", Global Environmental Change Vol 22, No 2, pp. 529–536

Coster, A.S., Adeoti, A.I. (2015). *Economic Effects of Climate Change on Maize Production and Farmers' Adaptation Strategies in Nigeria*: A Ricardian Approach. J. Agric. Sci., 7(5), 67–84 *Urban.* 20, 187–205. doi: 10.1177/0956247808089156

Ekoh (2021). *Vulnerabilities, Flood Risk Perceptions and Future Migration Intentions Among Coastal Residents of Lagos, Nigeria. College of Environmental Science*. Available online at. https://suny-esf researchportal.esploro.exlibrisgroup.com/esploro/outputs/doctoral/Vulnerabilities Flood-Risk-Perceptions-and-Future/99895521904826#file-0 (accessed March 16, 2023).

Ekoh S.S. & Temor, L (2023) Vulnerable spaces, unequal responses: lessons for transformative climate resilience in Lagos Front. Sustain. Cities, 18 April 2023. Climate Change and Cities Volume 5 - 2023 | https://doi.org/10.3389/frsc.2023.929121

Eshiet, I. (2022). Flooding And Adaptation: Coping Strategies of Slum Dwellers in Lagos, Nigeria. https://www.researchgate.net/publication/362016516

Filho W, Balogun AL, Olayide OE et al. (2019) *Assessing the impacts of climate change in cities and their adaptive capacity:* Towards transformative approaches to climate change adaptation and poverty reduction in urban areas in a set of developing countries. Sci Total Environ 692:1175–1190

Gandy, M. (2006). *Planning, anti-planning, and the infrastructure crisis facing metropolitan Lagos. Urban studies.* 43, 371–396. doi: 10.1057/9780230603349_12

Lawanson, O. I., Proverbs, D., and Ibrahim, R. L. (2023). *The impact of flooding on poor communities in Lagos State, Nigeria:* The case of the Makoko urban settlement. *J. Flood Risk Manag.* 16, e12838. doi: 10.1111/jfr3.12838

Liana, R., Pietro, D., Silvia, M., & Cerbara, L. (2012). *Investigating the livelihoods of the population dependent on natural resources and their concerns* (Working paper, adapting to climate change in coastal Dar es Salaam project). Rome, Italy: Sapienza University.

Marks, D. (2015). *The urban political ecology of the 2011 floods in Bangkok: the creation of uneven vulnerabilities*. *Pac. Aff.* 88, 623–651. doi: 10.5509/2015883623 1978-2004, Brookings Institution, Washington DC, 360 pages.

Moser, C.O.N., 2017: *Gender transformation in a new global urban agenda: challenges for Habitat III and beyond*. Environment and Urbanization 29(1), 221-236

Muse, S. A., and Narsiah, S. (2015). *The politics of participatory budgeting in Nigeria: a case study of community development associations* (CDAs). *J. Human Ecol.* 50, 263–269. doi: 10.1080/09709274.2015.11906884

Multiple Media Report 2022. https://climatechampions.unfccc.int/nigerias-cities-are at-severe-risk-from-climate-change-time-to-build-resilience-and-fast/

Nigerian Military Government (1978). *Land Use Decree 1978.* Lagos: Nigerian Military Government.

Obiefuna, J., Adeaga, O., Omojola, A. A. A., and Okolie, C. (2021). *Flood risks to urban development on a coastal barrier landscape of Lekki Peninsula in Lagos, Nigeria*. *Sci. African* 12, e00787. doi: 10.1016/j.sciaf.2021.e00787

Nwankwoala, H. N. L. (2015). *Causes of Climate and Environmental Changes*: The need for Environmental-Friendly Education Policy in Nigeria. Journal of Education and Practice Vol.6, No.30

Olotuah, A. O., (2007*). "Strategies of Public Sector Intervention in Housing in Nigeria" Proceedings of XXXV IAHS* (International Association of Housing Science) World Congress on Housing Science, Melbourne, Australia, 4-7 September, CD ROM

Opaluwa H.I, Opeyem G., Eleojo M.J (2020); *Determinants of Choice of Climate Change Adaptation Strategies Among Rural Farming Households in Lokoja LGA in Kogi State Nigeria*. Journal of Agribusiness and Rural Development 57(3) DOI:10.17306/J.JARD.2020.01324

Pelling, M. (2007*). Learning from others: Scope and Challenges for Participatory Disaster Risk Assessment. Disasters*, 31(4) 373-385

Revi, A., Satterthwaite, D. E., et al. (2014). *Urban areas*. In C. Field et al. (eds.), Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the IPCC, Cambridge University Press, 535 612.

Rojas, E., (2018): *No time to waste Appling the lessons from Latin America's 50 years of housing policies to rapidly urbanizing countries*, Environment and Urbanization, 30(2),

Satterthwaite, D., Huq, S., Pelling, M., Reid, H., and Lankao, P.R (2007). Adapting to Climate Change in Urban Areas: The Possibilities and Constraints in Low and Middle In Some Nations Human Settlements Discussion Paper Series.

Satterthwaite D. and S. Bartlett, 2017: *The full spectrum of risk in urban centers*: changing perceptions, changing priorities. Environment and Urbanization, 29(1) 3-14

Shemdoeb, R; Hulmec, D, Mwagenib, N, & Gough, N (2018): *Climate change and declining levels of green structures*: Life in informal settlements of Dar es Salaam, Tanzania Manoj Roya, Journal of Landscape and Urban Planning 180 (2018) 282–293

Schraven, B., Adaawen, S., Rademacher-Schulz, C., and Segadl, N. (2019). *Human Mobility in the Context of Climate Change in Sub-Saharan* Africa: *Trends and Basic Recommendations for Development Cooperation*. Bonn: Deutsches Institut für Entwicklungspolitik (DIE).

Singh, S. R., Eghdami, M. R., and Singh, S. (2014). The concept of social vulnerability: a review from disasters perspectives. *Int. J. Interdisciplinary. Multidiscipline. Stud.* 1, 71–82.

Thornton, T. F., & Manasfi, N. (2010). *Adaptation – Genuine and spurious: Demystifying adaptation processes about climate change*. Environment and Society: Advances in Research, 1(1), 132 155.

UN-Habitat (2003). The challenge of slums: global report on human settlements 2003. London: Earthscan 2003. *Manage. Environ. Qual.* 15, 337–338. doi: 10.1108/meq.2004.15.3.337.3

UN-Habitat (2016). *World Cities Report 2016: Urbanization and Development* – Emerging Futures, Nairobi

United Nations Framework Convention on Climate Change, Nigeria World Resources Institute (2018) Prepared communities: *implementing the Urban Community resilience assessment in vulnerable neighborhoods in three communities*, Washington, DC

Wang, J., Mendelsohn, R., Dinarc, R., Huangd, J., Rozellee, S., Zhangd, L. (2009). *The impact of climate change on China's agriculture. Agric.* Econ., 40, 323–337.

Watson, V., 2009: "Seeing from the "South*: 'Refocusing Urban Planning of the Globe's Central urban issues Issues,* Urban Studies 46: 2259-2275

Watson, V., (2011): *Engaging with citizenship and urban struggle through an informality lens, Planning Theory and Practice*, 12(1).

Weru, J., (2004): *Community federations and city upgrading:* the work of Pamoja Trust and Muungano in Kenya, Environment and Urbanization, 16(1) 47-62. 61

Wright J B (1985); *Geology and Mineral Resources of West*. Allen & Unwin 187 p.

Wisner, B. (2010). Climate change and cultural diversity. *International Social Science Journal, 61*(199), 131-140. Retrieved 8 29, 2023, from https://ncbi.nlm.nih.gov/pubmed/21132942

Wisner, B., Blaike, P., Cannon, T. & Davis, I. (2003). At Risk: *Natural Hazards, People's Vulnerability and Disaster*. Second Edition. London: Routledge

Wisner, B., Blaikie, P., Blaikie, P., Cannon, T., and Davis, I. (2004). *At Risk: Natural Hazards, People's Vulnerability and Disasters.* London: Routledge

World Bank Group, Washington, DC World Climate Research Programme (2019) *Global research and action agenda on cities and climate change science*

Case Study Report

"The two thirds divide: The status of, and strategies for, a Just Transition in Lagos' Built Environment"

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Abstract

There is increasing impacts of climate change in the built environment. Thus, the increasing impact of Climate Change has led to the growing awareness of the need to build for all (local and migrants), and to consider both environmental and human rights aspects of the building process. Lagos, home to 10% of Nigeria's population, is the most populated conurbation in Nigeria, with its metropolitan area projected to reach 16 million in 2023. At the same time, two thirds of this megacity live in informal settlements, under living and working conditions that do not respect the right to live in dignified, affordable, and healthy housing. This research examines the degree to which climate action and decarbonisation in Lagos' built environment acknowledges and addresses human rights dimensions. It also identifies underlying social, political, and economic explanations of the status of the just transition in the built environment. The research provides an overview of the national-local context, and the human rights risks and opportunities found, especially regarding governance, participation and decision-making processes, socio-spatial inequalities, and the right to housing. Findings revealed lack of collaboration and coordination between stakeholders, a top-down centralised government structure facing significant corruption, and ineffective enforcement of locally driven policies. Recommendations aim to inform key stakeholders in government, finance, and businesses on the roles each can play to help address these issues and move towards a just transition in Lagos' built environment.

Keywords

Just Transition, Human Rights, Decarbonisation and Built Environment

1. Background

Approximately 75% of Africa's total CO_2 emissions come from four countries: South Africa, Egypt, Algeria and Nigeria (Global Carbon Atlas, 2021). Nigeria, one of the biggest oil-producing countries in Africa is yet a context where many lack access to electricity. Therefore, it is crucial that the decarbonisation of the built environment in Nigeria is aligned with non-polluting methods e.g. renewable energy, and that it reaches people who need it most: the informal two-thirds of Lagos population. Efforts to decarbonise in ways that respect human rights and seek to address current injustices, are fundamental for policy makers and all built environment actors. (IHRB, 2019, 2021). However, the current context shows critical governance issues at three levels (national, city, and local) that express themselves in Lagos' built environment, and hinder efforts to achieve a just transition for those most affected.

1.1. National climate policies and lack of a built environment decarbonisation roadmap

The Department of Climate Change within the Federal Ministry of Environment (FMEnv) and the National Council on Environment lead the enactment and development of national climate policy in Nigeria. Key climate policies and plans considered in this study are:

• Nigeria's Energy Transition Plan defining the roadmap to meeting NetZero targets;

• Nigeria Long-Term Vision (LTV-2050) proposing to cut emissions in half by 2050 (vs. 2020);

• National Action Plan on Gender and Climate Change for Nigeria (2020) which aims at mainstreaming the consideration of gender equality in climate change initiatives;

• Nigeria Climate Change Act 2021 which aims to drive the country to net zero emissions by 2060.

These national policies and plans reflect the right direction for Nigeria, moving policy towards the ecological transition and attempting to include some social considerations. However, there are gaps in their full adoption. These documents are high-level overviews, and seldom mention the built environment as a key sector for climate action (Popogbe, Akinleye and Oke, 2022). Also, there it is missing a concrete tool such as a built environment decarbonisation roadmap that can be practically applicable at local level by multiple stakeholders

1.2. Neoliberal urban development plan transition plans

There are several and diverse plans, policies, and urban development strategies carried out by the Lagos State Government (LASG), supported by international cooperation agencies, the private sector, and international foundations. For example:

• Lagos Climate Action Plan 2020–2025

• Lagos State Development Plan (LSDP) 2052

• Mainland Central Model City Plan (commissioned to Dar)

• Ikeja Model City Plans, among many others.5

• Building Energy Efficiency Code (BEEC) Lagos State adoption

However, many of these plans and regulations draw on imported policies, ideas and models that are hardly adaptable to the local context. The LSDP 2052, for example, has a vehement focus on accelerating economic growth (GDP) by a factor of 10 and Lagos “becoming Africa’s Model Mega City and Global, Economic and Financial Hub that is Safe, Secure, Functional and Productive”. However, the plan’s strategy provides no detail on how to go from the current two-thirds divide (two thirds of people living in slums), to the proposed “exciting future”. The Ajegunle-Ikorodu Community Resilience Action Plan by Heinrich Böll Stiftung is the only plan that acknowledges and proposes to address the current acute human rights deprivations, and the real needs of the population regarding access to water, education, infrastructure, dignified housing, and clean environments (Onosemuode *et* al., 2022). Hence there is a clear gap between the status quo of Lagos and the futuristic visions of a liveable and thriving city. Since LASG and these plans fail to consider local precarity and because human rights are compromised to begin with, the government is unable to implement and enforce these plans and policies, especially with residents who rely on self-help to cover their basic needs.

1.3. Gaps manifested at the local level

National climate policies and state urban development plans are disengaged from the social and urban reality experienced by two thirds of the population living in slums. Government-led initiatives lack roadmaps to address precarity as a priority. So, despite the multitude of plans and policies, there is still a governance vacuum at caring for basic services in the built environment. This has largely resulted in a self-help approach—residents having to provide basic infrastructure and cover basic needs for themselves—which is unsustainable from the social, economic, urban planning, and political points of view. Lagos' urgent urbanisation challenge, is evident through its housing struggles, disorganisation, and inadequate urban systems that cannot cover inhabitants' basic needs. The results are marginalisation, social exclusion, and various human rights risks.

1.4 Research Methods

Field research was conducted in Lagos, Nigeria between September and December 2022, including literature review, stakeholder mapping, 19 semi-structured interviews with academia (3), finance (2), professional organisations (3), local and state government (3), non-governmental organisations (5), and the private sector (3). The data was collected and analysed through a framework at three levels: (a) national climate action and urban development policies, plans and governance, (b) city strategies for decarbonisation including issues and limitations, and (c) specific examples at the local level – Eko Atlantic City. Furthermore, a visioning session was held online on 3 November, 2022 to present the initial research findings and co-create a vision and pathways for a just transition of Lagos' built environment.

2. Human Rights Risks and Opportunities

The following sections cover some of the human rights issues found in Lagos' built environment. A rigid government structure with limitations of resources and authority poses serious hindrances to the delivery of basic infrastructure, which in turn, denies the right to a clean and dignified environment and right to physical and mental health. Socio-spatial inequalities –a physical manifestation of discrimination– are shaped by asymmetric investment flows and provision of public and social infrastructure to some neighbourhoods and not others. Also, the right to housing is alarmingly compromised by the acute inequalities in the territory and growing housing unaffordability, this is exemplified by the Eko Atlantic Project. Furthermore, lack of mechanisms for citizen participation in city-making processes deepen exclusion.

2.1. Government Structure: Mismatch of responsibilities and capacities

Many urban issues in Lagos are derived from a rigid and centralised government structure –from the central, state, and local governments – where the responsibility for infrastructure development and management is tied to the state government. These limitations handcuff local administrations through lack of flexibility and authority to govern, and therefore lack the executive power to attend to the needs of citizens at local level. This governing incapacity further reinforces the perception of citizens towards the Lagos State Government and its local authorities as inefficient and uncaring, in this way fueling a cycle of distrust. Concentrating local responsibilities and competences at the state level, in practical terms, also means excluding residents from (a) having a local go-to government that is close to them to hear their concerns; and (b) from participating in the processes that shape their own natural and built environments. However, this situation does not diminish the local authorities' central role, quite the contrary: "Nigeria's local governments are disproportionately important; if they functioned well, they would be best positioned

to meet people's basic needs and to build their resilience to cope with everyday challenges" (Amnesty International, 2006; (Popogbe, Akinleye and Oke, 2022).

2.2. Participation and decision making process

Corruption and many bottle necks with bureaucracy and lengthy processes frustrate the desire of residents to be acknowledged and to participate in transition processes. Psychological and physical marginalisation is further accentuated with the criminalisation of living in informal settlements. This results in a direct form of discrimination against these city dwellers and a systematic denial of their right to equal access to public services. The criminalisation also expresses a hardly-escapable paradox imposed by a contradicting, ineffective, and uncaring government system. Results showed top-down unilateral decision-making from the government and the private sector, with little or no engagement from other sectors. Consultations with a wide range of actors in academia, NGOs, and CSOs clearly voiced the need to reshape decision-making methods, to make such processes more inclusive, and thus more aligned with international standards addressing rights to access to information, and participation in public life. Changes would account for meaningful participation of small developers, academia and research institutes, community organisations, residents' associations, related independent professionals and activists. Just opening up the space for dialogue with other actors would contribute to activating a pathway that is more just, where the voices and interests of directly-affected groups can be heard. Some organisations already working to open these 'Spaces for Change' are the Heinrich Böll Stiftung projects, NGO Spaces for Change, HOMEF - Health of Mother Earth Foundation, Futuresavers Sustainable Development Initiative, Ijikoo Research NGO, and Justice & Empowerment Initiatives, among others.

2.3. Socio-Spatial Inequalities

Lagos is faced by acute socio-economic segregation and inequality by income, class and race (Oxford, 2017). Social discrimination against the most vulnerable has been a pattern since the early 2000s in Lagos and other parts of Nigeria. On one hand, massive forced evictions (with no genuine consultations, legal remedies nor compensation) violate the right to housing and also impact the right to work (Amnesty International, 2006). On the other hand, private foreign direct investment in luxury residential developments has made them completely unaffordable to the middle class. The result is an increase, rather than reduction, of the gap between supply and demand of affordable housing, exacerbating the long-present urban inequalities in Lagos. New and various city plans offer an opportunity to address urban governance errors of the past such as the criminalisation of informal settlements. Formal planning with the community in these settlements would help reintegrate and inclusively redevelop these neighbourhoods, while also strengthening people's agency. Most of the city development plans already have a vision of a sustainable and thriving future. What is missing is the formulation of the participatory process, rooted in community-led initiatives and actions that can be transformative towards that vision.

3. Challenging the Right to Housing: The Case of the Eko Atlantic City Project

The Eko Atlantic City (EAC) Project is one of the largest urban developments in Africa. It is located in Victoria Island's waterfront, a prime area in Lagos tailored for the elite and wealthy class. The mixed-use development is a public-private initiative between the Lagos State Government (LASG) and South Energy Nigeria Limited (SENL) with the advertised aim of "mitigating coastal threats, closing the demand and supply housing gap, and attracting foreign direct investment", apparently bringing environmental, social,

and economic benefits (Ajibade, 2017). However, the project's capacity to close the affordable housing gap, and meet criteria of human rights, social justice, and social sustainability is very questionable.

This is an exemplary case of "dispossession and repossession" (Acey, 2018), which is reflected in the 3 main concerns of NGOs, environmentalists, and human rights activists: (1) there are concerning transparency issues as the promoter disregarded regulations e.g. the Environmental Impact Assessment (EIA) was done only 3 years after dredging started, and it did not include the construction phase; (2) insensitivities to potential negative impact on the neighbouring communities, as public engagement was not part of LASG and SENL plans; and (3) the elitist nature of the project (Space for Change, 2013). According to an informal record gathered from the EAC office in October 2022, the minimum allottable area of land is 1,000 m2 (and up to 3,000 m2 plots) at $1,800/ m2 (₦ 803,620,000 Nigerian nairas) for inner plots, and $5,000/m2 (₦2,280,000,000) for plots on major roads and waterfront. This sets minimum purchases at $1.8 million and up to $15 million USD.

By striking contrast, the minimum wage in Nigeria is ₦30,000/month ($66 USD), and average income for residents in vulnerable neighbourhoods of Lagos is approximately ₦23,000/month ($50 USD) (Aliu, Akoteyon and Soladoye, 2021). It would take one of these citizens up to 36,000 months of their full salaries to save for the minimum plot purchase at EAC, so the possibility of accessing this housing is 3,000 years away from them. Hence, the fulfilment of the social aim of the project to "close the demand and supply housing gap" is also thousands of years away.

It could be argued that 1,000-square metres plots are meant to be bought by real estate developers who would in turn build apartments at scale, and not to be bought directly by the citizens. Nonetheless, there is no guarantee whatsoever that at such scale the developerled prices would ever become affordable to the average income citizen. Therefore, following their profit-making model, the business transaction is rather an acquisition for investment and high-rent extraction.

4.0. Conclusion

This research found multiple obstacles in the path towards a just transition in Lagos' built environment: (1) a central government system that allows corruption and incapacitates local authorities, (2) private-led elitist urban development, (3) difficulties in urban planning and policy enforcement due to the self-help model of urbanisation, (4) hyper-exclusion of city dwellers, manifested (5) spatially with two thirds living in criminalised slums, and (6) in the suppression of civil society and academia from decision-making processes.

Overall, there is a disconnection between the national and local scales, between policy and practice, norm and enforcement, and theory and reality. Foreign, privately led, highly financialised, extractive urban development projects exacerbate socio-economic inequalities to the point of creating parallel societies juxtaposed in the same territory, that do not interact with each other e.g. the residents of Eko Atlantic City Project and two thirds of Lagos population living in slums.

At the same time, there are also many opportunities to leverage for an inclusive and sustainable Lagos. The most evident opportunity for change is towards a decentralised inclusive governance structure that empowers local authorities to deliver programmes that meet the immediate needs of their communities. Empowering and monitoring the performance of local authorities would also aid transparency. There is also an incredible potential for innovation and sustainable solutions in the built environment being driven by Lagos' youth, the next generation of designers and architects, and the technology sector. Therefore, it is fundamental to support and channel funding to these emerging and promising grassroots actors.

Another key opportunity is making a conscious effort to strengthen multi-level collaboration between government, businesses, international investors, NGOs, CSOs, unions, universities, and citizens themselves, to ensure residents and workers' rights are upheld. These would be the first steps in rebuilding ties between governments and communities, especially showing more empathy and care towards residents (e.g. by stopping criminalisation of informal settlements) and harnessing the power (talent, knowledge, sources for ideas/solution, and labour force) of marginalised communities. Besides the benefit of improving relations, recognising and utilising community knowledge and local expertise can also generate innovative solutions to various (current and future) urban problems.

5.0. Recommendation

This research study revealed the need for more interactions between sectors, transparent governance, and the development and implementation of local policies to decarbonise the built environment. Interviewees emphasised the need to strengthen collaboration, especially inclusion of currently marginalised communities e.g. indigenous peoples and slum dwellers (who make up two thirds of Lagos' population). There was common agreement among interviewees that this should be championed by local governments by creating avenues for engagement and participation of these groups, which often lack institutional, technological, and financial capacities.

National Government: 2023 and the following years, present a crucial opportunity for new president-elect Bola Ahmed Tinubu and his cabinet to prioritise human rights in the built environment to (1) address the current deficit of basic services in Lagos to approx. 10 million people; and (2) in relation to climate action, fill in the gaps between current policies and plans, and their implementation in practice. This could be achieved by delegating competences and financial flows to local authorities, with strict transparency and accountability mechanisms to avoid corruption.

Ministry of Education and Academia: Initiate, conduct and oversee a curriculum overhauling process that, from primary education to tertiary education, is built around environmental and social sustainability, including just transitions and circular economy. This is essential for generational change of vision, attitude, and future actions.

Lagos State Government: The Lagos State Ministry of Physical Planning and Urban Development should shift to an inclusive urban planning approach, with efficient methods for citizen participation in city-making processes. This would actively employ the currently overseen knowledge, expertise, and scaling power of Lagos' 15 million people. Also, LASG should ensure training on and enforcement of local building codes, including their sustainability provisions.

Municipal Government: Adopt the social urbanism model of governance to prioritise provision of basic services in the built environment e.g. water, sanitation, electricity and dignified affordable housing, in the slums, followed by social infrastructure e.g. health facilities, schools, and community centres. The focus should be on reducing urban inequalities, and respecting human rights of all residents, in particular slum dwellers (two thirds of the population).

Business (Architecture, Engineering and Construction) Seek to engage in projects that benefit the two-thirds of Lagos residents who live in informal settlements and are often overlooked in built environment investments. Avoid corruption and conduct meaningful consultation and human rights due diligence from the earliest stages of projects.

Financial Actors

Instead of extracting rents from one high-priced project, such as Eko Atlantic City, private and financial actors work together with the local and/or state government to create a city-wide housing development/

investment model that allows financial gains from low-priced locked rents at a massive (15 million people) scale.

6. References

Acey, C., 2018. Eko Atlantic and practices of dispossession and repossession in Nigeria. *Disassembled Cities: Social and Spatial Strategies to Reassemble Communities*. , pp. 51–61. https://doi.org/10.4324/9781315104614-5/RISE-SYNTHETIC-CITY-CHARISMA-ACEY

Ajibade, I., 2017. Can a future city enhance urban resilience and sustainability? A political ecology analysis of Eko Atlantic city, Nigeria. *International Journal of Disaster Risk Reduction*, *26*, pp.85-92. . https://doi.org/10.1016/J.HABITATINT.2020.102293.

Aliu, I.R., Akoteyon, I.S. and Soladoye, O., 2021. Living on the margins: Socio-spatial characterization of residential and water deprivations in Lagos informal settlements, Nigeria. *Habitat International*, *107*, p.102293.

Amnesty International (2006). "Nigeria: Making the destitute homeless – forced evictions in Makoko, Lagos State. January 24, 2006 Index Number: AFR 44/001/2006. https://www.amnesty.org/en/documents/afr44/001/2006/en/

Eko Atlantic (2019), Eko Atlantic's Ronald Chagoury Jr talks on challenges, opportunities of doing business in Nigeria, https://www.ekoatlantic.com, Accessed 5th January 2023

Global Carbon Atlas, Country emissions 2021. http://www.globalcarbonatlas.org/en/CO2-emissions

Heinrich Böll Stiftung Nigeria 2018, Urban Planning Processes in Lagos: Policies, Laws, Planning Instruments, Strategies and Actors of Urban Projects, Urban Development, and Urban Services in Africa's Largest City https://ng.boell.org/sites/default/files/180920_upp_2nd_digital.pdf Accessed 5th June 2023

IHRB 2019, Dignity by Design: Human Rights and the Built Environment Lifecycle. https://www.ihrb.org/focus-areas/builtenvironment/report-dignity-by-design-humanrights-and the-built-environment-lifecycle;

IHRB 2022, Transforming the Way, We Build: Advancing a Just Transition in the Built Environment. https://www.ihrb.org/ focus-areas/built-environment/transforming-the-way-we-build advancing-a-just-transition-in-the-built-environment.

Onosemuode, M.O., Airunugba, S.A., Onamade, A.O. and Hussain, K.D., 2022. Impact of Urban Design on Socio-Economic Segregation and Spatial Inequality in Metropolitan Lagos. *Journal of Good Governance and Sustainable Development in Africa*, *7*(2), pp.22-31.

Oxford Analytica, 2017. Lagos's urban development could exacerbate inequality. *Emerald Expert Briefings*, (oxan-db). . https://doi.org/10.1108/OXAN-DB219743.

Page, M.T. and Wando, A.H., 2022. Halting the Kleptocratic Capture of Local Government in Nigeria. Carnegie Endowment for International Peace. https://carnegieendowment. org/2022/07/18/halting-kleptocratic-capture-of-local-government-in-nigeria-pub-87513

Popogbe, O.O., Akinleye, S.O. and Oke, D.M., 2023. A tripartite approach to social inclusion in selected slums in Lagos State, Nigeria. *Review of Economics and Political Science*, *8*(1), pp.2-18.

Rivera, A.V., 2021. Urban context's role in the emergence and development of social innovation. In *Research Tracks in Urbanism: Dynamics, Planning and Design in Contemporary Urban Territories* (pp. 42-50). CRC Press.

Rivera Vinueza, A. (2022). Social Urbanism: Transforming the Built and Social Environment. In: The Palgrave Encyclopedia of Urban and Regional Futures. Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-030-51812-7_58-1

Space for Change (2013), Eko Atlantic City Project: In whose interest? https://spacesforchange.org/eko atlantic-city-project-in-whose-interest/, Accessed 5th June 2023

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From Concept to Implementation; A Lecture for Increasing the Awareness Level of People about Sustainable Cities and Communities in terms of Sustainable Transportation

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Abstract

Transportation is the main driving force and currently the largest end-use of energy in many countries either economic developed or developing countries. So, sustainable transportation is the key element for our future of cities in terms of infrastructure, logistics, affordability, public transportation networks, safety and efficiency of the systems. Besides, not only economic activities, but also the social and physical conditions like air quality, congestion, reducing greenhouse gas emission directly depend on improving the sustainable transportation systems. Increasing the awareness of sustainable transportation tools is a critical issue for communities in order to reduce the gas emissions and efficient use of transportation modes. Universities are one of the stakeholders for enhancing the conscious about sustainable transportation systems. Under the enlightenment of UN Sustainable Development Goals, Abdullah Gül University established the Global (GLB) courses in Kayseri-Turkiye for increasing the awareness of SDG's. This paper analyzes the outcome of the university course (GLB205 Sustainable Cities & Communities – Sustainable Transportation) in terms of SDG11 Sustainable Cities and Communities. Kayseri Metropolitan Municipality is one of the supporters of the lecture by providing the public transportation mode services and bikes. The lecture consists of many individual activities, presentations, group works as well as a case study. During the semester, students experience different transportation modes from the point of sustainability and they recorded their observation weekly. Besides, a survey handled with students and inhabitants in Kayseri for measuring the awareness level of people for sustainable transport modes and zero emission. Inhabitants selected by randomly in downtown Kayseri. According to the outcomes, the analysis points out that not only inhabitants in the city, also students are not aware of why sustainable transportation is crucial for saving our futures. Since 2022, the lecture carried out for four semesters and the results figure out that if the conscious about sustainable transport is improved by education and if the education supported by many activities like experiencing different transportation modes especially bike and other not motorized vehicles, then the awareness of the sustainability from the point of transportation modes increased notable either university students or inhabitants in the city. One of the main outputs of the survey is education level has a direct impact on people behaviors for choosing the sustainable transportation modes. Besides, people are also sensitive about environmental issues and if they have chance to change the climate effects circumstances, they want to help the authorities and other stakeholders in the systems. All in all, the study shows that increasing the awareness of environmental issues by educating people has a positive impact for chancing the transportation mode behaviors and it allows the authorities to reduce the cost of environmental problems by producing new eco-friendly policies.

Keywords: Sustainable Transport, GHG Emission, University

1. Introduction

Transportation is the main driving force and currently the largest end-use of energy in many countries either economic developed or developing countries. One of the important reasons for increasing the greenhouse gas (GHG) emission is enhancing the mobility of people and goods all around the world depending on to the transport activities. This also looks like an achievement of transportation investments, but on the other hand, due to low level of consciousness during the consumption, and choosing the transportation modes, unfortunately environmental conditions are getting worst. Besides, even many saving programs organize, sustainable operations plan and some eco-friendly transportation investments implement, there is still a long way to succeed the Sustainable Development Goals targets.

Sustainable Development Goals (SDGs) are the outcomes of Rio+10 conference on sustainable development that determined by member states of United Nations. There are 17 Goals in a wide range of global problems and each Goal tries to solve a global problem. SDG11 – Sustainable Cities and Communities is one of these goals. SDG11 is about to make cities and human settlements inclusive, safe, resilient and sustainable (United Nations, 2016). In order to achieve SDG11 goal, tenth targets are determined in terms of disaster risk reduction, sustainable transport, sustainable cities and human settlement and national strategies and SDG integration.

European Commission (EC) also try to enhance the sustainable transport modes and mobility in member countries. EC prepared many white papers, reports, legislations for disseminating the sustainable mobility actions (European Commission, 2018). Current tendency for transportation modes is to become more safe, eco-friendly, low carbon emission and resilient systems. For achieving this target, national and local authorities promoting the bike and walking activities. Besides, many cities declare their sustainable urban mobility plan for increasing the modal sharing in cities (Ilieva, et al., 2020).

Sustainable transport implementations have big capacity to interfere the global issues in a short time apart from infrastructural investments. They are cross-cutting indicators especially for climate change programs. For this reason, as it described in the UN report (United Nations, 2021);

> *"…goals can be realized only if the interlinkages between sustainable transport and the Sustainable Development Goals (SDGs) and their targets are well understood and intentionally leveraged to resolve trade-offs and to benefit from potential synergies."*

Practical training is notable for either students or civilians. People gain habits by training on the field trips or during implementation process. Students learn theoretic information in class or via digital platforms whilst training on the fields improve their implementation experiences. As Putz et. al. points out that field trips build knowledge, improve attitudes and enhance behavioral intentions for using sustainable transportation modes either in short or in the long term (Putz, et al., 2018). Without group tasks or navigating by an instructor, experimenting alone isn't good at to learn and to retent for students. Trainers mostly give up to do the activities or doing the exercises if there is no encouragement for them (Halpern & Hakel, 2003).

Abdullah Gül University was established in 2010 as a state university in Kayseri. Since its establishment, the university takes global issues seriously up to its education curriculum either undergraduate or post-graduate programs. GLB (Global Issues) courses are one of the outcomes of this tendency. The courses consist of several components depending on to their relations with SDGs. GLB205 - Sustainable Cities and Communities lecture is one of these courses that is related to SDG11.

The paper mainly consists of four parts:

1-Introduction part that describes the current circumstance about the SDGs, sustainable transportation, Abdullah Gül University position and the GLB205 course description.

2-Methodoly part draws the indicators of the paper such as data, case study method, e.g.

3-Course Concept and Its Implementation part figures out the detail of the course and its impacts on inhabitants.

4-Evaluation part has some conclusion and general comments for the outcomes of the case study and future estimates for sustainable transportation and the level of consciousness about environmental issues.

2. Methodology

The content of this paper is based on a range of sources including TurkStat, either national or international organizations and associations data as well as a case study results in which no data were available, own predictions. Own predictions have mainly been developed to get an idea of the lack of case study results by comparing the local and global tendency.

During the semester, each week students keep their individual recordings in terms of transportation modes. For example, one of the course weeks, students experience the public transportation like tram. Students either group or individual, they start their trip from home or school, thus the trip is home-based school or home-based other. Besides, they also have non home-based trips. So, their trips turn on not an ordinary trip, but they start to recognize the environment and problems. During the journey, they focus on different issues such as driver manners, vehicle circumstances, environmental impacts, traffic jam, passenger attitudes, municipal necessities, e.g. Following week, they present their experience to other students in the first part of the class. By this way, they understand the transportation problems deeply from the different point of modes. Then in the second part of the lecture they experience another mode like bus, taxi, e-scooter, bike. These activities continue during the semester and the data gathers cumulatively. At the end of the semester, students experience all transportation mode in the city.

Bike activity is special for the course content. For the bike lecture week, we organize a bike tour in Kayseri in cooperation with Kayseri Metropolitan Municipality and Kayseri Police Department, and not only GLB205 students, but also the other GLB courses' students join this activity. The bike group pass through the city streets during the lecture hours. By this activity, we try to enhance the awareness of people for non-motorized vehicles.

At the end of the semester, students bring all their experience and write their reports by adding the case study results. The case study consists of ten questions that are all related to measuring the awareness level of people for sustainable transport modes and zero emission. The questions are about the passengers' sexuality, age, literacy, occupation, transportation mode choice, effect size of transportation vehicles on air pollution and carbon emissions, e-vehicle development, doing any facility for producing less carbon emission and saving energy, current transportation tendency, and their suggestions for improving the knowledge about eco-friendly sustainable transportation development.

So, this study is sum of all these activities and recordings as well as case study. Gathered data are compared with other works and a cross-tab analysis did under the enlightenment of case study results.

3. Course Concept and Its Implementation

3.1. GLB Courses and GLB205 Content

Global Issues (GLB) courses consist of several components that are directly linked to SDGs. Each semester many GLB courses open for bachelor students. For instance, 2023 Spring semester, there are fourteen courses for different SDGs. GLB205 Sustainable Cities and Communities – Sustainable Transport course is one of these courses. The course basically organizes with many different components such as individual activities, presentations, group works as well as a case study.

Table 1: GLB205 Sustainable Cities and Communities course description.

Code	GLB 205.01
Name	Sustainable Cities & Communities – Sustainable Transportation
Hour per week	3
Credit	3
ECTS	4
Level/Year	Undergraduate
Semester	Fall / Spring
Type	Elective

Table 2 figures out the course contents. There are 6 learning outcomes (LO) in the course. By the end of the course, the student will be able to;

LO1: Demonstrate how this specific SDG are aligned with AGU values by using a media they chose.
LO2: Analyze SDG11 based on the impacts of transportation to environment and human by observing the city as well as a case study by using specific parameters.
LO3: Relate these goals with your individual fields as well as other fields and make comparison between green transportation modes and others.
LO4: Recognize the impact of your own action and lifestyle while developing a simple plan of action based on that SDG11 rubric.
LO5: Defend the necessity of interdisciplinary understanding of SDGs according to that sustainable transport context of SDG11.
LO6: Identify sources and resources for learning more about SDGs to make important personal and professional decisions by formulating useful questions about sustainable transport and its derivation via experiencing different type of modes.

Table 2: GLB205 course contents and their relationship between learning outcomes.

Topics	**Outcomes**
1st Week; Introduction to the course	
2nd Week; Introduction to Sustainable Transport	LO1, LO2, LO5, LO6,
3rd Week; Transportation Systems	LO2, LO3, L04
4th Week; Sustainable Transport and Urban Planning	LO3, LO4, LO5
5th Week; Public Transport	LO3, LO4, LO5
6th Week; Economic, Environmental and Social Cost of Car Walking activity	LO3
7th Week; Transportation Modes and Sustainability Bus activity	LO3, LO4, LO5
8th Week; Legislation and Institution Taxi activity	LO1, LO2, LO4
9th Week; Bicycle as a Sustainable Transportation Mode Bike activity	LO2, LO3, LO4
10th Week; Bicycle tour in Kayseri	
11th Week; Problems-Challenges-Strategies-Policies-Solutions Tram activity	LO5, LO6
12th Week; Tendencies, Alternative Ways and Zero Emission	LO4, LO5
E-scooter activity	
13th Week; Group Presentations	
14th Week; Case Study	

Lecture aims to assist students to increase their awareness of the definition of SDG11 and enhance conscious about sustainable transport. Lectures have several group studies as well as individual works. Expectation from course members is wide-range conversations with a deep debate and improving the knowledge and conscious about sustainable transport. The course consists of several individual activities, presentations, group works as well as a case study. During the semester, students experience different transportation modes from the point of sustainability and they recorded their observation weekly. The course divided into to two parts. The first part is about verbal section, and the second part is urban activity that students experience the city life and transportation modes in a different perspective by writing their observations systematically as well as recording the activities.

3.2. Transportation Mode Activity

There are currently seven transportation modes in Kayseri. For public transportation, people travel by bus, tram, and bike. Private companies run e-scooter mode not only in Kayseri but all around Türkiye. Taxis also run by privately either individual or companies. Private car and walking are the other alternative transportation modes.

Kayseri Metropolitan Municipality manages the public transportation modes. Actually, the ticket price for bus and tram are quite expensive in terms of purchase power. However, the Municipality offers some discounts to the passengers depending on to their travel time, age, occupation and distance. Price list presents in the Table 3. All prices exchange to US dollar based on July, 2023.

Table 3: Ticket price for public transportation modes in Kayseri.

Ticket Type	Price ($)
Single without discount	0,33
Single with discount	0,16
Subscription without discount	13,8
Subscription with discount	4,6
Teacher	0,31
Credit Card	0,33
Early travel time without discount (05:00-06:45)	0,29
Early travel time with discount (05:00-06:45)	0,14

(Source: (Kayseri Metropolitan Municipality, 2023))

Image 1-2: Bike activity during the GLB205 course in 2023.

During the semester students experience all transportation modes in Kayseri. This activity aims to introduce the student transportation modes for the sake of their effects either social or environmental. In the first part of the lecture, there is an interactive part. Instructor presents a presentation and students talk about their last activities that they did previous week. In the second part of the lecture, students experience a

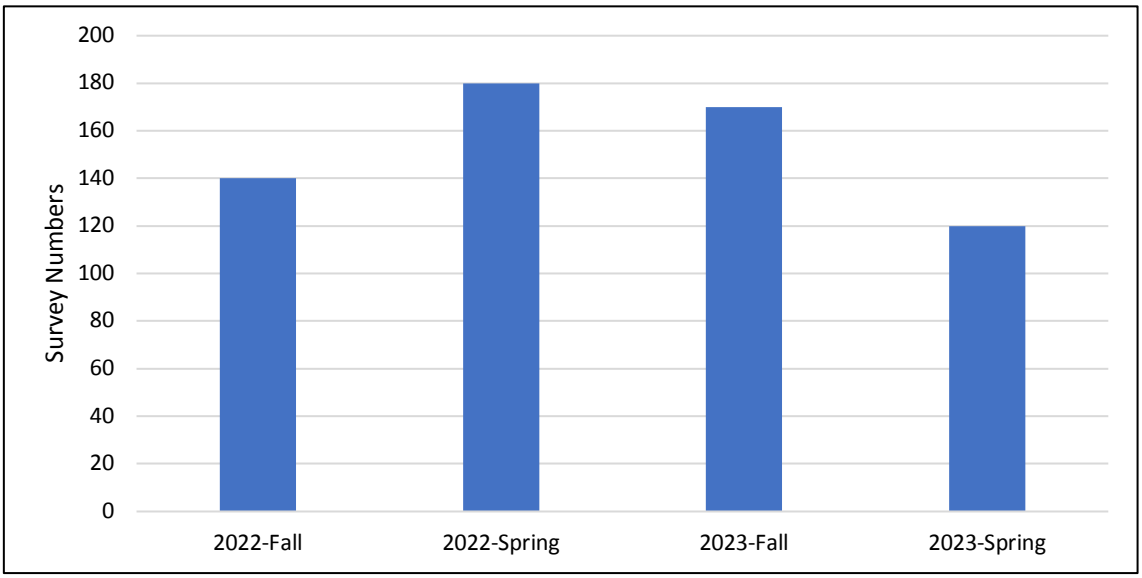
new transportation mode. Along the trip, they write their observations in terms of transportation mode effects to social, cultural, environmental and economic circumstance. They keep up this activity during the semester and at the end of the term, they prepare a portfolio about their experiences. The students come across along the activity with local people and they speak with them about the transportation modes, current problems of modes, expectations for future developments e.g. So, the students recognize the city and its components by practical training.

3.3. Case Study

At the end of the semester, GLB205 course students do a survey in order to measure the awareness level of people for sustainable transport modes and zero emission. Basically, the survey consists of ten questions. However, six of ten questions have also sub-questions. Each student is responsible for doing five surveys randomly in the city. It takes one week and all students enter their results to a google document sheet. By this way, at the end of the week, students are ready to prepare their reports as well their recordings. Table 4 and Graph 1 figure out the descriptive statistics for the case studies that were done for four semesters from 2022 to 2023.

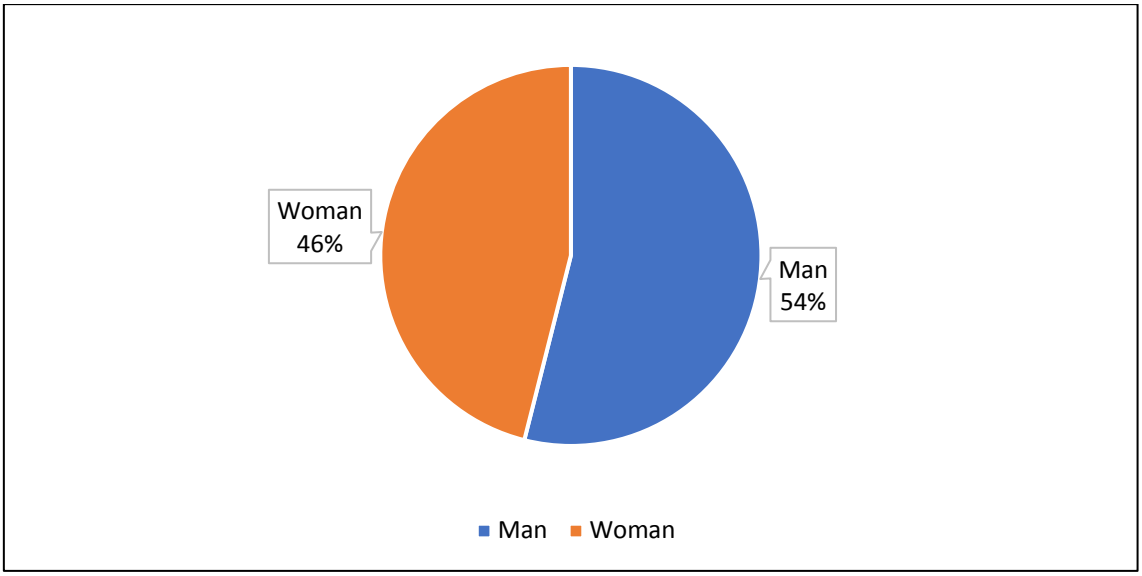
Table 4: Descriptive statistics for case study.

Year-Term	Survey	Sexuality	
		Man	Woman
2022-Fall	140	86	54
2022-Spring	180	91	89
2023-Fall	170	88	82
2023-Spring	120	64	56
Total	610	329	281



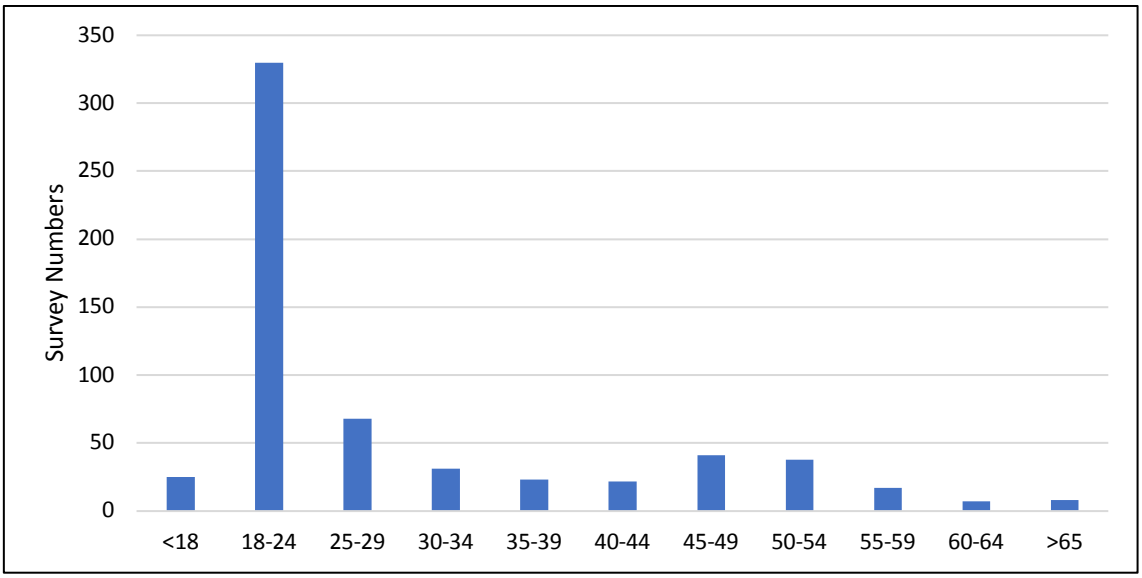
Graph 1: Surveys distribution in terms of year-term.

According to the survey, 54% of the surveyors are man and 46% of them are woman (Graph 2). Besides, half of them is in between 18-24 age (Graph 3). So, the survey points out that students are the majority group and the other groups differentiate from students. It is clear that the survey results describe the common tendency in these groups, thus, in this study, both of the two groups analysis in terms of research question.



Graph 2: Sexual distribution of surveyors.

Age distribution shows that students cover the half of the surveys. This identifies tremendous information for us. It allows to compare the students position with respect to other people in terms of their awareness according to the environmental issues particularly transportation systems. A cross-tab analysis is done to compare their position and according to the analysis, there is meaningful differentiation between these two groups (Table 5). For instance, students mostly choose public transportation during their education, but after they graduate from university, they shift up to private car mode and walking conditions are getting worst as time goes.



Graph 3: Age distribution of surveyors.

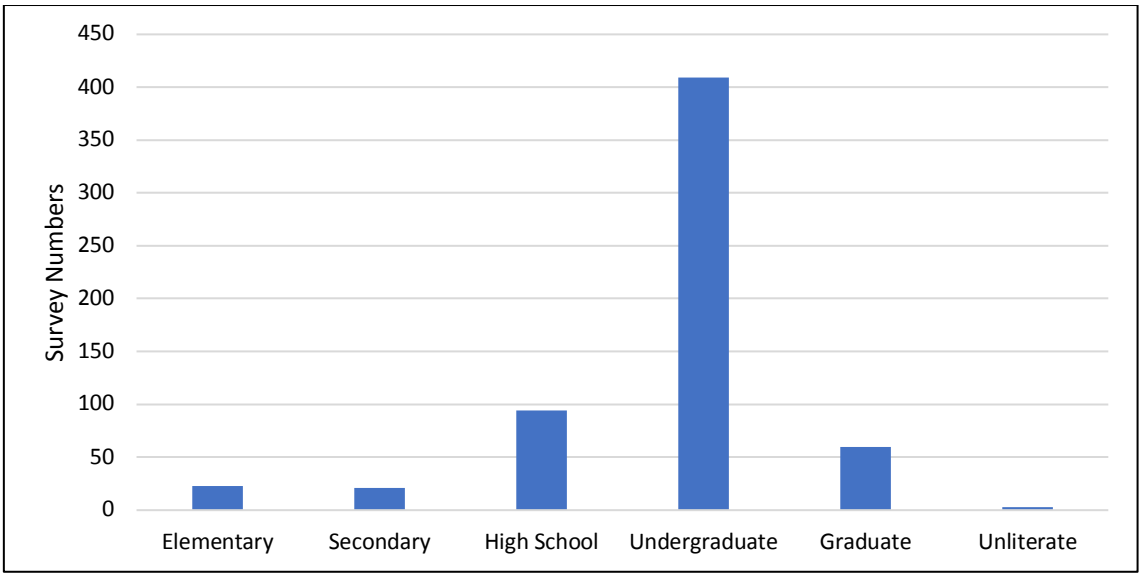
Income level also another factor for students to shift their transportation modes. They start a job after their graduation and they become more mobile. Even they are not a car ownership, the company or firm in which they work, provide them a car and they are able to drive car, thus, the car dependency increases after the graduation.

One of the remarkable results of the survey is about elder people mode choice. Over 65 years old people as called them retired people, choose walking for their transportation mode. Probably, elderly people visit nearby mosques, parks and friends by walking.

Table 5: Transport mode choice of surveyors depending on age.

		Mode Choice				
Age	**Total**	**Walking**	**Bus**	**Tram**	**Car**	**Other**
<18	25	0,16	0,24	0,20	0,20	0,20
18-24	330	0,11	0,52	0,07	0,24	0,06
25-29	68	0,04	0,24	0,10	0,59	0,03
30-34	31	0,00	0,19	0,00	0,81	0,00
35-39	23	0,00	0,26	0,04	0,70	0,00
40-44	22	0,09	0,36	0,09	0,45	0,00
45-49	41	0,10	0,17	0,05	0,68	0,00
50-54	38	0,03	0,16	0,00	0,79	0,03
55-59	17	0,06	0,06	0,12	0,76	0,00
60-64	7	0,14	0,00	0,14	0,71	0,00
>65	8	0,25	0,25	0,13	0,38	0,00

Education level also one of the important indicators to understand the mode choice in Kayseri. As it understands from the Graph 4 and Table 6, there is a parallel increase between the education level and car use. Even the private car use is the first mode in elementary, secondary and high school graduates, the ratio increases 80% in graduate people group. This is also because of increasing of the income level.



Graph 4: Education level of surveyors.

Table 6: Transport mode choice of surveyors depending on education level.

		Mode Choice				
Education	**Total**	**Walking**	**Bus**	**Tram**	**Car**	**Other**
Elementary	23	0,17	0,22	0,04	0,52	0,04
Secondary	21	0,14	0,24	0,05	0,57	0,00
High School	94	0,11	0,38	0,10	0,37	0,04
Undergraduate	409	0,10	0,44	0,07	0,35	0,03
Graduate	60	0,07	0,08	0,03	0,80	0,02
Unliterate	3	0,00	0,33	0,00	0,67	0,00

A meaningful level of awareness has been formed in all education levels for the effect of transportation vehicles on air pollution and producing carbon emissions. In this respect, it has been evaluated that fossil fuel-consuming vehicles have a great effect on air pollution and carbon emissions. Besides, people agree with the huge size of GHG emission because of fossil fuel consumption (Table 7). Moreover, they thought that it could be prevent by improving engine technologies like e-vehicle and more renewal energies.

According to the survey results, education level has a positive impact for e-vehicle. People thought that e-vehicle will reduce the air pollution and carbon emission, and the belief of this thought ratio is increase depending on to education level (Table 8).

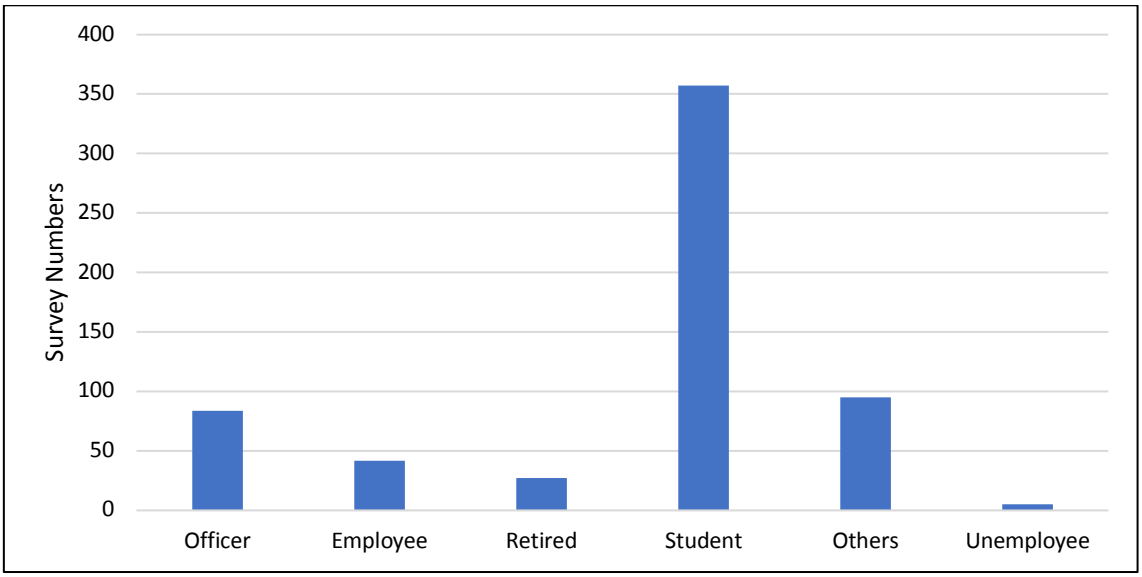
Table 7: General view for transportation vehicles emission products depending on education level.

		Effect size of transportation vehicles on air pollution and carbon emissions				
Education	**Total**	**Very high**	**High**	**Mid**	**Low**	**Very low**
Elementary	23	0,30	0,35	0,30	0,04	0,00
Secondary	21	0,14	0,52	0,33	0,00	0,00
High School	94	0,27	0,43	0,26	0,03	0,02
Undergraduate	409	0,34	0,43	0,19	0,03	0,01
Graduate	60	0,35	0,40	0,20	0,05	0,00
Unliterate	3	0,33	0,00	0,67	0,00	0,00

Table 8: E-vehicle position for reducing the air pollution and carbon emission depending on education level.

		E-vehicle will reduce the air pollution and carbon emission		
Education	**Total**	**Yes**	**No**	**No Comment**
Elementary	23	0,57	0,09	0,35
Secondary	21	0,57	0,14	0,29
High School	94	0,63	0,11	0,27
Undergraduate	409	0,80	0,11	0,09
Graduate	60	0,75	0,17	0,08
Unliterate	3	0,33	0,33	0,33

Transportation mode choice differentiates in terms of occupation in Kayseri. According to the survey result, as it expected, 59% of the students choose public transportation, on the other hand, the other groups like officer, employee, retired people choose car for their daily trips (Table 7).



Graph 5: Distribution of surveyor's occupations.

A significant ratio of surveyors whom thought that e-vehicles will not reduce air pollution and carbon emissions that more carbon emissions are produced during the production processes of vehicles. For this reason, they don't believe that e-vehicles will reduce the air pollution and carbon emission. At the same time, the surveyors whom not believe that e-vehicle will not reduce air pollution and carbon emission, thought that electric is produced by fossil fuels, thus maybe e-vehicles not produce carbon dioxide, but for during the electric production, large amount of harmful gases enter to the atmosphere.

Table 7: Transport mode choice of surveyors depending on occupation.

		Mode Choice				
Occupation	**Total**	**Walking**	**Bus**	**Tram**	**Car**	**Other**
Officer	84	0,02	0,15	0,04	0,79	0,00
Employee	42	0,07	0,26	0,10	0,55	0,02
Retired	27	0,11	0,15	0,11	0,63	0,00
Student	357	0,13	0,51	0,08	0,24	0,04
Others	95	0,06	0,26	0,04	0,60	0,03
Unemployed	5	0,00	0,00	0,20	0,80	0,00

As it can be understood from the Table 8, all of the participants are engaged in an activity for carbon emission and saving energy. Especially as the education level increases, consciousness level of consumers for electricity consumption and saving energy increase. In fact, it is seen that some educated people show more effort in terms of low carbon emissions and energy conservation by engaging in more than one activity.

Table 8: Doing facilities for producing less carbon emission and saving energy depending on education level.

		Doing any facility for producing less carbon emission and saving energy				
Education	**Total**	**1**	**2**	**3**	**4**	**5**
Elementary	23	0,17	0,00	0,52	0,17	0,13
Secondary	21	0,29	0,05	0,24	0,33	0,10
High School	94	0,22	0,10	0,37	0,24	0,06
Undergraduate	409	0,32	0,14	0,26	0,21	0,07
Graduate	60	0,20	0,07	0,38	0,25	0,10
Unliterate	3	0,33	0,33	0,00	0,33	0,00

1. I drive less for my travels,
2. I ride bicycle for my daily trips,
3. I choose the A+++ energy products (refrigerator, washing machine, dishwasher e.g.),
4. I choose less energy consumption lamps for lighting,
5. Others,

4. Evaluation and Limitation

4.1. Evaluation

The aim of this study is to point out the impact of a university course that were designed to increase students' awareness of sustainable transport under the enlightenment of SDG11 as well as change their attitudes and behavioral intentions. This paper contributes to the literature by combining the theoretical and practical training for teaching sustainable transportation modes and system.

Combining practical training and experimental activities in university programs about global issues enhance students' knowledge and improve their approaches to sustainable transportation problems. At the end of the semester, according to the students' feedback, they understand why sustainable transport is very important for a better and green world. Many of the students change their mind against to drive car and some of them learn how to ride bicycle and e-scooter during the semester. Besides, they also become familiar to e-vehicle like e-bike, e-scooter in the lecture and they accept to ride these vehicles in their lives. So, it is understood that if theoretical education combines with the practical training, people change their attitudes. Perhaps, it takes much time, but yet it has an impact on the behavioral shift in terms of sustainable transport modes.

Although most of the people are sensitive to environmental issues, they often do not know what to do. Moreover, people work on the elimination of environmental problems within the power of their capacities. As with the transportation mode choice, people often cause environmental problems to grow without realizing it. However, they state that they can shift their transportation mode choice when the results of their actions are shown in practice.

For conclusion, the study shows that the attitudes can be changed by practical training, awareness can be increased by educating, and more importantly coming future sustainable transportation modes will spread all around the world and people currently do not adopted their-selves to this reality.

4.2. Limitation

The study also has some limitations either literature or case study part. For the first critic, there is a lack of literature for the SDGs studies in university course. If there will be more courses for SDGs recognition, it will be easy to compare the studies in terms of different countries, nations, students e.g. Besides, perhaps there could be some exchange and integrated programs organize from different universities. It allows students to come-across different views against global issues.

The other limitation is for case study. It needs to improve from the point of surveyors and students. The study might consist of many other indicators such as long-term expectation, economic circumstance e.g., for a better understanding.

5. References

European Commission. (2018). Europe on the Move - Sustainable Mobility for Europe; Safe, Connected and Clean. Brussels: European Commission.

Halpern, D. F., & Hakel, M. D. (2003). Applying the Science of Learning to the University and Beyond: Teaching for Long-Term Retention and Transfer. Change: The Magazine of Higher Learning, 35(4), 36-41.

Ilieva, L., Rossenov, L., & Simeonov, N. (2020). The Role of Education for Sustainable Urban Mobility. In Proceedings of 8th Transport Research Arena. Helsinki.

Kayseri Metropolitan Municipality. (2023). Fiyat Tarifeleri. Retrieved July 13, 2023, from https:// www.kayseriulasim.com/tr/kayseri-ulasim/bilet-temin/fiyat-tarifeleri

Putz, L.-M., Treiblmaier, H., & Pfoser, S. (2018). Field Trips for Sustainable Transport Education: Impact on Knowledge, Attitude, and Behavioral Intention. The International Journal of Logistics Management, 29(4), 1424-1450.

United Nations. (2016). Goal 11. Retrieved July 10, 2023, from https://sdgs.un.org/goals/goal11

United Nations. (2021). Sustainable Transport, Sustainable Development. New York: United Nations.

Case Study Report

Inclusive Climate Action in Cities:
An elusive goal for local authorities?

Muna SHALAN, German development corporation (giz)

Abstract

In response to climate change impacts, cities engage in corrective actions aiming at adaptation as well as optimising urban planning and design of operations to promote mitigation. As the regulator and planner of local climate action, cities leverage green infrastructure to achieve ecological, economic and social benefits. Nevertheless, the challenges of competing land use, weak interdepartmental coordination, and insufficient data availability are impeding their efforts to devise technically-sound solutions and attract investment. This study investigates the experiences from two cities in which city planners are navigating a multitude of interconnected aspects of designing and implementing climate-responsive projects, with an overarching goal of meeting the needs of the local community and building resilience against climate change impacts. By leveraging green infrastructure solutions, city planners aim at striking a balance through achieving ecological and social benefits while bridging the infrastructure investment gap.

Keywords

Local climate action, climate-responsive solutions, flood mitigation, green infrastructure, infrastructure investment gap

1. Introduction

Fulfilling the role of a regulator and planner of climate action is among the most challenging roles for local administrations. It calls for extensive human and financial resources that may exceed the capacities of local authorities. A dedicated interdisciplinary unit that comprises experti e in various Āelds such as urban planning and design, public health, climate protecti n and energy, and emergency response is a prerequisite for successful devising of policies and implementati n tools. Developing strategies based on quanti ativ evidence is another decisive factor that highlights a major need for establishing rigid database that empowers local authoritie to conduct accurate data analysis and management. Partnerships and collabora. on are other important factors that comprise public par. cipati n and outreach to local stakeholders as well as collaborati n at regional and internati nal levels. While the former is vital to ensuring buy-in and awareness raising, the la. er facilitates the transfer of knowledge about practi e-oriented soluti ns and in some cases securing funding. Devising instruments for cost recovery to finance climate action measures, nonetheless, requires an enabling legal and financial framework reflected in legislation and funding programs that local authorities can utilise.

While prioritizing climate-responsive projects, city planners face the challenge of competing land use, weak interdepartmental coordination, and insufficient data availability. Coupled with insufficient organisational capacities, these factors impede municipal efforts for securing financing whether via private sector participation or via external financing. This study demonstrates the ongoing efforts in two cities to plan the implementation of green infrastructure measures including securing funds. In both

contexts, city planners are exploring how green infrastructure can increase land value and contribute to spatial, social and economic dimensions of urban inclusion. Focusing on concrete and current examples, the study reveals multiple challenges that the local administration must address for an effective implementation of the devised measures. In the case of Khan Younis municipality, the lack of baseline data and key performance indicators are impediments that the municipality should address to improve the bankability of its envisioned climate-responsive project. Meanwhile in Kisumu county, establishing a link between green infrastructure measures and the surveys on climate and flood risks is key to securing external financing for upgrading of the riverside of Auji creek.

2. Case Studies

2.1. Khan Younis: towards climate-resilient public spaces

In an effort to leverage nature-based and green infrastructure solutions and promote climate resilience, Khan Younis municipality in the Gaza strip has planned a 50 Km^2 park to serve more than 400K residents aiming at increasing the share of open public spaces in the city. Due to the high population density in potential extreme flood areas, several locations in Khan Younis have been identified as very high-risk areas which requires immediate actions to mitigate flood risk, including employing natural hydro-ecosystem structure and green infrastructure toward flood risk reduction. According to UN Habitat (2020), open public spaces currently make up only 0.9 square kilometers representing only 1.7% of urban land, from which seventy-two public spaces were found to have soft surfaces and fifty-nine have hard surfaces. Green and public spaces (with soft texture) aim at reducing risks such as flooding, as well facilitate sustainable land management and restoration, and build resilience to extreme weather. Given the envisaged climate mitigation impacts, establishing public gardens for multiple purposes including awareness raising for climate change the project was recommended in the sustainable energy access and climate action plan for the municipality of Khan Younis (SEACAP 2022). Nonetheless, the lack of baseline data and indicators especially carbon inventory rendered efforts to access carbon finance futile. Indeed, the municipality's application for the Cities for Climate grant[i] failed and the evaluation showed incapability in budget preparation and sustainability, in particular the exit strategy and revenue stream. The municipality is currently seeking to capture private sector investment which calls for articulating the economic values by the city planners: contributions to the tax base, number of jobs created, and value added to the local economy against the values of trees, flowers, and green space. Hedonic pricing is one evaluation technique that can estimate both on-site and external benefits. This technique infers the value of a non-market resource from the prices of associated goods and services that are traded in the market-place (Engström, G., & Gren, A. 2017). For urban parks, this is accomplished by looking at the value of surrounding properties: parks produce benefits which presumably make a neighborhood a nice place to live, and these benefits are reflected in the prices of surrounding real estate i.e. increasing property value due to park.

At the current stage of planning and strategy development, key steps are needed such as setting tailored key performance indicators and defining the target group and beneficiaries. Creating alternatives for the master plan and strategy (inclusion and empowerment of stakeholders) is also necessary to compare and evaluate the status quo to target values and numbers. In these alternatives, it is necessary to prioritise green infrastructure as it offers a suite of benefits to mitigate climate change, alleviate flood risk, and improve public health, which are economically affordable: For municipality planners and managers, green infrastructure measures often prove more cost-effective than grey infrastructural measures, with options for more citizen-centered, collaborative governance configurations. As an important breakthrough, the project proposal has passed the initial screening to receive technical support from one of the initiatives of the Global Covenant of Mayors for Climate and Energy (GCoM) to conduct a prefeasibility study, which will focus on 1) Further assess possible options towards feasibility, including for bundling, 2) guidance on possible sources (including municipal own sources of revenues) and instruments, 3) Business model development and preliminary financial planning.

Figure 1. Current status of the envisaged park. Source: Haya Al Agha- Khan Younis municipality

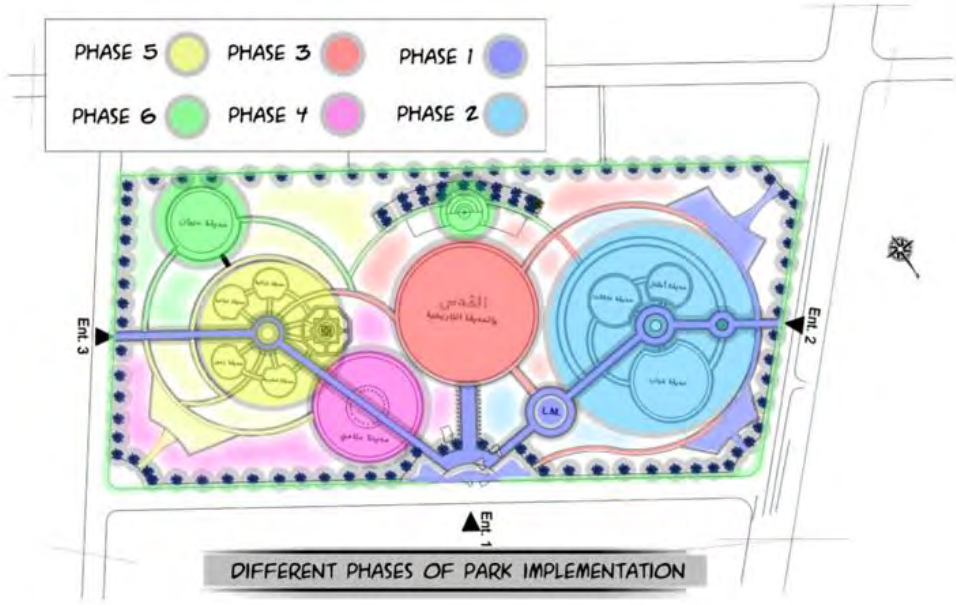


Figure 2. Envisioned phases of implementation of the park. Source: Haya Al Agha- Khan Younis municipality

2.2. Urban upgrading of the riverside of the Auji creek in Kisumu, Kenya through green infrastructure initiatives

Kisumu is the third-largest port city in Kenya located on Lake Victoria. The land-use development plan of Kisumu county envisions an urban upgrading process of the riverside of the Auji Creek by constructing a park as part of a network of open spaces linking the city with the Lake Victoria. The main objectives of this project are reducing urban flooding, increasing urban cooling, and creating a recreational green space for

the community. The project will transform the Auji River area into a comfortable green space by improving the bridges and walkways around the river and creating a green canopy for better outdoor thermal comfort.

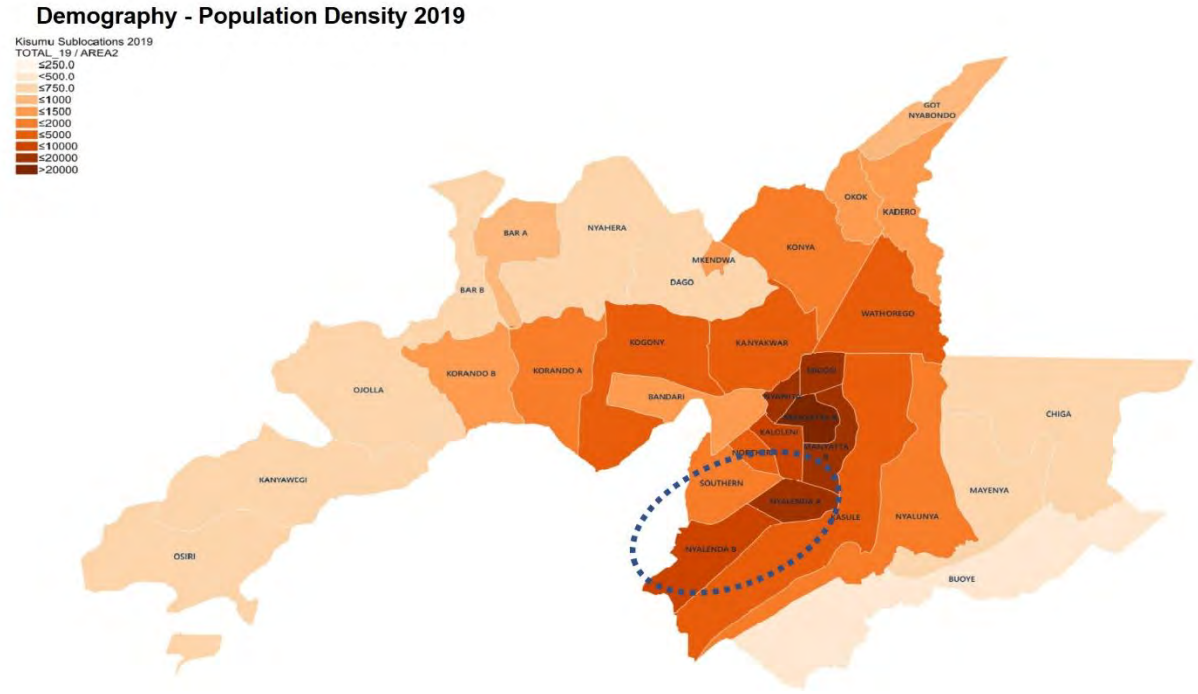


Figure 1. Demography- Population Density in Kisumu in 2019. Source: James Opondo Nyagol-Kisumu County Government

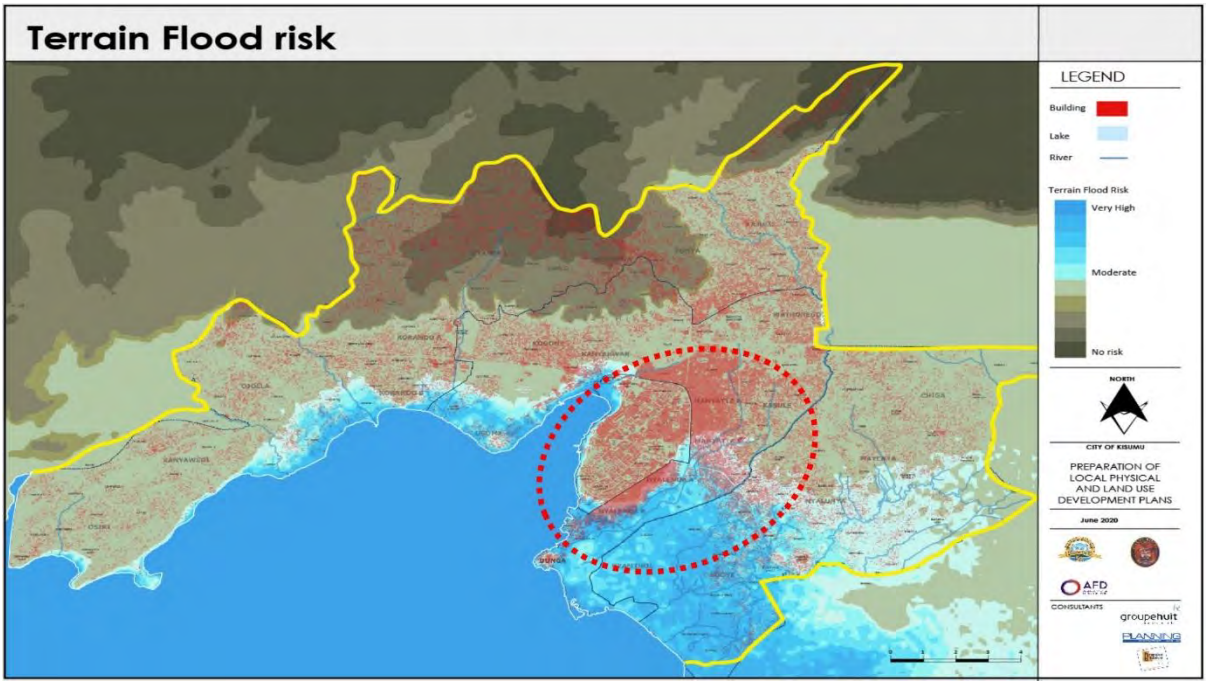


Figure 4. Flood Risk Terrain in Kisumu. Source: James Opondo Nyagol-Kisumu County Government

For the city planners green infrastructure measures can be more cost-effective than grey infrastructural measures, with options for more citizen-centered, collaborative governance configurations that are uniquely suited to sub-Saharan Africa. Although engineered solutions, such as bunds and culverts for flooding are prioritised over nature-based solutions, there are good experiences on soil restoration, climate resilience, and urban agriculture via green infrastructure. For example, through ecosystem restoration grasses and endemic species grow back forming a natural barrier and puff up the soil thus improving water infiltration. It is thus important to link green infrastructure measures to survey on climate and flood risks. As such, the city planners will select a pilot area based on criteria defined by topography plans (using GIS) and the flood risk management plan while capitalising on existing local solutions (ecosystem restoration or mitigating flood risk). In parallel, the development of the concept includes formulating key performance indicators to mitigate climate risks (heat and floods) as well as reassessing regulations for rainwater harvesting and stormwater diversion. Furthermore, city planners are addressing the challenge of competing priorities of land use (e.g. prioritizing motor-ways) and the overlapping responsibility for the management of riverbeds which calls for a coordination body.

Progressing in the project development is influenced by the availability of funds and community approval of the project who will be at the risk of relocation. As financing is among the decisive factors determining the success of the project, local authority is exploring several funding streams including leveraging community-based finance approaches such as partnering with social enterprises to create urban gardening activities. This approach can also be complimented with a partnership with a local university to establish a laboratory for integrated techniques for landscape restoration and agriculture. Ecosystem restoration leads to improving water infiltration, and thus grasses and endemic species shall grow back forming a natural barrier and puffing up the soil.

Against this background, the local authority envisaged a plan that categorises actions according to complexity and cost. For example, the local authority will carry out a tenure analysis of riverine area to assess existing encroachments. It will also prepare detailed Community Conserved Area Management Plan for the People's Park and ensure management structures are in place. Lobbying for improved land use management and soil conservation actions in the catchment area for the Auji Creek is also among the low-cost actions that the local authority will implement in collaboration with other counties in Kenya. Furthermore, it will facilitate community action (as part of clean-up) to remove identified invasive plants and solid waste from Auji creek and recycle such waste. The local authority also envisions actions that are low-cost but are long-term. Such actions are either regulatory such as posing penalties on industries that discharge polluted effluent into the river or related to increasing organizational capacity for example through supporting civil society action in the management, benefit flows and actions that are needed for maintaining the conserved area. From an organizational standpoint, ensuring that all actions undertaken are climate smart and climate- proof calls for building up specialist skills of the relevant municipal staff to be capable of identifying impactful action areas and integrating climate considerations in the action to be undertaken. Similarly, building capacity of different communities and CBOs who border the Auji Creek and Wetland area is necessary to raise awareness about their rights and responsibilities.

Figure 2. Current state of Auji creek. Source: James Opondo Nyagol-Kisumu County Government

Another group of actions identified by the city planners requires limited funding that can be secured via the city budget. This includes mapping and demarcating Auji Creek and Wetland as well as water testing of the Auji river (from source to lake) to identify pollutants and suggest remedial action, in addition to dredging river areas which are blocked to enhance water flows to lake. The local authority plans to promote the usage of modular biodigester septic tanks to ensure no raw sewage is discharged in the river and plant grass strips as footpaths and for flood water management.

A critical group of interventions identified by the local authority requires significant funding which will be acquired either via partnership with the private sector or external financing from donors. The local authority plans to commission a People's Park financing study and act on its findings, including the development of funding proposals for donors. Cost-intensive interventions include the construction of six bridges to be elevated with detailed specifications. This intervention – as part of the People's Park – could be implemented via private sector participation ("Adopt a Bridge") or as part of a donor-funded project or a combination. Other cost-intensive interventions include building dykes on each side of the river beside the grass strips to beautify (with indigenous trees on top) and mitigate flood risks by restoring existing dykes. Similarly, extending Auji Wetland Board Walk based on the existing one at Dunga to at least 1 Km in length and constructing and landscaping at least four re-creation areas within Auji Creek and Wetland Conservation area for residents to use are also envisioned cost-intensive interventions on the long-term.

In both case studies, city planners are challenged with the infrastructure investment gap and to a varying degree by the availability of quantifiable baseline information. Transforming the envisaged plans into bankable project proposals is an arduous process that should integrate concepts such as coupling the GI activities with income-generating activities (e.g. urban gardening by partnering with local social enterprises) as well as producing evidence on reduction of carbon emissions to secure external funding by linking green infrastructure initiatives with climate vulnerability assessment. The following section elaborates on international programmes focused on unlocking cities climate finance. The programmes ultimately aim at strengthening the capacity of cities to fast-track mid-stages of project development and help them identify relevant sources of financing and support to further move towards implementation.

2.3. From challenges to tangible results: the arduous path of unlocking climate finance

Transforming plans for local climate action into bankable project proposals is a complex process that may exceed the technical capacity and know-how of local city planners. Beyond planning and strategy development, local plans for climate action mature through a multi-level process that includes, project

definition/prefeasibility, technical project feasibility, financial project feasibility, and structuring/ procurement preparation. Once a project proposal successfully passes these stages, access to finance can be achievable.

To support local authorities on their quest for unlocking climate finance, international development initiatives have been providing technical advisory in the form of supporting city climate strategy development and analytics to assess the climate potential of plans, strategies, and investment programs. These initiatives include Cities Finance Gap Fund[ii], Connective Cities[iii], C40 Climate Finance Facility[iv] and FELICITY.[v] Besides providing advisory for the prioritization of investments as part of a climate strategy or investment program, the initiatives and programmes support local authorities in defining project concepts and preparing prefeasibility studies as well as undertaking studies to prove technical and project feasibility, and socio-environmental risk mitigation strategies. Furthermore, local authorities are assisted in developing a business case and financial model, procurement planning, and linking projects to finance. FELICITY, which is a Cities Advisory Facility, aims at pipelining of projects, setting up project financing requirements along with European Investment Bank. Meanwhile the C40 City Finance Facility, creates an implementation/continuity framework.

Given the widespread need for securing investments and exploring innovative solutions for inclusive climate action in cities, there is a need to further invest in facilitating exchange of experience and municipal know-how through peer learning. The international community of practice for sustainable urban development- Connective Cities employs this approach as its business model and thus supports member municipalities in project preparation and clustering to sustain a pipeline of project ideas. In parallel, members of the Community of Practice-Connective Cities benefit from peer advisory to disseminate know-how about innovative and practical solutions that they can channel to their municipalities.

3. Concluding remarks: overcoming the impediments of inclusive climate action at the local level

As the case studies demonstrate, the pursuit of inclusive climate action by local authorities is registering various degrees of success. Local authorities in developing countries face highly constrained budgets, stretched in meeting existing priorities in service delivery. Limited resources and expertise impede the cities' efforts to turn their climate-resilient ideas into strategies and finance-ready projects. Local authorities are in need for capacity development and advisory on financing interventions devised as part of climate-responsive planning. Providing upstream technical support for local governments to enhance resilience building efforts plays a major role in preparing high-quality, climate-smart urban investments. This support should cover different areas and instruments including aligning local projects for climate adaptation with Nationally Determined Contributions, since international finance institutions provide financing at the national level. Besides external financing, it is important to support local authorities in optimising local revenue collection, e.g. through property tax or land value capture to increase local budgets streamed to climate action or by devising cost recovery mechanisms. Despite their efforts to capture private sector finance, public private partnership or community-based finance approaches remain largely untapped due to the limited size or even lack of market for urban green projects in many countries. Local authorities miss their opportunity to gain the interest of private investors, as they fail to market their urban green infrastructure projects with regard to returns and risks. In addition, cities need the support of central governments to build capacity and ensure that they possess the requisite financial, technical and legal expertise, as well as sufficient bargaining power when negotiating private-sector financing to achieve fair deals. Against this background, the role of global development programmes specialised in finance, such

as the Cities Climate Finance Gap Fund and the Cities Finance Facility, is key in bridging this gap by supporting cities prepare bankable projects and linking them to finance.

4. References

Clima-Med. (2022). The municipality of Khan Younis Sustainable energy access and climate action plan. Available at: https://www.climamed.eu/wp-content/uploads/files/Final-Khan-Younis-4-April.pdf

Engström, G., & Gren, A. (2017). Capturing the value of green space in urban parks in a sustainable urban planning and design context: pros and cons of hedonic pricing. Ecology and Society, 22(2). Available at: http://www.jstor.org/stable/26270097

UN-Habitat. (2020). A guide to citation. Public space assessment: eliminating violence against women in the West Bank and Gaza strip. Available at: https://unhabitat.org/sites/default/files/2021/07/khan_younis_city-wide_public_space_assessment_report-_english.pdf

[i] Climate for Cities' Call for Proposals ran up till the end of March 2021 and has buildt directly on the achievements of CES-MED and Clima-MED projects, by supporting and accelerating the funding of SECAPs and similar initiatives aimed at increasing climate resilience and sustainable use of natural resources at local level.
[ii] https://www.citygapfund.org/
[iii] https://www.connective-cities.net/en/

[iv] https://www.c40cff.org/
[v] https://www.eib.org/en/products/advisory-services/felicity/index.htm

Research Paper

The city as an urban palimpsest:
Gdańsk between periodic reincarnations

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Abstract

When taking about a city with a multi-layered historic temporal dynamic, one has to unfold these temporal dynamics activating its urban forms thus, a crucial question arises, whether the heritage product can be completely lost in its new development plans, or one can read it as a salient state between periodic reincarnations?

Therefore, this article utilizes the city of Gdańsk as a case study to investigate it from the perspective of urban palimpsests (Corbez, 1983), documents the Joint ISOCARP - ITACUS Young Professionals Workshop that took place in Gdańsk between 16 - 21 April 2023, and discusses its findings on shaping the on-ground and underground public spaces, developed on the occasion of the tunnelling project being part of the extension of the Popieluszki street, introducing an urban mobility connection between two significant zones of the area divided by the Motława river while utilizing urban acupuncture as an approach to provide an in-depth understanding of the city's collective identity and helps to reverse the decline of the industrial urban landscapes of one of its significant historic areas.

Keywords

Urban Palimpsest, Urban Acupuncture, Cultural Heritage, Public Spaces, Urban Mobility, Gdańsk.

1. Introduction

The notion of "palimpsest" linguistically refers to a manuscript page that has been partially or completely erased and overwritten, while traces of the previous text still remain (Carter, 2012). The earliest definition of palimpsest, which emerged in the 17th century, described a tangible object such as paper or parchment that could be erased and reused for writing. As time went on, particularly in the 19th century, the term became more specific, referring to a manuscript where new writing had been added over earlier erased.

"All history was a palimpsest, scraped clean and re-inscribed exactly as often as necessary." as wrote by George Orwell in his notable novel Nineteen Eighty-Four. In the 1800s, palimpsest took on a metaphorical sense, signifying something that had been repurposed or modified while still bearing remnants of its previous form, akin to a complex and layered historical record (Diener and Hagen, 2018).

Terminologically, in the context cities and urbanism, the metaphor of a palimpsest suggests that urban environments are layered with historical, Socio-cultural, and physical imprints from different periods, even if they are no longer visible or immediately apparent (Corboz, 1983).

The metaphor of the city as a palimpsest, as introduced by in his influential essay "The Land as Palimpsest**"** (Corboz, 1983), offers a profound lens through which to perceive the urban environment. Corboz highlights the city's multifaceted nature, emphasizing its historical layers and the continual process of erasure, inscription, and reinvention. Furthermore, exploring the meanings behind this metaphor, focusing on the

concept of the city as a salient state between periodic reincarnations. By delving into the complexities of urban development, this analysis sheds light on the dynamic nature of cities, their cycles of destruction and rebirth, and the enduring traces of their past.

Perceiving the city as an urban palimpsest significantly contributes to understanding of the city as a dynamic organism shaped by its historical layers (Engbersen, 2001). Through the metaphor, it highlights the complex interrelation between past and present, emphasizing the city's ability to reinvent itself while retaining traces of its previous incarnations.

This paper shall investigate the notion of city as urban palimpsest unfolding the temporal dynamics that activate the city's urban forms. Additionally, the paper documents the outcome of the Joint ISOCARP - ITACUS Young Professionals Workshop that took place in Gdańsk between 16 - 21 April 2023 with the participation of multidisciplinary young professionals. Moreover, developing a better understanding of urbanization and heritage interpretations which can have better impact on urban development, cultural significance, and climate resilience.

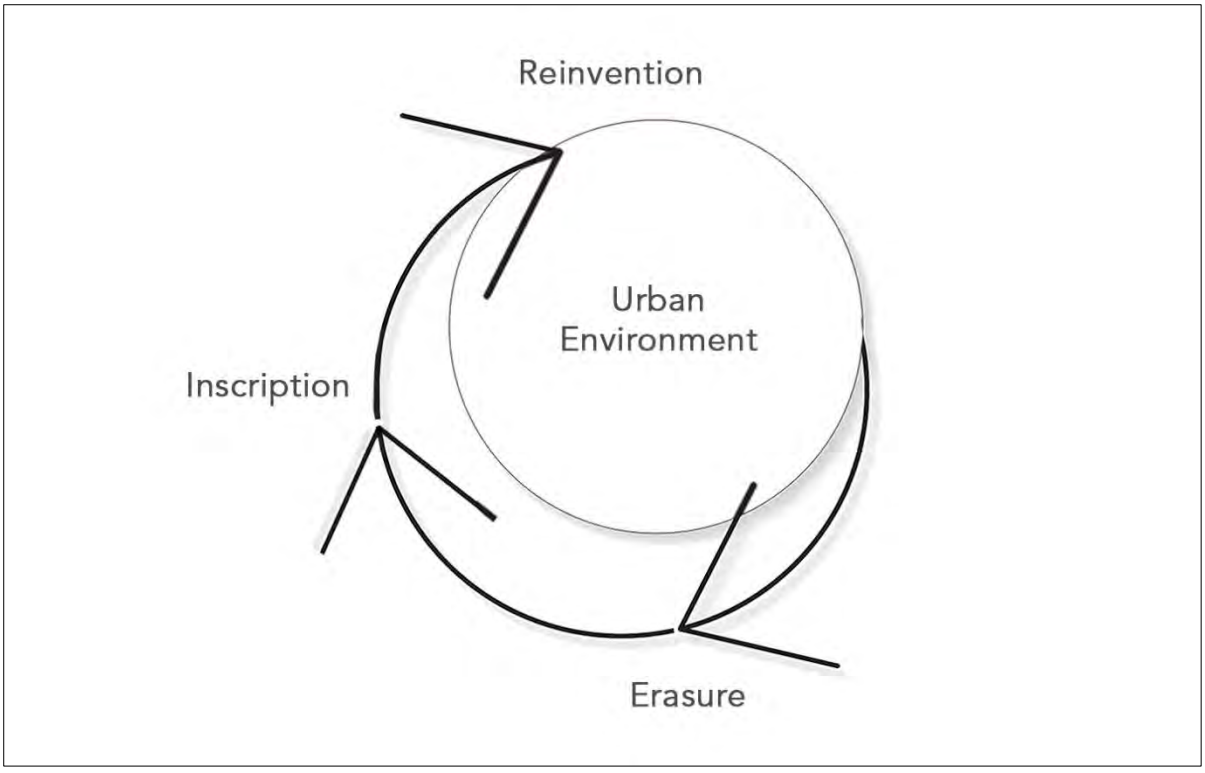

Figure 1. Illustration on City as an urban palimpsest between periodic reincarnations. Source: Authors, 2023.

2. Methodology

Through the lens of understanding the city as an urban palimpsest (Corboz, 1983), this article employs Urban Acupuncture (Lerner, 2014) as a qualitative multi-method approach that provides an in-depth understanding of Gdańsk collective identity and helps to reverse the decline of its public spaces and industrial urban landscapes calling for various planning tactics to produce more egalitarian socially inclusive culture-specific results.

Urban Acupuncture as a methodology shall emphasize on the recognition and activation of underutilized or neglected urban spaces to actualize transformative impacts on the urban fabric (Lerner, 2014). Just as a palimpsest contains hidden layers waiting to be uncovered, the city is replete with forgotten or overlooked areas that hold immense potential for revitalization. By identifying these pockets of potential, Urban

Acupuncture interventions can breathe new life into forgotten spaces, reintegrating them into the urban fabric and enriching the city's cultural narrative injecting a sense of vibrancy and diversity into the city.

Moreover, Urban Acupuncture interventions are often context-sensitive (Hoogduyn, 2014), responding to the challenges of a specific location through the lens of its characteristics as shown in *figure 2.* This approach mirrors the understanding of the city as a palimpsest, where each layer represents a distinct period in the city's history. By carefully considering the existing urban fabric, historical context, and social dynamics, Urban Acupuncture interventions can blend seamlessly with the layers of the city, creating a harmonious integration of past and present fostering adaptability, flexibility, and allowing for continuous experimentation and evolution over time.

The research starts with literature review in order to better understand cities as an urban palimpsest and to contextualize that in the case of Gdańsk, Poland. In parallel, it takes a series of qualitative methods to derive readings extracted throughout the Joint ISOCARP - ITACUS Young Professionals workshop, developed, and finally represented in a spectrum of design concepts and interpretations pertaining to the urban development in Gdańsk informing its placemaking strategies, and as a result provides a critical reflection on its development plan.

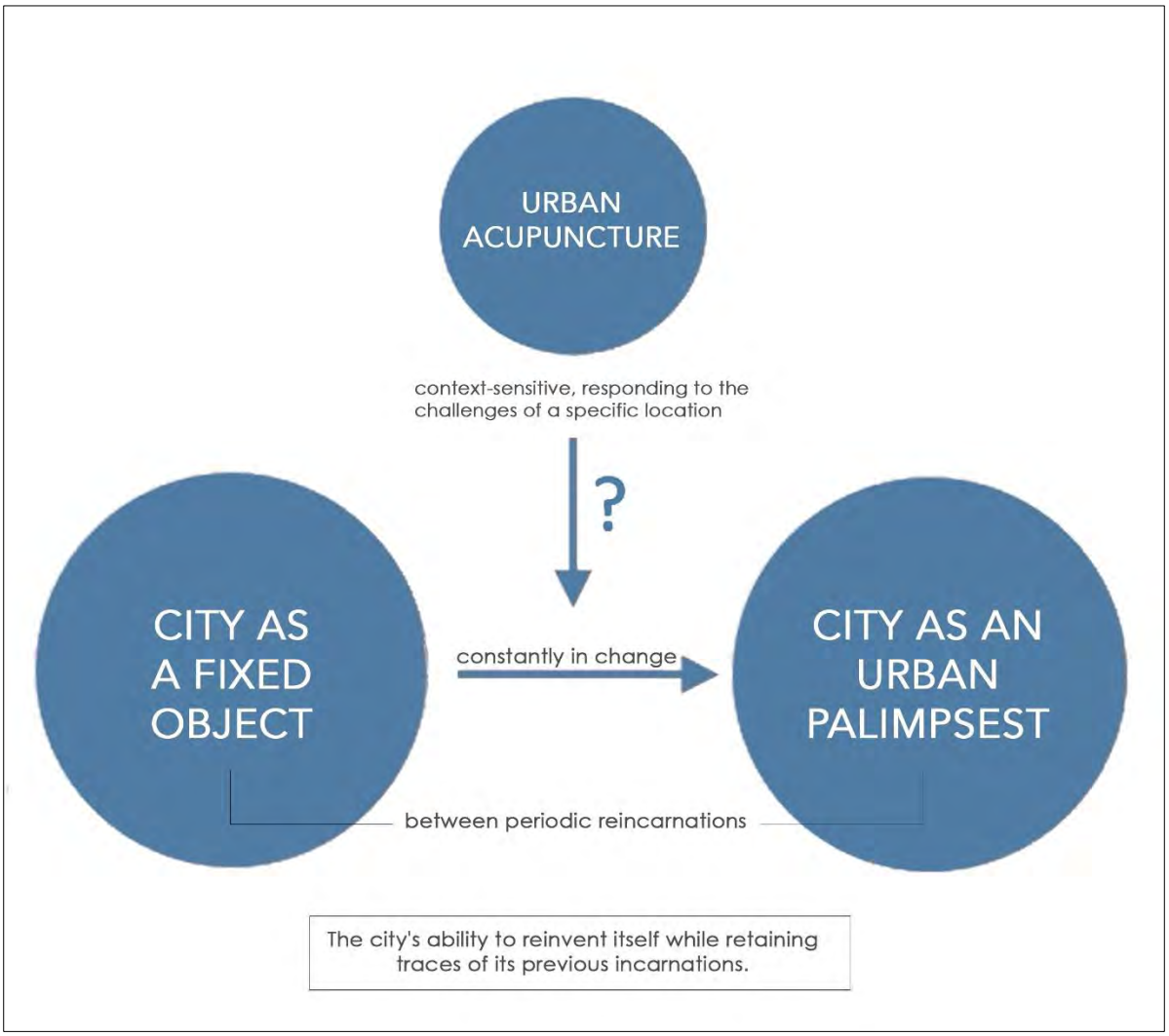

Figure 2. Illustration on the research methodology. Source: Authors, 2023.

3. The city as a Layered Narrative

3.1. Unravelling the Palimpsestic Layers of a Reincarnating City

Cities serve as vessels of human history (Blank, 2005), preserving the narratives of generations past. Corboz's palimpsest metaphor accentuates the intricate layers that constitute the urban fabric. Like a manuscript overwritten multiple times, the city bears imprints of diverse urban tissues, architectural vocabularies, cultural attributes, and socioeconomic patterns. Each layer embodies a particular phase's aspirations, beliefs, and struggles, thus transforming the city into a living archive.

These historical layers not only contribute to a city's physical form but also shape its collective memory and identity (Huyssen, 2003). By engaging with the urban palimpsest, one could unravel the narratives and trajectories that have defined its existence. This correlation fosters a profound appreciation for the depth and richness of the urban experience, transcending the surface-level impressions occasionally associated with the formation of cities.

Expanding upon the metaphor of the city as an urban palimpsest by introducing the notion of the salient state (Corboz, 1983). This notion portrays the city as a dynamic entity constantly in change, undergoing periodic reincarnations. It critiques and challenges the perception of a city as a fixed, unchanging object and emphasizes its inherent adaptability and resilience (Alexander, 2019). In the salient state, the city exhibits a constant state of becoming, reflecting the cyclical nature of urban development. It is not a linear progression, but a dynamic process characterized by construction, destruction, and transformation. As erasure and inscription occur, the city's physical, social, and cultural landscape morphs, allowing for continuous reinvention (Powell, 2008).

Moreover, the salient state acknowledges the coexistence of various historical layers within the city. Each layer represents a distinct period, yet their interaction shapes the urban environment (Engbersen, 2001). The palimpsestic nature of the city enables the presence of multiple narratives, voices, and perspectives, resulting in a complex fabric of meanings.

3.2. Periodic Reincarnations: Cycles of Destruction and Renewal

Within the framework of the urban palimpsest, the allegory of periodic reincarnations encapsulates the periodic nature of urbanism and planning (Corboz, 1983). Cities experience phases of destruction and reconstruction, akin to the shedding of layers from a manuscript before rewriting begins (Carter, 2012). These cycles occur gradually, perpetuating the salient state of the city.

Periodic reincarnations manifest in various ways. They can be triggered by natural disasters, human-caused disasters, or deliberate urban planning interventions. Each incarnation introduces novel urban and architectural forms, spatial and cultural expressions, and social practices while preserving remnants of the past. Thus, the city becomes a palimpsestic amalgamation of temporalities, with echoes of multiple layers resonating through its spaces. The traces of previous incarnations within the city fabric evoke a sense of historical continuity. They remind inhabitants and visitors of the city's evolution, connecting past and present. This continuity becomes a powerful testament to the adaptive capacity of cities and their ability to rise reinventing themselves (Bartolini, 2014).

4. The Salient State of Gdańsk

4.1. Historical Layers and Cultural Narratives

The city of Gdańsk in Poland is a captivating urban landscape shaped by its significant historical phases. The city's heritage product bears witness to its dynamic past (Köhler, 1893). In order to explore the impact of Gdańsk's historical layers on its urban development, one has to delve into the ways in which the city's history has influenced its planning, spatial scheme, urban design, and architecture shaping its cultural identity, in order to a better understanding of the intricate interaction between past and present in shaping the city's fabric.

Situated on the Baltic Sea, the city has witnessed the rise and fall of various powers throughout its history, resulting in a palimpsestic urban fabric reflecting its complex past (Clark, 2016), with Gothic, Renaissance, Baroque layers, and Hanseatic influences coexisting harmoniously (Geisler, 1918). The historical layers embody the narratives of different periods, each leaving their imprints on the cityscape.

The influence of the Hanseatic League:

This can be seen not only in the urban and architectural vocabularies but also in the city's spatial scheme. Gdańsk's layout, with its narrow streets, open squares, and proximity to the waterfront, reflects the strategic considerations of medieval trade (Tölle, 2008). The compact and interconnected nature of the city facilitated commercial activities and fostered a sense of community among merchants.

The medieval core of Gdańsk, exemplified by the magnificent Gothic architecture of St. Mary's Church and the iconic Crane Gate, reveals the city's origins as an important trading hub (Nicolle, 2014). These structures stand as reminders of Gdańsk's prosperity during the Hanseatic League era and its role in Baltic maritime trade (Tölle, 2008). The city's Renaissance and Baroque layers emerged during the era of Polish sovereignty over Gdańsk. These layers illustrate the city's flourishing cultural and intellectual life during the Polish Golden Age (Friedrich, 2012).

Renaissance and Baroque Flourishing:

The Renaissance and Baroque periods brought further transformations to Gdańsk's urban development (Köhler, 1893). As a city under Polish sovereignty, Gdańsk experienced a flourishing cultural and intellectual life during the Polish Golden Age (Omilanowska-Kiljańczyk, 2008). The emergence of elegant Renaissance buildings such as the Artus Court and the stunning façades along the Long Market reflected the city's newfound prosperity and artistic aspirations.

The urban and architectural elements of the period brought a sense of grandeur and refinement to Gdańsk's urban fabric. The Baroque period further embellished Gdańsk with ornate details and rich decoration (Friedrich, 2012). Notable examples include the magnificent Golden Gate and the opulent interiors of many churches and palaces. The Baroque influence extended beyond architecture and permeated the city's urban design and public spaces (Geisler, 1918). Elaborate sculptures, fountains, and gardens enhanced the visual experience of Gdańsk, creating a vibrant and harmonious cityscape.

Reconstruction and Post-War Identity:

The impact of historical layers on Gdańsk's urban development is also evident in the city's reconstruction efforts following the devastation of World War II. The destruction of Gdańsk's historic centre presented a significant challenge in reconciling the preservation of cultural heritage with the need for modernization

(Jeleński, 2018). The post-war reconstruction efforts in Gdańsk were driven by a desire to rebuild the city's identity while acknowledging its historical layers. The meticulous reconstruction of iconic places and monuments, such as the Long Market and the Granary Island, aimed to restore the city's cultural memory and create a sense of continuity (Friedrich, 2012). The rebuilt façades, carefully replicating their original appearance, serve as a tangible connection to Gdańsk's past.

Gdańsk's palimpsestic fabric is further enriched by the remnants of its tumultuous history. The scars of World War II and the subsequent post-war reconstruction efforts are etched into the cityscape (Clark, 2016). The reconstructed façades along the Long Market and the Granary Island serve as a testament to the resilience and determination of Gdańsk's inhabitants in preserving their cultural heritage.

4.2. Between Destruction and Rebirth

Gdańsk's history is marked by cycles of destruction and rebirth, making it an adequate example of the salient state between periodic reincarnations. The city experienced severe damage during World War II, with its historic centre devastated (Tölle, 2008). However, Gdańsk's post-war reconstruction efforts aimed not only to rebuild the physical structures but also to revive the city's cultural identity (Bugalski, 2017). The process of reconstruction in Gdańsk presents a complex interaction between preserving the historical layers and introducing new elements (Clark, 2016). Urban planners and architects made meticulous efforts to restore the city's iconic places and monuments while incorporating contemporary design principles. This approach resulted in a harmonious blend of old and new, reinforcing the conception of Gdańsk as a palimpsestic city as illustrated in *figure 3*.

The palimpsestic nature of the city serves not only as a historical reference but also as a means to preserve cultural memory. The layers of Gdańsk's urban fabric are carefully curated, allowing residents and visitors to navigate the city's past and forge their connections. Museums, exhibitions, and commemorative sites play a crucial role in bringing these narratives to life, fostering a collective understanding of Gdańsk's identity (Bugalski, 2017).

Moreover, the metaphor of the city as a palimpsest offers valuable insights into the future of Gdańsk. Recognizing the city's salient state and the cyclical nature of urban development encourages sustainable approaches to growth. It prompts urban planners to introduce a balance between preserving historical layers and facilitating contemporary needs, ensuring that future additions to the urban fabric contribute to the city's evolving narrative.

4.3. Urban Challenges of Gdańsk: Public Spaces and Heritage Assets

Gdańsk has experienced rapid urbanization in recent decades, leading to increased pressure on its public spaces. The growing population, coupled with tourism and economic development, has resulted in a higher demand for usable and accessible public areas. However, the scarcity of land and the historical nature of the city present challenges in meeting these demands (Workshop lecture by Lorenz, 2023).

The lack of adequate public spaces can lead to limited urban social life, and community interaction. As the city continues to grow, it becomes crucial to prioritize the enhancement of public spaces, ensuring that they cater to the diverse needs of residents and visitors. Gdańsk's rich tangible and cultural heritage is a significant asset, attracting tourists and contributing to the city's identity. However, the challenge lies in finding a balance between contemporary needs and the preservation of heritage.

The pressure for urban development and the need to accommodate contemporary infrastructure and amenities often clash with the preservation of historical buildings and urban fabric. The temptation to demolish or modify historic structures to make way for new developments poses a threat to Gdańsk's

authenticity and cultural continuity. To address this challenge, careful planning and urban design strategies are crucial. By repurposing heritage buildings and integrating them into the new development, Gdańsk can preserve its heritage while meeting the demands of urban growth.

Additionally, strict regulations and guidelines for new construction can ensure that urban and architectural expressions are sensitive to the city's character. Preserving Gdańsk's historical assets requires ongoing maintenance and conservation efforts. The aging infrastructure, combined with the effects of weathering and urban pressures, poses a significant challenge to the upkeep of urban mobility plans, heritage buildings, and public spaces.

Limited financial resources and competing priorities make it difficult to allocate adequate funding for conservation projects. As a result, some heritage structures may deteriorate over time, compromising their integrity and authenticity. Proper maintenance and conservation are crucial to protect the cultural significance and to ensure the longevity of its public spaces. Collaboration between the government, heritage organizations, and the local community is crucial in addressing this challenge. Seeking external funding, establishing heritage conservation programs, and engaging in community-driven initiatives can provide the necessary support and expertise for the preservation of Gdańsk's public spaces and heritage assets (Workshop lecture by Czyż, 2023).

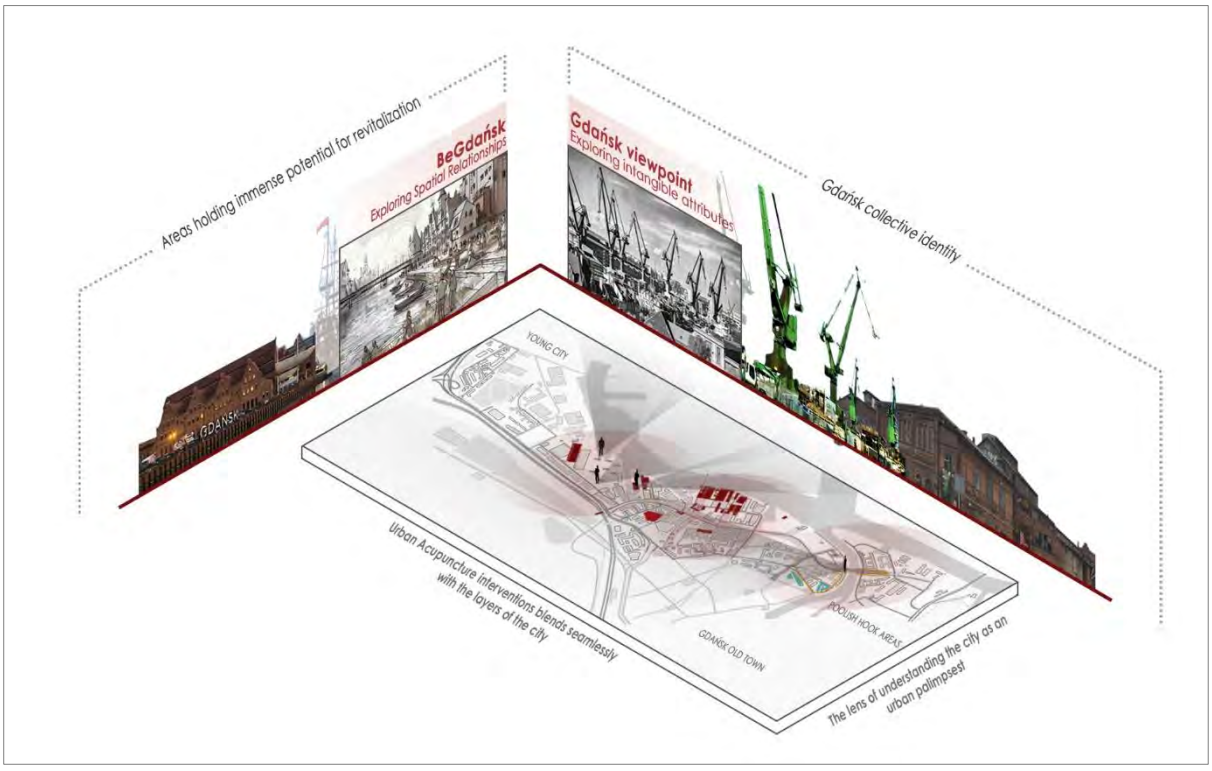

Figure 3. Illustration on palimpsestic layers of the reincarnating city of Gdańsk. Source: Authors, 2023.

5. The Joint ISOCARP - ITACUS Young Professionals workshop

5.1. Contextual overview and workshop challenges

A recent agreement between ISOCARP (The International Society of City and Regional Planners) and ITACUS (International Tunnelling and Underground Space Association's Committee on Underground Space) in cooperation with the city of Gdańsk as the host called for the organisation of a YPP (Young Planning Professionals) - YPTDP (Young Professionals Think Deep Programme) Workshop. The workshop aims to provide a forum for Young Professionals around the globe who have a keen interest in the fields of city planning, urban design, and civil engineering to collaborate on a particular urban development issue (Joint ISOCARP-ITACUS Young Professionals Workshop, 2023). In this instance, the workshop's subject is related to rethinking the northern part of Gdańsk city centre offers a potential to address its heritage product, in which its intangible attributes define the city's physical territory, urban spaces, and architectural expressions.

Given the numerous proposals represented in a spectrum of design concepts through which were generated during the workshop for the design of above and belowground public spaces resulting from the proposed tunnelling project for the Popiełuszki street extension, this part of the paper focuses on explicating two proposals conducted by two groups that represent two sides of the same coin, categorized into the tangible spatial layers tackled in the first proposal named "*BeGdańsk*", and the intangible socio-cultural attributes in the second one named "*Gdańsk Viewpoint*".

The two proposals were selected based on their attempt to understanding the city as urban palimpsest addressing the workshop challenges through utilizing Urban Acupuncture as a methodology with a deep focus on the mobility connection between two riverbanks of the Motława river. By examining the two proposals in depth, this shall provide a comprehensive review of the potential benefits and drawbacks of Urban Acupuncture as an approach to enhance the public realm on both tangible and intangible levels.

5.2. Proposal 01: Exploring Spatial Relationships

Considering both tangible and intangible attributes of the city's setting is crucial providing a comprehensive understanding of the complex nature of the urban landscape. The first proposal focuses on the tangible aspects of the built environment, such as spaces, streets, and buildings. These elements shape the way people experience and interact with the city. In the area where the discussions were held, the tangible assets that were recognised as different layers of historical monuments include several elements such as the cranes and their trackways, the flooring of the old yard. Additionally, the street grid that remains intact and reflects the industrial functions that once took place on the Shipyard estate is considered a significant component in terms of its function (Huang a et al., 2020).

Therefore, the "*BeGdańsk*" proposal emphasises how significant it is to see the tunnel as a crucial component of its surroundings, taking into account its connection to the ecological and historical components underneath. The proposal also bears in mind any potential future effects of the tunnel. It proposes a method that enhances public realm complementing the area of intervention with its heritage product as illustrated in *figure 4.*

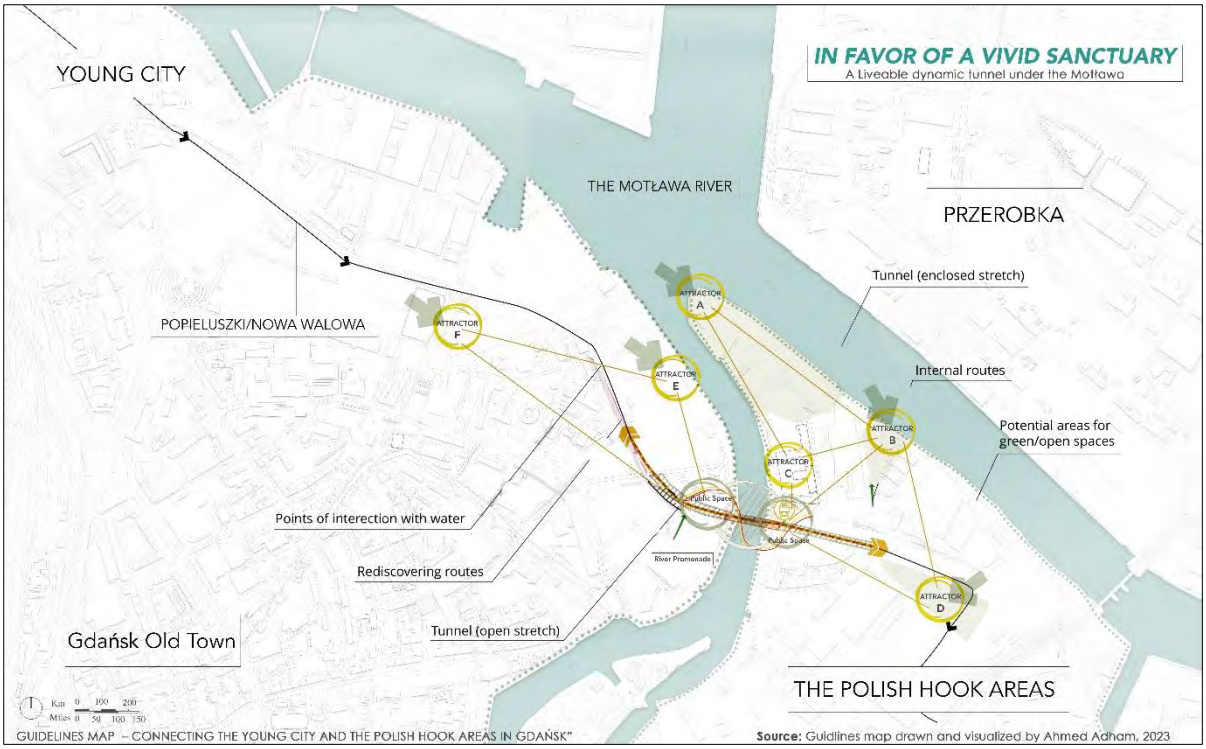

Figure 4. Guidelines map for "BeGdańsk" proposal. Source: Ahmed Adham, 2023.

Objectives and Urban Strategies

The overall objective of the proposal is to empower the sense of community among residents of Gdańsk by creating a new communal space that reflects the area's physical and historical characteristics, while also contributing to the public health and vitality of the city. To achieve this goal, "BeGdańsk" outlines several urban strategies as shown in *figure 5*, including conducting a community engagement process to gather input and feedback from residents, incorporating sustainable design principles and materials into the development of the shared space, and establishing partnerships with local organizations and stakeholders to promote the use of sustainable mobility options.

Additionally, it seeks to activate public awareness of the natural and historical characteristics of the area through a range *of* community events such as art festivals, social hubs, markets that showcase the area's local image within a public space.

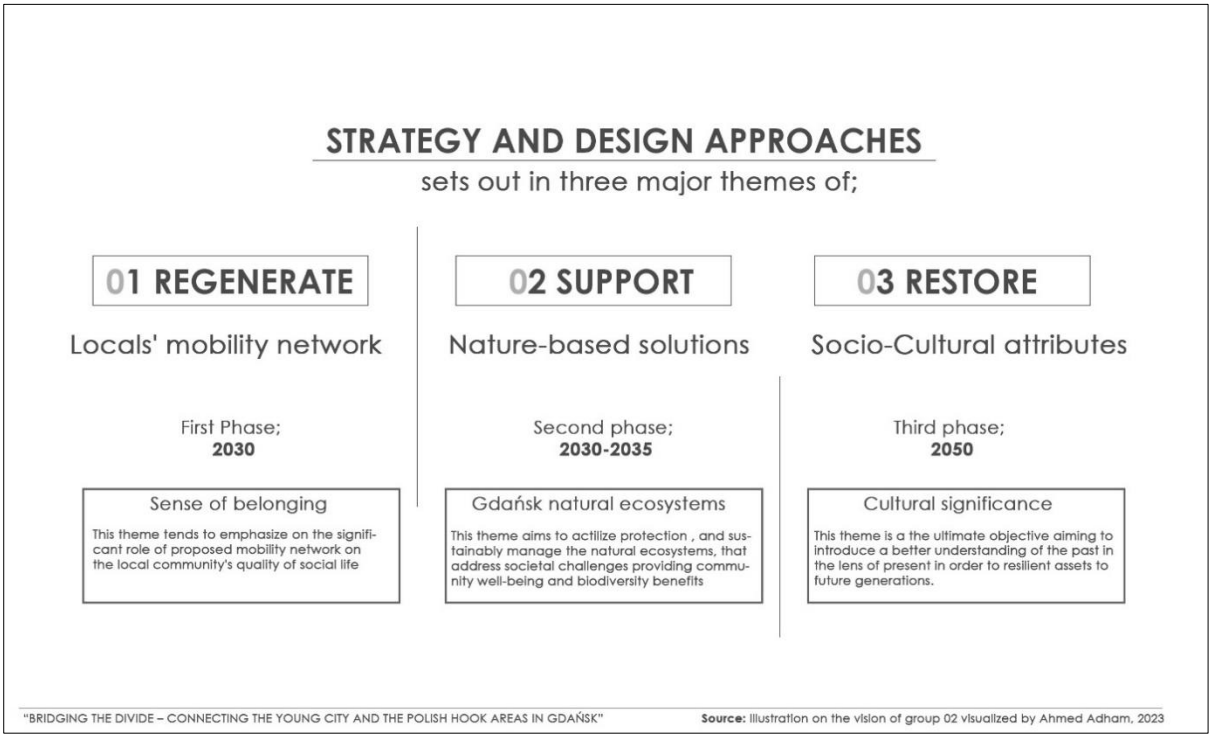

Figure 5. Illustration showing the design strategies "BeGdańsk" proposal. Source: Ahmed Adham, 2023.

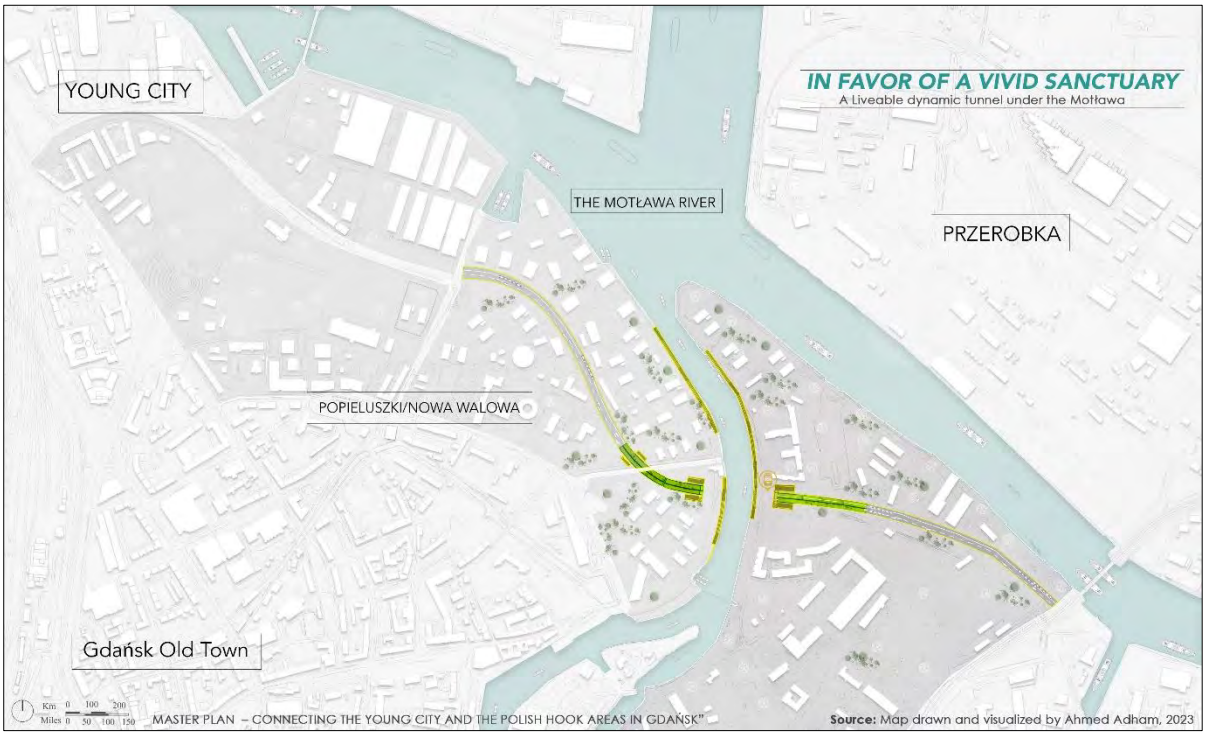

Figure 6. Masterplan showing the proposed connection of the riverbanks. Source: Ahmed Adham, 2023.

Design Proposal through the lens of Urban Acupuncture

The proposal involves constructing a double-deck tunnel beneath the Motława River to connect both riverbanks as illustrated in *figure 6*. The first deck shall be enclosed for pedestrians, while aboveground shall be public spaces with a diverse activities, attractions proposed include socio-culture, community initiatives, art, and recreation as shown in *figure 7.*

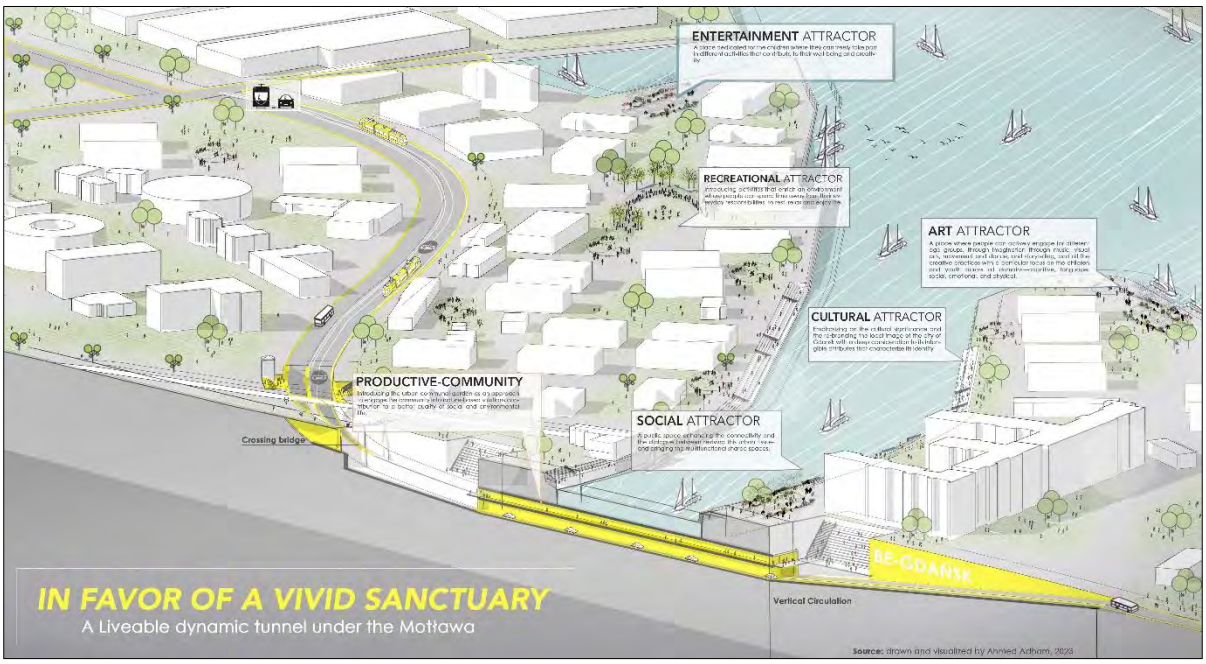

Figure 7. Illustration showing the public spaces and the urban attractors. Source: Ahmed Adham, 2023.

Findings and outcome of "BeGdańsk"

The urban palimpsest can reflect and inspire Urban Acupuncture approach targeting the interrelation spatial layers of "BeGdańsk". Therefore, the combination of urban acupuncture and understanding the city as urban palimpsest can provide a powerful framework for creating a genuine change in the urban context as illustrated in *figure 8*. By taking a holistic approach that considers both the physical and cultural layers of the urban environment and the specific urban challenges that need to be addressed.

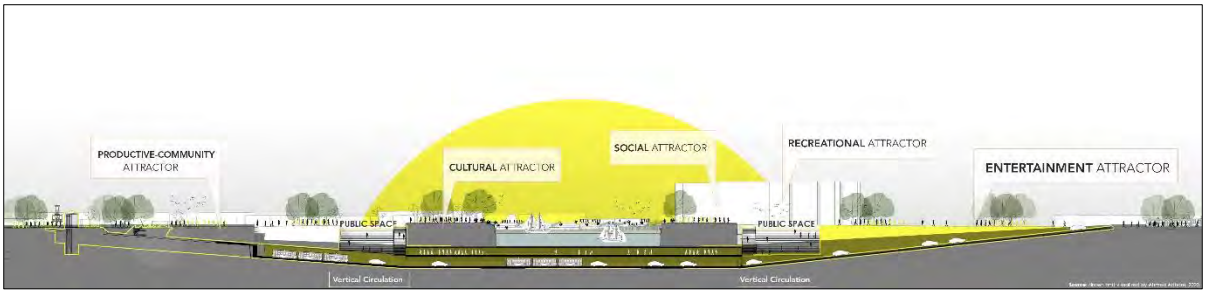

Figure 8. Section showing the attractors and its relationship to the tunnel. Source: Ahmed Adham, 2023.

5.3. Proposal 02: Exploring intangible attributes

The intangible aspects shape the way people use and perceive the urban environment having a significant impact on the socio-cultural life of the city (UNESCO, what is intangible cultural heritage? 2011). Likewise, the intangible attributes of Gdańsk young city together with the polish hook areas are closely linked to the history of the shipbuilding industry, which dates back to the mid-19th century, and the legacy of one of Poland's most significant social movements. The events of December 1970, the founding of the NSZZ "Solidarity" movement, and the agreements signed in August 1980 are all part of this heritage product. These events shaped the region's identity and left a lasting impact on its culture, traditions, and social values.

The intangible heritage associated with these events is a testament to the resilience and determination of the people of the region in the face of adversity (Huang a et al., 2020). Accordingly, to better connect with Gdańsk city according to the "*Gdańsk viewpoint*" proposal, there are plans to create a new spine that shall extend from Popiełuszki street helping people to explore and engage with the city's industrial heritage as shown in *figure 9*. This new spine shall serve as a comprehensive loop that encircles the city and will involve the construction of a tunnel beneath the Motława River (SCG Stocznia Centrum Gdańsk, 2022).

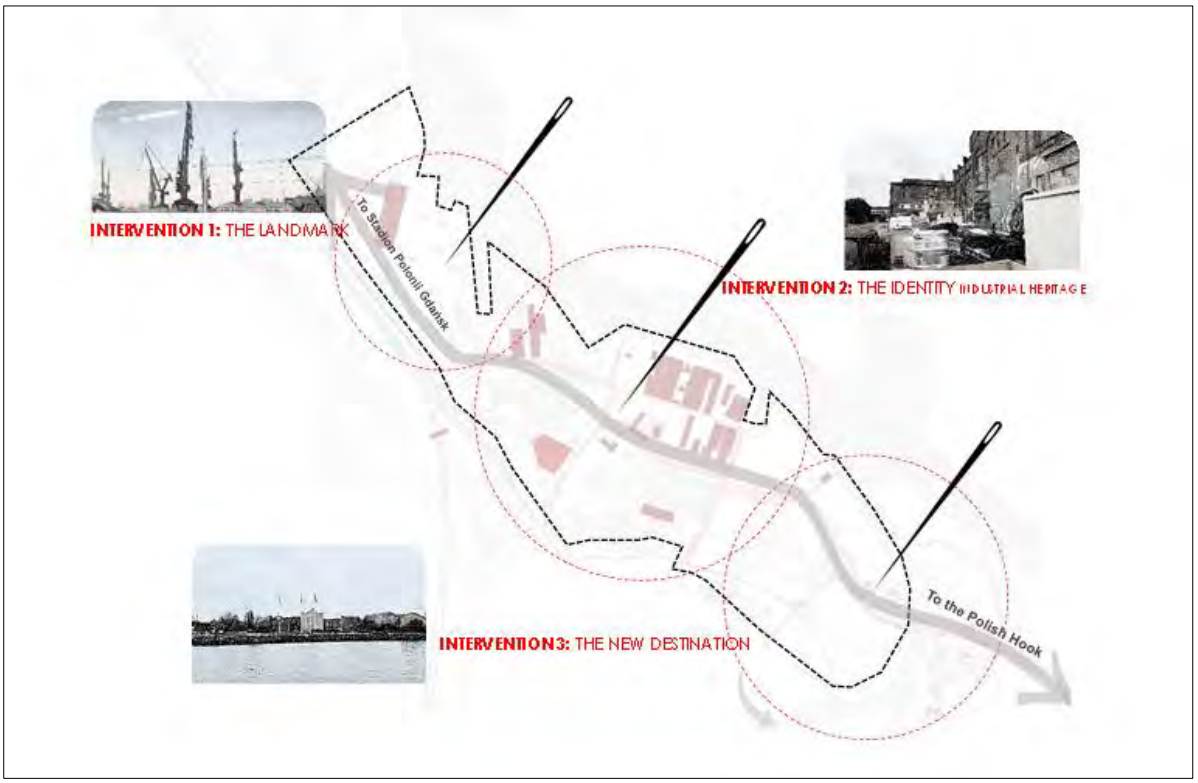

Figure 9. Illustration showing the proposed network on interventions. Source: Donia Tayel, 2023.

Objectives and Urban Strategies

The proposed project aims to empower the identity of the study area in Gdańsk by introducing public spaces that cater to the needs of local communities and visitors, while also improving the overall quality of life in the neighbourhood and the city. Ending the proposed spine with the "Viewpoint" attraction point shall encourage people to explore the area's industrial heritage and waterfront, while generating a flow of people through the area. It shall involve the creation of an overall permeable ground level that will empower new solutions of public-private partnerships to benefit all stakeholders involved, including the local community, tourists, and businesses as illustrated in *figure 10.*

Figure 10. Guidelines map for "Gdańsk viewpoint" proposal. Source: Donia Tayel, 2023.

Design Proposals through the lens of Urban Acupuncture

Gdańsk has the potential to foster sense of belonging among residents through a connected community celebrating the city's history and identity. The proposal begins by emphasizing how crucial it is to create a spine that aims to connect the Young City and the Polish Hook areas by creating a continuous route that leads to the significanct Cranes of the former Shipyard. This route connects the Shipyard to a new destination, showcasing advancement and innovation. Likewise, the spine aims to connect the city's industrial heritage with the future. Accordingly, particular points of action that might significantly affect the city's public health and vitality were identified. The hotspots, the industrial heritage, and the new destination are the three key layers of intervention in this proposal as shown in *figure 11.*

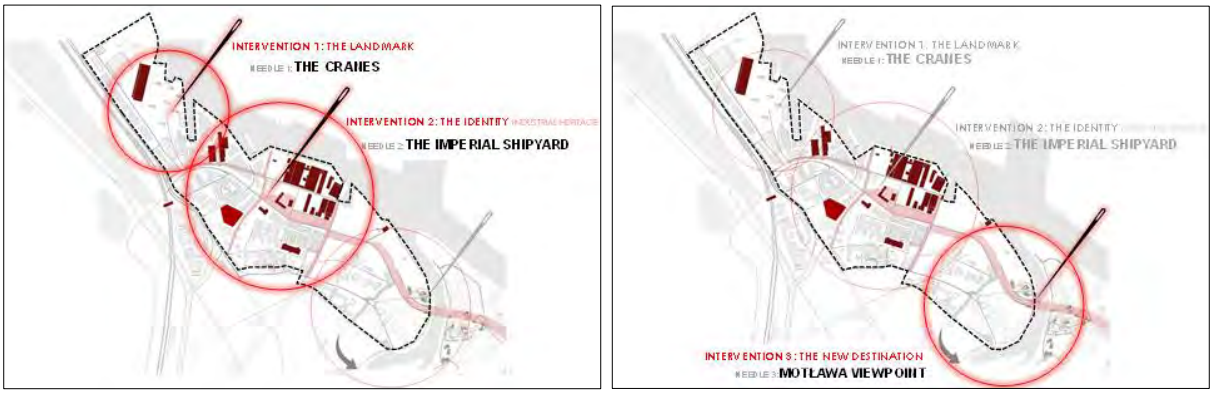

Figure 11. Detailed Guidelines for the layers of interventions. Source: Donia Tayel, 2023.

"Gdańsk Viewpoint" also concentrates on the Motława viewpoint as a new destination, with the expectation that it will have a beneficial impact on the neighboring region. This may involve generating fresh economic prospects for the nearby enterprises, raising property prices, and fostering a greater feeling of community pride and unity. Furthermore, this area could act as a driving force for additional progress in the Young City and the Polish Hook, resulting in a livelier and more energetic urban setting as in *figure 12*.

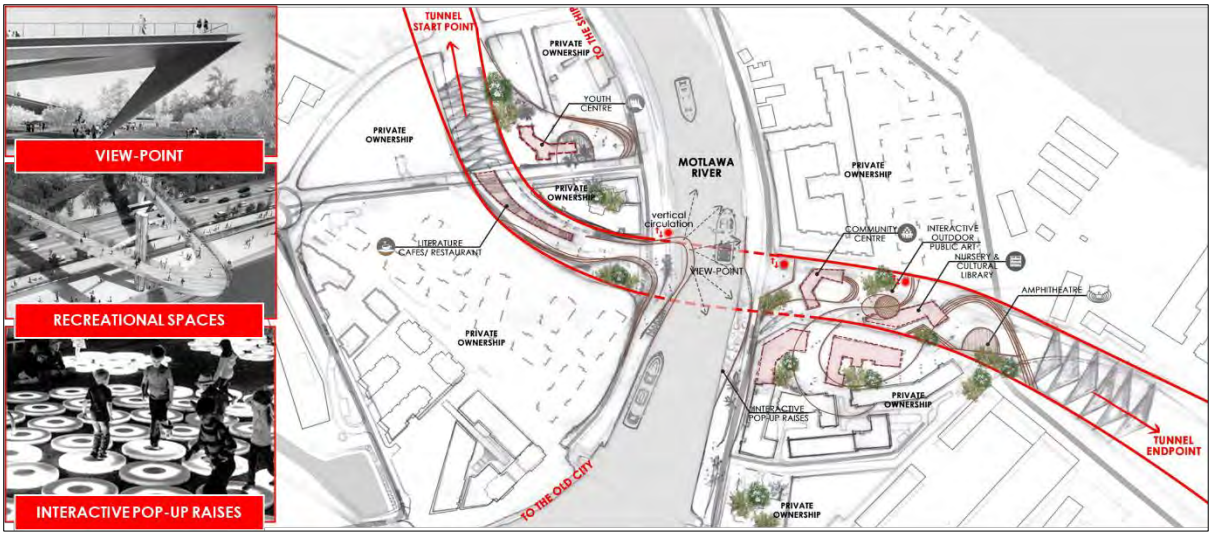

Figure 12. Masterplan showing the proposed view-point and urban spaces. Source: Donia Tayel, 2023.

Findings and outcome of "Gdańsk Viewpoint"

The "Gdańsk viewpoint" developed proposal includes several findings that contributes to the ongoing evolution of the urban palimpsest, ensuring a dynamic relationship that can adapt to future needs as illustrated in *figures 13 and 14*. Also, empowering intangible arributes of cultural and recreational assets for locals and tourists through a cultural spine that offers a unique and cohesive experience for visitors, showcasing the city's heritage and culture while providing practical amenities for the local community.

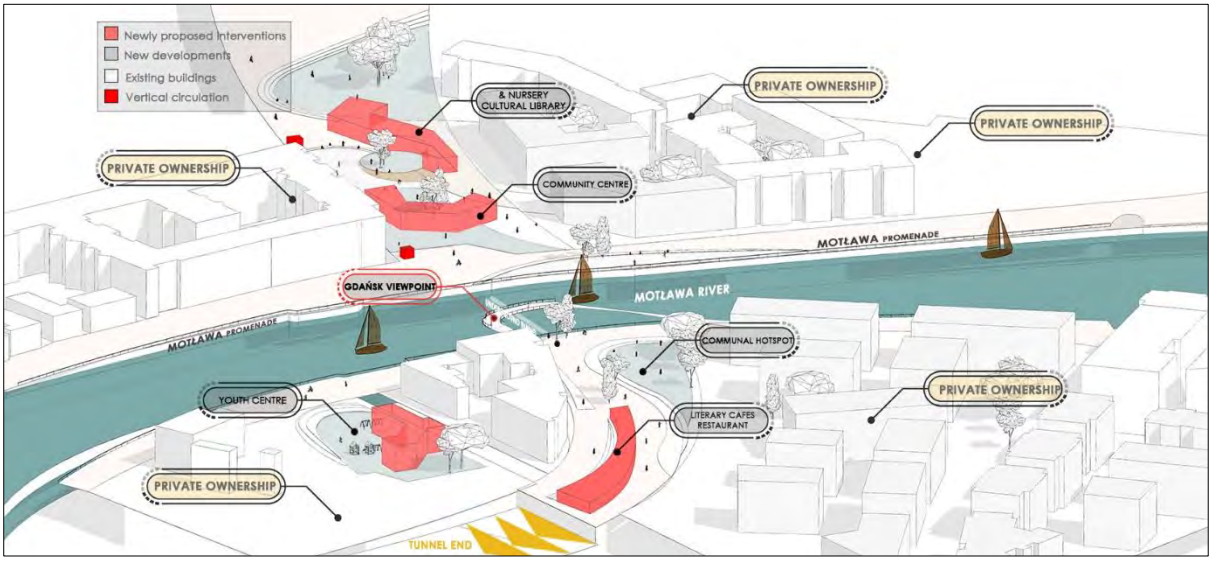

Figure 13. Illustration showing the new proposed interventions within the setting. Source: Donia Tayel, 2023.

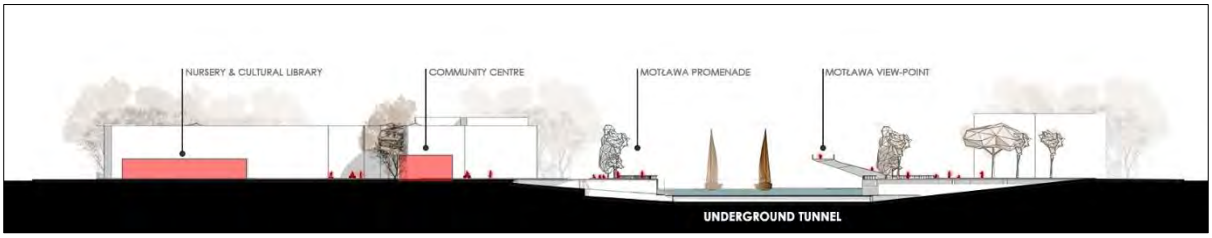

Figure 14. Section showing the activities on both riverbanks. Source: Donia Tayel, 2023.

6. Conclusion and Discussion

Urban palimpsest's allegory offers several valuable insights into the complex nature of cities and their historical depth. By conceptualizing the city as a palimpsest, it encourages appreciating the layered narratives embedded within urban landscapes. This approach highlights the richness and complexity of urban environments, where the physical structures, cultural heritage, and socio-cultural attributes intertwine to create a multicellular organism. The allegory of periodic reincarnations adds another layer of understanding to the palimpsestic city. Corboz argues that cities undergo cycles of destruction and renewal, resulting in a continuous state of change. This perspective challenges the common perception of cities as fixed trees (Alexander, 2019) and emphasizes their capacity for adaptation and resilience. By acknowledging the cycles of change and transformation, they bring attention to the socio-cultural and environmental factors that shape urban development.

Moreover, the focus on the salient state between periodic reincarnations sheds light on the transitional periods when the traces of past iterations blend with the emerging urban fabric. This concept acknowledges that the city's transformation is a gradual and ongoing process, rather than abrupt or linear. It helps to recognize the inherent complexity and continuity of cities, bridging the gaps between different historical layers and facilitating a holistic understanding of urbanism and development. Furthermore, exploring the palimpsestic city invites a multidisciplinary approach to urban studies. By emphasizing the interconnectedness of planning, urban design, architecture, politics, sociology, heritage studies, and climatology. It encourages scholars from various fields to engage with the urban landscape as a living tissue.

While the metaphorical framework provides valuable insights, it also presents some limitations that warrant consideration. First, the metaphor might oversimplify the complexity of urban development. While it highlights the coexistence of historical layers, it may overlook the nuances and conflicts that arise from the juxtaposition of diverse urban and architectural norms, social dynamics, and cultural practices. The metaphor risks reducing the city's richness to a mere chronological accumulation of physical and cultural imprints, potentially overlooking the power dynamics, contestations, and socio-economic factors that shape urban spaces.

Additionally, the metaphor of periodic reincarnations can be problematic in its portrayal of urban transformation. It may imply a sense of renewal and progress without sufficiently acknowledging the losses and displacements that occur during cycles of destruction. It could inadvertently romanticize or overlook the social, economic, and environmental consequences that marginalized communities often face in the process of urban renewal. Furthermore, the salient state between periodic reincarnations, while acknowledging the city's transitional nature, may be insufficiently explored by Corboz. His ideas provide limited guidance on how to navigate these transitional periods and address the tensions that arise between preserving the city's historical layers and facilitating contemporary needs. A more nuanced examination of the salient state would have required a deeper exploration of the complex interactions between continuity, change, tradition and innovation.

7. Acknowledgements

The authors would like to thank ISOCARP and ITACUS for their great efforts to actualize their agreement in cooperation with the city of Gdańsk to host the YPTDP Workshop.

We gratefully acknowledge the time and effort that the respected members of the two groups “BeGdańsk” and “Gdańsk Viewpoint” have expended in their deep cooperation with the authors during the workshop in the city of Gdańsk.

8. References

SCG Stocznia Centrum Gdańsk. (2022). The yard in dialogue - SCG.PL. Available at: https://scg.pl/wp-content/uploads/2023/02/Report_The-Yard-in-dialogue.pdf (Accessed: 15 Mai 2023).

Alexander, C., 2019. A city is not a tree.

Bartolini, N., 2014. Critical urban heritage: From palimpsest to brecciation. International Journal of Heritage Studies, 20(5), pp.519-533.

Blank, Y., 2005. The city and the world. Colum. J. Transnat'l L., 44, p.875.

Bugalski, Ł.U.K.A.S.Z., 2017. Gdańsk's Cultural Heritage. The City Centre District and Municipal Historical Policy. Przeglad Zachodni, pp.189-207.

Carter, P., 2012. Policy as palimpsest. Policy & Politics, 40(3), pp.423-443.

Certeau, M. de (no date) The practice of everyday life, volume 1, Google Books. Available at: https://books.google.com/books/about/The_Practice_of_Everyday_Life.html?id=WVn1XMEO168C (Accessed: 02 June 2023).

Clark, E.M., 2016. Gdańsk, Story of a City When Diplomatic History and Personal Narrative Intersect. The Polish Review, 61(1), pp.61-79.

Corboz, A., 1983. The land as palimpsest. Diogenes, 31(121), pp.12-34.

Diener, A.C. and Hagen, J., 2018. The city as palimpsest. The city as power: Urban space, place, and national identity, 1.

Engbersen, G., 2001. The urban palimpsest. Focaal-European Journal of Anthropology, 38, pp.125-138.

Friedrich, J., 2012. Polish and German heritage in Danzig/Gdańsk: 1918, 1945 and 1989. na.

Geisler, W., 1918. Danzig, ein siedlungsgeographischer Versuch. Druck von AW Kafemann, GmbH.

Hoogduyn, R., 2014. Urban Acupuncture" Revitalizing urban areas by small scale interventions".

Huang, J., Obracht-Prondzynska, H., Kamrowska-Zaluska, D., Sun, Y. and Li, L., 2021. The image of the City on social media: A comparative study using "Big Data" and "Small Data" methods in the Tri-City Region in Poland. Landscape and Urban Planning, 206, p.103977.

Huyssen, A., 2003. Present pasts: Urban palimpsests and the politics of memory. Stanford University Press.

Huyssen, A., 2003. Present pasts: Urban palimpsests and the politics of memory. Stanford University Press.

JANUSZAJTIS, A., Aus der Geschichte der Selbstverwaltung Danzigs.

Jeleński, T., 2018. Practices of built heritage post-disaster reconstruction for resilient cities. Buildings, 8(4), p.53.

Joint Isocarp-Itacus Young Professionals Workshop - Gdansk, Poland 2023 (2023) ISOCARP. Available at: https://isocarp.org/2023-gdansk-ypp/ (Accessed: 23 June 2023).

Köhler, G., 1893. Geschichte der Festungen Danzig und Weichselmünde bis zum Jahre 1814 in Verbindung mit der Kriegsgeschichte der freien Stadt Danzig (Vol. 1). W. Koebner.

Lerner, J., 2014. Urban acupuncture (p. 547). Washington, DC: Island press.

Nicolle, D., 2014. Forces of the Hanseatic League: 13th–15th Centuries. Bloomsbury Publishing.

Omilanowska-Kiljańczyk, M., 2008. The question of national and regional identity on the example of Polish and German interpretations of Gdansk architecture in the 19th and 20th centuries.

Powell, K.A., 2008. Re mapping the city: Palimpsest, place, and identity in art education research. Studies in Art Education, 50(1), pp.6-21.

Tölle, A., 2008. Gdańsk. Cities, 25(2), pp.107-119.

Unesco - what is Intangible Cultural Heritage? (no date) Intangible Cultural Heritage. Available at: https://ich.unesco.org/en/what-is-intangible-heritage-00003?ssp=1 (Accessed: 23 June 2023).

Vâlceanu, D.G., Kosa, R.A. and Tamîrjan, D.G., 2014. Urban landscape as palimpsest. Urbanism. Arhitectura. Constructii, 5(4), p.17.

Research Paper

Examining Sensitivity between Air Pollution and Land uses

to Conform Climate Responsive Planning in Lahore

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Abstract

Remorseless air pollution has threatened the fragile environment of our cities and traditional policies initiatives have failed to combat it. revamping urban planning for the revitalization of urban air quality is the need of the day. The innovative urban planning strategies: the power of mixed land use can contribute significantly to controlling air pollution. Furthermore, it is a great initiative to conform climate response planning in Lahore. Receiver Operating Curve (ROC) analysis has been used to verify an in-depth effect of mixed land uses of air quality indices. The paper suggests policy measures for the adoption of climate response spatial development.

Keywords

Air Quality Indices, Land use Mix, Receiver Operating Curve, Green House Gases, National Environmental Quality Standards

1. Introduction

Urban population is increasing rapidly in the World. Enormously expanding cities with inundated land uses layouts, have increased motor vehicles usage tremendously. Consequently, consumption of energy increased unprecedentedly. The consumption of energy in South Asia is very high as compared to the other regions of the World**.**

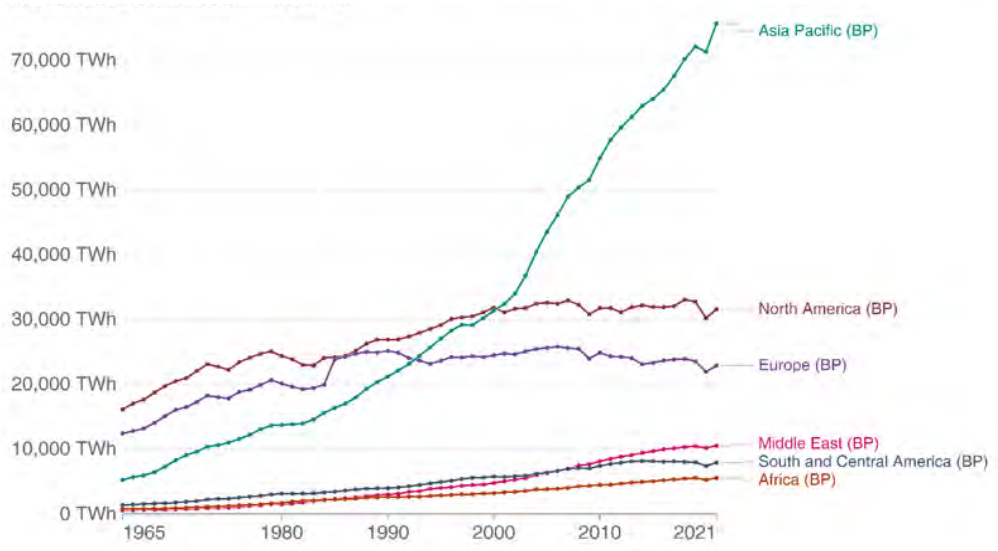

Figure 1 Energy Consumption in different Regions[1]

Private cars account for less than one-third of the total trips in cities worldwide but are responsible for 73 percent of urban air pollutants. Private cars per capita generate three times more greenhouse gas emissions than public transport systems like buses.(Toni,2015)

The situation of Pakistan is like the South Asia, shows a perplexing rise in demand for energy. Fuel consumption in the country is expected to increase six-fold with an 18% rise in transport by 2050 (SDPI,2005). More is consumed, more is the emission and environmental degradation. Remorseless air pollution has threatened the flimsy environment of big cities with the onus of unrelenting future emission. Different causes are associated with air pollution in Pakistan. For example, traffic exhausts, untreated emissions of industries, and solid wastes all are important sources of air pollution. But the prime source of air pollution in big cities of Pakistan is vehicular exhaust. The three important contributors, namely, transport, industry and power have increased SO_2 emission to twenty-three-fold in the last twenty years and NO_2 to twenty-five fold. Pakistan per capita greenhouse gas (GHG) emissions are far below the Global average (Khawaja and Shaheen,2005). Average PM_{10} in the national and provincial capitals shows a gloomy picture of urban environment when compared with WHO guidelines. Pakistan pays a heavy cost of air pollution from the public exchequer.

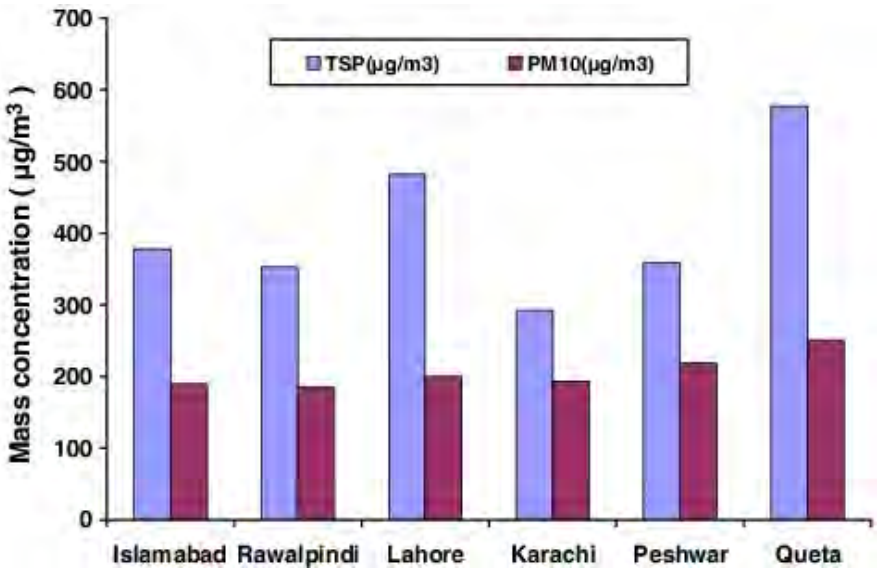

Figure 2 Concentration of PM_{10} in Six Major Cities of Pakistan [5]

High economic costs are a result of the growth in urban population as well as the excessive air pollutants released by automobiles, industries, and municipal trash burning. For urban air pollution, an estimate of the economic impact is Rs. 65 billion (or US$ 650 million) each year. (World Bank,2009)

The mixing of the land uses brings origins and destinations closeness and encourages plying of non-motorized vehicles. An appropriate layout of complementary land uses not only increases the value of the land, but also helps in achieving a high density living. Furthermore, it fosters compact development of cities and helps to cut short expenditures to be incurred on the provision of trunk infrastructure.

The Land Use Mix (LUM) measures the degree of separation of land uses. Mixed land uses generate street activities and make the neighborhood more livable and plausibly dense. There are two ways of calculating land uses mixed index, intended globally or locally. Global mixed land uses are determined by an overall land use mix of a city or town while local show, the distribution of land uses within a city. Mixed land uses

affect sustainability through its impact on environmental, social, and economic costs (Musaka and Niekerk,2013)

2. Situation in the Study Area

Lahore is a metropolitan city of Pakistan and the provincial capital of Punjab. Lahore has 365 kilometers of roadways, and 1.4 million automobiles are registered with the city. The population of Lahore is increasing by 4% annually.(Ali and Athar,2010)

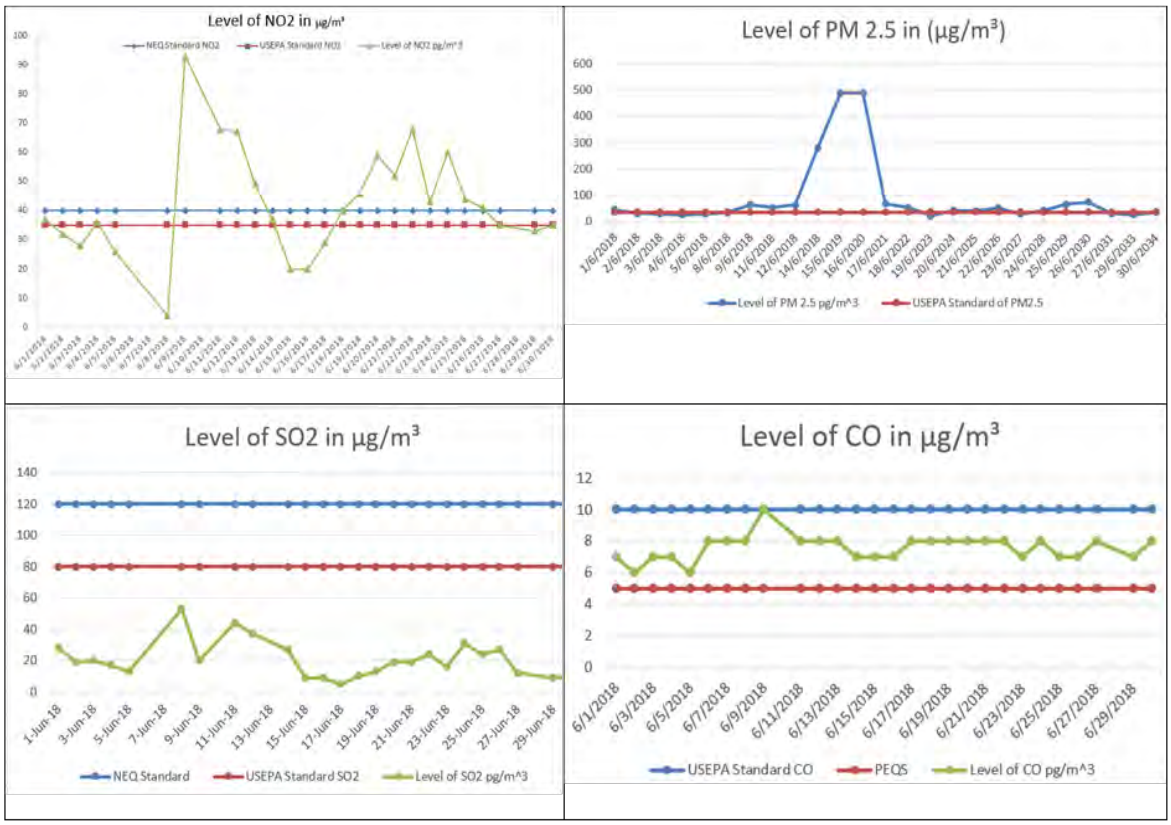

Figure 3 Level of Air Pollution in Lahore [9]

An investigative study (Ashraf et al.) carried out at different locations in Lahore, shows that the emission levels at most of the locations are above United States Environmental Protection Agency (USEPA) and National Environmental Quality Standards (NEQS) permissible limits.

Some significant gaps were found when we compared data of ambient air quality with World Health Organization (WHO) standards. A considerable rise was noticed in the carbon monoxide (CO) levels in Karachi and Lahore. Particulate matter contents have crossed the safety levels in major industrial cities in the Punjab province (Khawaja and Shaheen,2005). These pollutants cause substantial damage to human life and their inexorable emission is a significant threat to the urban environment. Mortality data shows that more than 63000 people die annually in Lahore, of whom around 1250 die because of air pollution (The Daily Times,2006). Pakistan pays a heavy cost in billions for treatment of patients affected by the air pollution borne diseases. A breakup of the cost along with common diseases and attributed of the cases highlighted below:

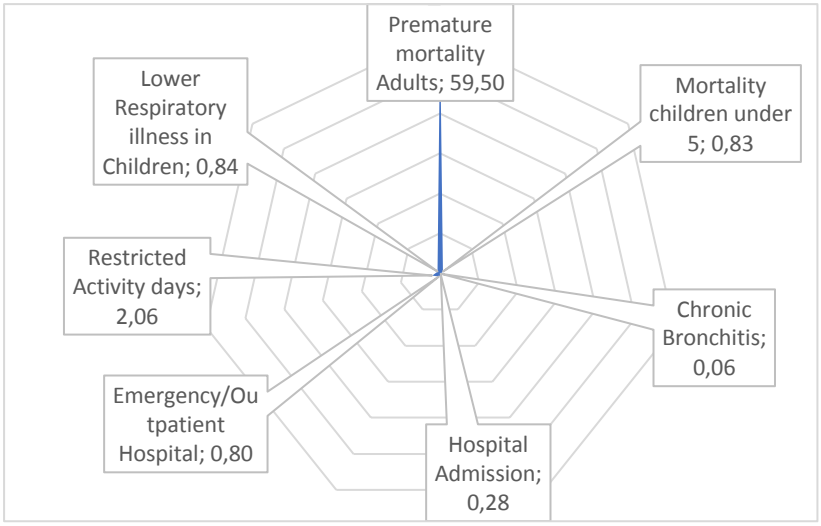

Figure 4 Annual Cost on Ambient Urban Air Pollution Health Impacts [12]

Conventional methods of land use planning, having master plan as the main tool for development control are being practiced in the city. Inarticulate land-uses with frequent changes, in line with the change in land-use policy adopted by the District Government in Lahore,have increased motorized trip tremendously. Consequently, allowing a proportionate reliance on motor vehicles. Land use planning of the city has primarily intensive on division and separation of different land uses with the focus to discourage development of mixed land use zones**.**

3. Research Methodology

Methodology of research comprises of the following steps

3.1. Sample Size

Keeping in view the secondary data and available resources for research, Lahore, a metropolitan city of Pakistan has been selected as a case study. To ease the burden of calculations for in-depth analysis, Lahore has been divided into nine towns as per existing administrative setup. These towns have been taken for comparative and correlational studies.

3.2. Collection of Data and Application of Modelling

The Integrated Master Plan of Lahore- 2021 and the Lahore Urban Transport Master Plan have been conferred for secondary data in addition to the data obtained directly from relevant organizations like Environment Protection Agency (EPA). In the light of this data, Air quality indices and Land use mix (LUM) of the towns have been calculated.

A land use mix index or entropy index has been applied to determine urban form characteristics for all towns of Lahore. The formula used for Land uses mix (LUM) is.

LUM = - ∑ pi ln pi/ ln n; (Kong et al.,2015)

Where pi is the percentage of the land use area devoted to land use i, and n is the number of land uses. The Receiver Operating Curve (ROC) Analysis has been applied to see the sensitivity of Land use Mix (LUM) and Air Quality Indices. Furthermore, the nature of the relationship between air quality and LUM has been testified.

4. Analysis of the Data

4.1. Air Quality Indices (AQI)

Air quality indices have been calculated by using the formula of average emission /National Environmental Quality Standards (NEQS) in the following manner.

(Average Emission of Pollutant 1/NEQ+ ……. ..+ Average Emission of Pollutant 5/NEQ)

5 (The Total number of Pollutants)

Fig 4 shows a significant variation in the quality of air in towns of Lahore. The AQI of Data Gunj Buksh town is significantly higher than Aziz Bhatti Town

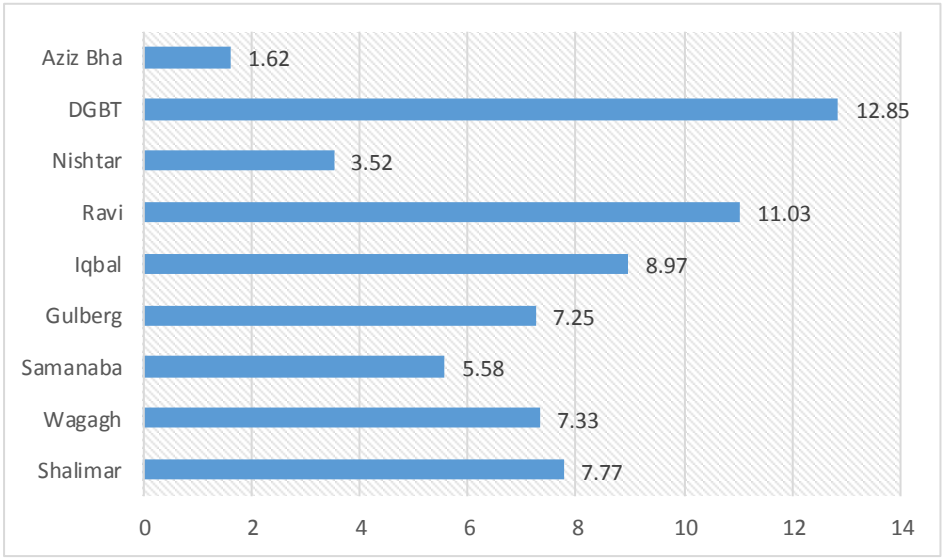

Figure 5 Air Quality Indices of the Towns of Lahore [14]

4.2. Land uses Distribution and Land uses Mixing

Land uses arrangements support credible control of the urban environment. Land uses distribution given in the Integrated Master Plan for Lahore-2021 has been used to establish a relationship with air quality indices. Fig 5 shows the percent distribution of Land uses in all nine towns with a significant allocation to residential and agricultural uses. It highlights that Data Gunj Buksh and Ravi have more types of land uses or mixed land uses zones.

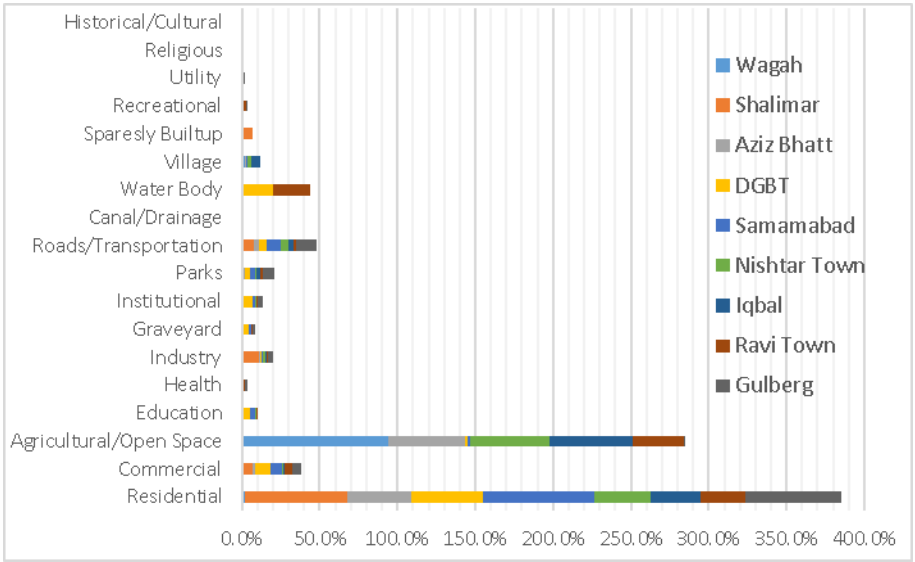

Figure 6 Percent Distribution of Land uses [15]

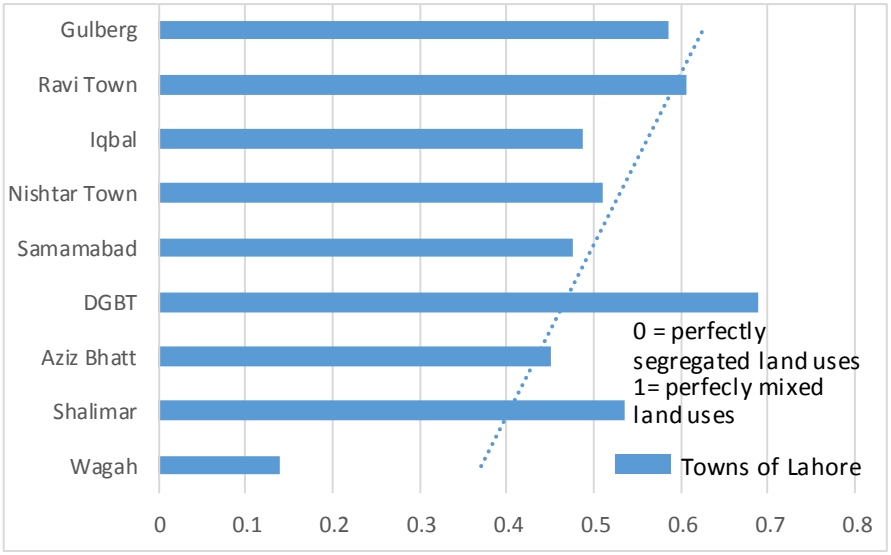

Figure 7 Land Uses Mix and Trend Line in Towns of Lahore

4.3. Sensitivity Analysis Using ROC Curve

Sensitivity analysis or ROC Curve analysis has been used to obtain significant trade-off between sensitivity (Air Quality) and specificity (land uses mixing). At different values of land uses mix, sensitivity of air quality has been testified. Area under the curve (AUC) is used to compare goodness of the test. A perfect test has the value 1.0 whereas the value 0.5 indicates failure of the test. An AUC value ranging between 0.99 to 0.9 shows an excellent test, a value between 0.89 to 0.8 indicates a good test, a value between 0.79 to 0.7 indicates a fair test whereas a value between 0.69 to 0.51 shows a poor test. It has been found that maximum sensitivity can be achieved between 0.34 to 6.0 values of Land uses mix. The maximum area under curve i.e., 0.875 has been obtained by putting a value of Land uses mix as 0.6.

Test Result Variable(s): AQI

Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
.750	.153	.439	.450	1.000

Table 1 Area Under the Curve

Table 1 shows that area under the curve is 0.75 which shows fairly good sensitivity between two variables. The cutoff value of Land uses mix at this critical point is 0.34

Test Result Variable(s): AQI

Positive if Greater Than or Equal To[a]	Sensitivity	1 - Specificity
.6200	1.000	1.000
2.5700	1.000	.875
4.5500	1.000	.750
6.4150	1.000	.625
7.2900	1.000	.500
7.5500	1.000	.375
8.3700	1.000	.250
10.0000	.000	.250
11.9400	.000	.125
13.8500	.000	.000

Table 2 Coordinates of the Curve

Table 2 shows sensitivity and specificity against different values of test variable. At a value 0.62, sensitivity is 1 and specificity is (1-1) =0. Furthermore, at 13.85 sensitivity is 0 and specificity is 1.

Test Result Variable(s): AQI

Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
.875	.117	.245	.646	1.000

Table 3 Area Under the Curve

Table 3 shows that the area under the curve is 0.875 which shows excellent sensitivity between two variables. The value of LUM at this critical point is 0.60.

5. Results and Discussion

There exists a perception that land uses effect the level of air pollution. But what is the nature of this relationship and at what values of LUM this relationship is more sensitive and beneficial to control air pollution. In this context, the area under the curve is important. We consider LUM values against which the area under the curve is maximum or minimum to ascertain the level of sensitivity. The findings of the research showed that a core relationship exists between land uses and air quality. Land uses can play an important role in curtailing air pollution if their mixing has a plausible range. Mixed land uses having values between 0.34 and 0.60 showed more sensitivity towards air quality which means that an effective

range of mixing the land uses lying between 0.34-0.60 can linearly affect the air pollution in the study area. The findings of the research also highlighted actuality that air quality indices of some towns which have less buildable areas were significantly higher as compared to the towns with more buildable areas. It indicates that in the built-up towns these mixed land uses are already in a plausible range and only attention is required to focus on the land uses of the buildable/growing towns. The mixing of the land uses in built/established towns is fortuitously in sensitivity range and therefore, requires a policy shift to declare and maintain threshold of the land uses mix. There is no provision of land uses mixed zones in master plans of the city. There is a need for the provision of mixed uses zones, districts, and provincial land uses plans. The following policy measures have been recommended to be taken to control air pollution.

- Land uses layout may be adopted as the foremost measure to control urban air pollution, especially in big cities.
- Mixed land uses may be encouraged as a policy tool to control air pollution in the city with an effective range of mixing.
- The land uses mixing calculations may be made a mandatory part of every spatial/master plan.
- A model of compatible land uses mix may be introduced in spatial/master plans of big cities.
- Change in land use policy (land use classification and reclassification rules) may be pursued only under an effective limit of compatible mix land uses.
- To curtail air pollution there is a need of district land uses plan with a plausible notified threshold value of mixing.

References

1. BP (2019) Statistical Review of World Energy [Internet]. Available from: <https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html> accessed on July,2022
2. Tony L. (2015) Transport Plays a Key Role in Urban Air Quality [Internet]. Available from:
3. <http://www.wri.org/blog/2015/02/transport-plays-key-role-urban-air-quality>accessed on Feb3,2015
4. Sustainable Development Policy Institute (2005) Air Pollution: Key Environmental Issues in Pakistan, P.3 Islamabad
5. Khawaja M.A and Shaheen K (2005) Air Pollution: Key Environmental Issues in Pakistan, P.1, Islamabad
6. World Bank (2006) Atmospheric Ecosystem [Internet]. Available from: <http://www.mocc.gov.pk/gop/index.php?q=aHR0cDovLzE5Mi4xNjguNzAuMTM2L21vY2xjL3VzZXJmaWxlczEvZmlsZS9FQ0NPL0NoYXB0ZXItMDUucGRm>

World Bank (2009) National Sustainable Development Strategy of Pakistan, UNEP Regional Workshop, Bangkok.

Musaka W. and Niekerk A (2013) Implications of land use change for the sustainability of urban areas: A case study of Stellenbosch, South Africa, Cities 32 (2013) 143–156

Ali M and Athar M (2010) Impact of transport and industrial emissions on the ambient air quality of Lahore City, Pakistan, Environmental Modelling and Assessment 171:353–363

Ashraf et al. 2013) Preliminary monitoring of tropospheric air quality of Lahore City in Pakistan International Journal of Chemical and Biochemical Sciences IJCBS, 3(2013):19-28

Khawaja M.A & Shaheen K (2005) Air Pollution: Key Environmental Issues in Pakistan, P.1, Islamabad

The Daily Times (2006) Deadly particles killing 1,250 in Lahore, Lahore

Hui Kong et al. (2015) Paths to mixed-use development: A case study of Southern Changping in Beijing, China, Cities 44 (2015) 94–103

World Bank (2006) Pakistan Strategic Country Environment Assessment. South Asia Environment and Social Unit, Islamabad.

Environment Protection Agency (2013) Ambient Air Quality Monitoring Report of Lahore, Environmental Protection Agency, Lahore

Lahore Development Authority (2004) Integrated Master Plan for Lahore-2021, Lahore.

Research Paper

Winter assessment of indoor air quality of middle-income households in Kolkata, India

Indoor pollution contributory factors

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Abstract

Indoor air pollution is a growing concern for everyone alike, as it poses significant health risks and can have far-reaching economic consequences. The vulnerability and level of impact crucially depend upon the economic status of the society and individuals. According to a report by the Energy Policy Institution, Indian residents, exposed to the highest levels of air pollution in the world, lose about 6 years of life due to air pollution. The study selectively targets the middle-income group that constitutes the major share of the population in India, which is natural ventilation dependent and where air conditioning or purification is not likely. Detailed indoor air quality audits were conducted in residential buildings located in different neighbourhoods in Kolkata, the second most polluted mega-city in India after Delhi. The study attempts to study indoor air quality in detail and demonstrate the relationship between indoor pollutant concentration and building-related aspects like floor level, window area, and ventilation. The study assesses indoor air pollution levels and their determining factors detailing the difference in single-side and cross-ventilated homes. By taking action to improve indoor air quality, we can promote occupant health, and economic growth, and create a sustainable and equitable future.

Keywords

Air Pollution, Urban Built-Environment, Indoor Air Quality, Occupant Health, Economic Status

1. Introduction

Indoor air quality (IAQ) is the term used to describe how well a building or other structure's occupants can breathe, which has a direct bearing on their health and wellbeing (World Health Organization, 2019). People spend a lot of time indoors, especially in homes, offices, schools, and other indoor environments, so maintaining good IAQ is essential (Smith, 2020). IAQ is influenced by a number of elements, including indoor activities, building components, ventilation systems, and outdoor air pollution (ASHRAE Standard 62.2, 2016). Numerous health issues, including fatigue, allergies, and respiratory problems, can be brought on by poor IAQ (Steigvilė Byčenkienė, 2017). Additionally, it may affect general comfort, mental performance, and productivity (Mujeebu, 2019). However, maintaining high IAQ encourages a comfortable and healthy indoor environment, which benefits health outcomes, productivity, and overall quality of life (WHO,2021). Everyone is becoming increasingly concerned about indoor air pollution because it poses serious health risks and may have significant negative economic effects. The economic condition of the society and the individuals has a significant impact on the vulnerability and severity of indoor pollution. Buildings with modern Heating Ventilation and Air Conditioning (HVAC) are often studied, especially commercial buildings, shelving naturally ventilated residential buildings which form a major proportion specifically in Asian cities catering to lower to middle income population.

Due to poor housing conditions and limited access to advanced ventilation or air purification technologies, lower to middle income communities frequently experience higher indoor pollution exposure (Swanya Prabha Maharana, 2018). Indian citizens are exposed to some of the highest levels of air pollution in the world, which results in an estimated loss of 6 years of life due to air pollution, according to a report by the Energy Policy Institution. In light of this, it is crucial to speak specifically to the indoor air quality (IAQ) issues that the middle-income group, which represents a major segment of the Indian population. The middle-income group is more vulnerable to indoor pollution because, in contrast to higher-income households, they frequently rely on natural ventilation rather than air conditioning or sophisticated air purification systems (Katiyar, 2019). To bridge this gap, this study carried out in-depth indoor air quality audits in 56 residential settings situated in various neighbourhoods in Kolkata, the second most polluted megacity in India after Delhi (Government of India, 2020), (Central Pollution Control Board, 2020), in order to gain deeper insights into the indoor air quality conditions of middle-income households (Majumdar, 2020).

Due to the city's high levels of pollution and preponderance of middle-class households, Kolkata was chosen as the study area. The study's goal is to offer important insights that can be used in similar contexts worldwide by concentrating on Kolkata by thoroughly examining indoor air quality and determine how factors related to buildings, such as floor level (Chan, 2008), window area (Farzad Bazdidi-Tehrani, 2020), and ventilation systems (ASHARE, 2016), affect indoor pollutant concentrations. The degree of indoor pollution and the efficiency of natural ventilation in reducing pollutant levels are greatly influenced by these variables (Wei Ye, 2017). Many recent studies have highlighted the role of urban built environment in determining IAQ of a building which include factors like spatial distributed housing stock (Jonathon Taylor, 2019), planning layouts in residential areas (Shuhan Yang, 2020), urban planning and air quality management zones (Joanna Badach, 2020), and the influence of building height variability on pollutant dispersion in urban areas (Jian Hang, 2012). The study also aims to highlight the variations in indoor air quality (IAQ) between single-side ventilated homes and cross-ventilated homes. The comparison enables a better comprehension of the influence of ventilation patterns on the accumulation and dispersion of indoor pollutants. Policymakers, architects, and locals may find this information helpful when designing and retrofitting buildings to improve ventilation effectiveness and reduce levels of indoor pollution (Prashant P Bhave, 2015), (The Economic Times, 2019). Taking steps to improve indoor air quality shall address broader sustainability objectives such as occupant health, and economic growth.

2. Methodology

To conduct an indoor air quality (IAQ) audit relevant information about the household, including the number of occupants, building characteristics (e.g., age, construction materials), and any known or suspected sources of indoor air pollution was gathered. A visual Inspection was conducted to identify potential sources of indoor air pollution and block them at least one hour prior to the audit. Portable air quality monitors were used to provide real-time readings. To evaluate the effectiveness of natural ventilation system in the household, windows were kept completely open to ensure proper airflow and exchange of indoor and outdoor air. Household activities and occupant behaviour that could impact IAQ like smoking habits, use of chemical products, cleaning practices, cooking methods, were restricted for the audit period in order to clearly estimate the impact of building parameters on IAQ exclusively with minimal disturbances. The collected data is compared to IAQ standards to Identify areas of concern or potential improvements. For this study, 56 rooms in total were audited for various IAQ parameters such as particulate matter (PM 2.5 & PM 10), Total Volatile Organic Compounds (TVOC), Benzene (C_6H_6) and Formaldehyde (HCHO). The pollutants were selected keeping in mind prominent pollution sources in Kolkata city and households.

2.1 Household Selection based on Socio-economic Status

The definition of the middle-income group can vary depending on the context and the source. However, in general, the middle-income group refers to individuals or households that have a moderate level of income between the lower-income group and the upper-income group. The specific income range defining the middle-income group can vary widely and may depend on factors such as location, cost of living, and prevailing economic conditions. V Understanding the importance of socio-economic background of the residents, and how it relates to indoor air quality, the IAQ Audits have been conducted particularly for the MIG, this was ensured through a group of questions in the questionnaire filled by the participants before the audit. The Reserve Bank of India (RBI) describes the middle income group (MIG) as households having an annual income between INR 6,00,000 to 18,00,000 (Reserve Bank of India, 2018), (Ministry of Statistics and Programme Implementation, 2019).

Table 1. Household description and Building

	Annual Income (Millions)	Construction Year	Last Painted	Floor Level	Floor Area (m^2)	No. of Openings	Fenestration (m^2)	Furniture flat-surface Area (m^2)	Furniture Volume (m^3)
Mean	1.2	2005	2014	1	12.48	1	1.68	5	3.25
Minimum	0.6	1878	2005	0	7.83	1	0.50	0.2	0.1
Maximum	1.8	2017	2021	4	28.08	3	5.80	10.61	9.50

The family size for the said households varied from single person to a family of six. However the earning members for these households ranged from 1 to 3 persons. The occupation of the earning members included IT professionals, schoolteachers, pension holders, bank officers, Private servicemen, Software engineers, retired professionals, college lecturer, architect, small businessmen. The house area of the households where it from small 600 ft.² apartments two 5000 ft.² The audited residences had to had mostly two or three bedrooms however a few households had five or six bedrooms distributed in two or three floors. The buildings selected for IAQ audit were low-rise buildings with floor level varying from ground floor to forth floor only. The buildings constituted of both old and new buildings ranging from construction year of 1878 to 2017. The interior of the building last painted in the year 2005 to 2021. The average floor area of the rooms was 12.5 m^2 with atleast one window opening for natural ventilation.

3. Analysis

The selected rooms were classified into two categories namely, single-side ventilated and cross ventilated. The single-side ventilation category refers to rooms with windows on one side wall surface and cross ventilation category refers to rooms with window openings on two or more wall surfaces.

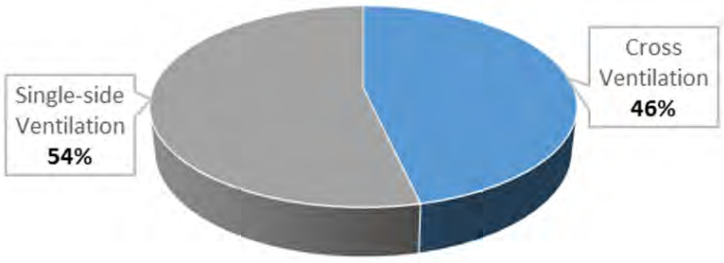

Figure 1. Categorization of audit rooms as per natural ventilation type

As shown in figure 1., 54% of the rooms had single side ventilation and 46% had cross ventilation. This categorisation has been further used to analyse different building parameters that may potentially impact IAQ. When analysing non-parametric air pollution data with a lognormal distribution, after the data preparation with relevant information such as pollutant concentrations, locations, and timestamps, visual graphs were created for better interpretation. The data visualization helped to gain insights and identify patterns. The relationships between the Indoor Air Quality Index (I-AQI) of the studied pollutants with building parameters were then conducted through Spearman's rank correlation coefficient to summarise the strength and direction (negative or positive) of the association.

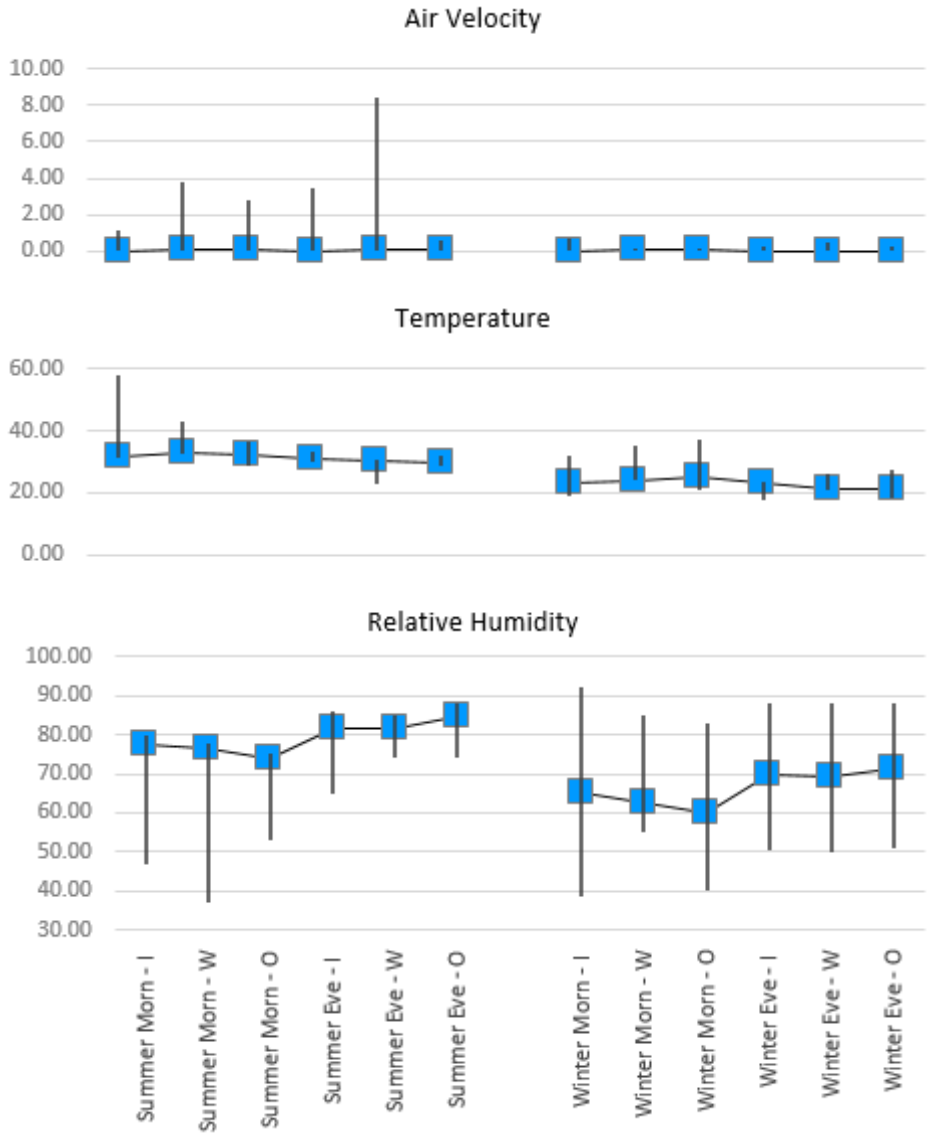

Figure 2. Indoor environmental factors for audited HHs in winter and summer

Local conditions and specific pollutant characteristics were taken into account when assessing the impact of IAQ variables. Temperature plays a significant role in the formation and dispersion of air pollutants. High temperature can accelerate chemical reactions involving pollutants like volatile organic compounds (VOCs) contributing to higher pollutant concentrations (Srivastava, 2000); it also creates more unstable conditions, leading to better mixing and dispersion of pollutants. Humidity can influence particulate matter (PM) through the condensation of water vapor onto existing particles, which can increase their size and mass (World Health Organization, 2020). Higher air velocity promotes better dispersion and dilution of pollutants (Junyan Yanga, 2020).

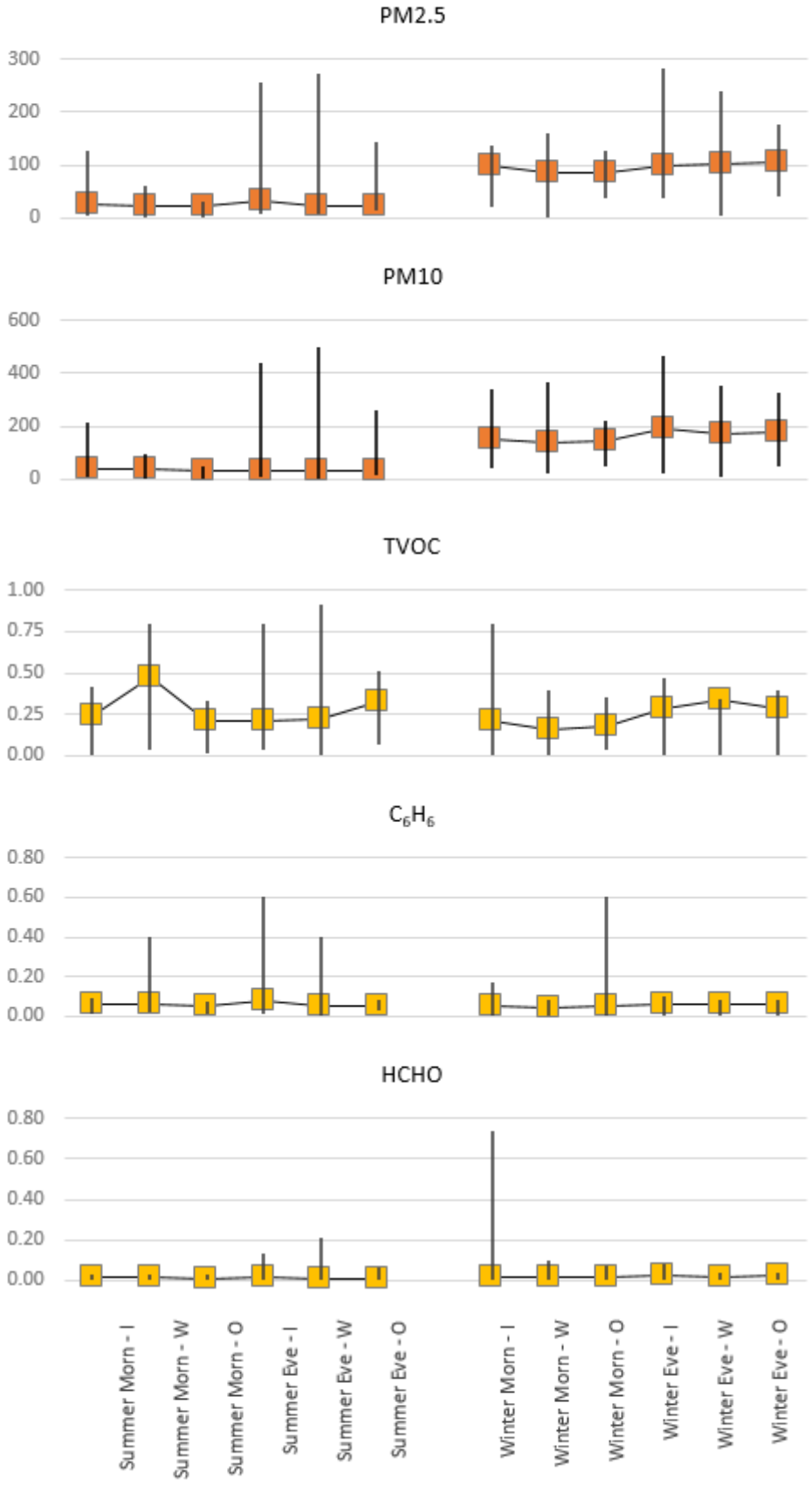

Figure 3. Indoor pollutant concentration for audited HHs in winter and summer

Winter often feature lower wind speeds and reduced atmospheric turbulence, resulting in stagnant air masses. This stagnant air hampers the dispersion of pollutants, allowing them to accumulate and build up near the surface. In developing countries, the use of solid fuels for residential heating, such as wood, biomass, or coal, is prevalent. These fuels often produce high levels of smoke and particulate matter when burned inefficiently, leading to localized air pollution problems, especially in areas with poor ventilation and inadequate combustion technologies. Cold temperatures can negatively impact the efficiency of vehicles' emission control systems, leading to increased emissions of pollutants. Additionally, during winter, people tend to drive more frequently and for longer durations due to reduced walking or cycling opportunities, leading to higher vehicular emissions and thus increased pollution.

As per world health organisation (WHO) indoor air quality standards, the benchmark level for PM2.5, PM10, TVOC, C6H6, and HCHO are 5 µg/m3, 15µg/m3, 3 mg/m3, 0.11 mg/m3) and 0.1 mg/m3 respectively. On comparison with the WHO standards, it is observed that maximum of the households falls within the prescribed limit for volatile organic compounds. Nevertheless, almost all of the households have higher PM2.5 and PM10 concentration than the prescribed limits. The audit results reflect that the particulate matter AQI goes up to 20 times more than the standards. During the winter months of December and January, a few peaks of approximately 250 µg/m3 PM2.5 and 450 µg/m3 PM10 are observed which are set to be hazardous to human health. In the figure above, the acronyms I,W and O represent indoor window and outdoor locations of measurement respectively. As depicted in the figure, the indoor concentration of most pollutants is found to be higher than concentrations at window level and building outdoors.

Indoor air pollution can be affected by multiple building related factors such as floor levels, Area of Fenestrations (A_F), Openable fenestration-to-floor area Ratio (A_F / A_R), Natural Ventilation Rate (ACH), Furniture surface-to-room surface Ratio (A_{FH} / A_R), Furniture volume to room volume Ratio (V_F / V_R), and Cleanliness factor. The current study aims to understand the association of these parameter with IAQ. An Indoor Air Quality Index (I-AQI) for all the measure pollutants was calculated using the below formula:

$$\textbf{Indoor Air Quality Index (I-AQI)} = (C_P / C_S) \times 100$$

Where, CP is the measured concentration of the pollutant and CS is the standard benchmark value prescribed by WHO.

Table 2. list of variables associated with indoor air quality

Independent Variables (Building)	Dependent Variables (IAQ)
Floor Level	PM2.5 I-AQI
Area of Fenestrations (A_F)	PM10 I-AQI
Openable fenestration-to-floor area Ratio (A_F / A_R)	TVOC I-AQI
Natural Ventilation Rate (ACH)	C6H6 I-AQI
Furniture surface-to-room surface Ratio (A_{FH} / A_R)	HCHO I-AQI
Furniture volume to room volume Ratio (V_F / V_R)	Velocity
Cleanliness factor	Temperature
	Relative Humidity

Indoor air quality can be influenced by various factors such as ventilation, pollutant sources, and occupant activities, which may or may not play a significant role in determining IAQ.

3.1 IAQ contributory factors in single-side naturally ventilated households during winter

Negative correlation with Floor Level: A negative correlation with the floor level is evident from the Heatmap with spearman's correlation coefficient (ρ) value of -0.75 for PM2.5 I-AQI and -0.63 for PM10 I-AQI. This clearly indicates with increase in floor height or level, the particulate matter of varying sizes

decrease in the indoor air. This is mainly due to higher air velocity at higher elevation entering through windows and helping in dilution of pollutants. Also, the heavy particulate matter particles tend to settle down and are not carried at a greater height by the urban canyon winds to enter through windows.

Negative correlation with Air Changes per Hour (ACH): The ρ value of -0.39, -0.49, -0.60, -0.66, -0.14 is obtained for association with PM2.5 I-AQI, PM10 I-AQI, TVOC I-AQI, C_6H_6 I-AQI, and HCHO I-AQI respectively, indicating the importance of ventilation. A higher rate of air changes per hour can be beneficial for indoor air quality. ACH refers to the number of times the entire volume of air within a space is replaced with fresh outdoor air per hour. Increasing ACH helps to dilute indoor pollutants, remove odours, and improve ventilation. Higher ACH values are generally associated with better IAQ.

Negative correlation with Cleanliness: The ρ value of -0.59, -0.49, -0.60, -0.23, -0.28 is obtained for association with PM2.5 I-AQI, PM10 I-AQI, TVOC I-AQI, C_6H_6 I-AQI, and HCHO I-AQI respectively. Occupant behaviour and habits significantly affect IAQ, this result shows that more often and thoroughly cleaning is carried out in homes, lesser will be the level of indoor pollution. Regular cleaning practices, including dusting, vacuuming, and removing accumulated debris, help to reduce the presence of dust, allergens, and other particulate matter in the indoor environment.

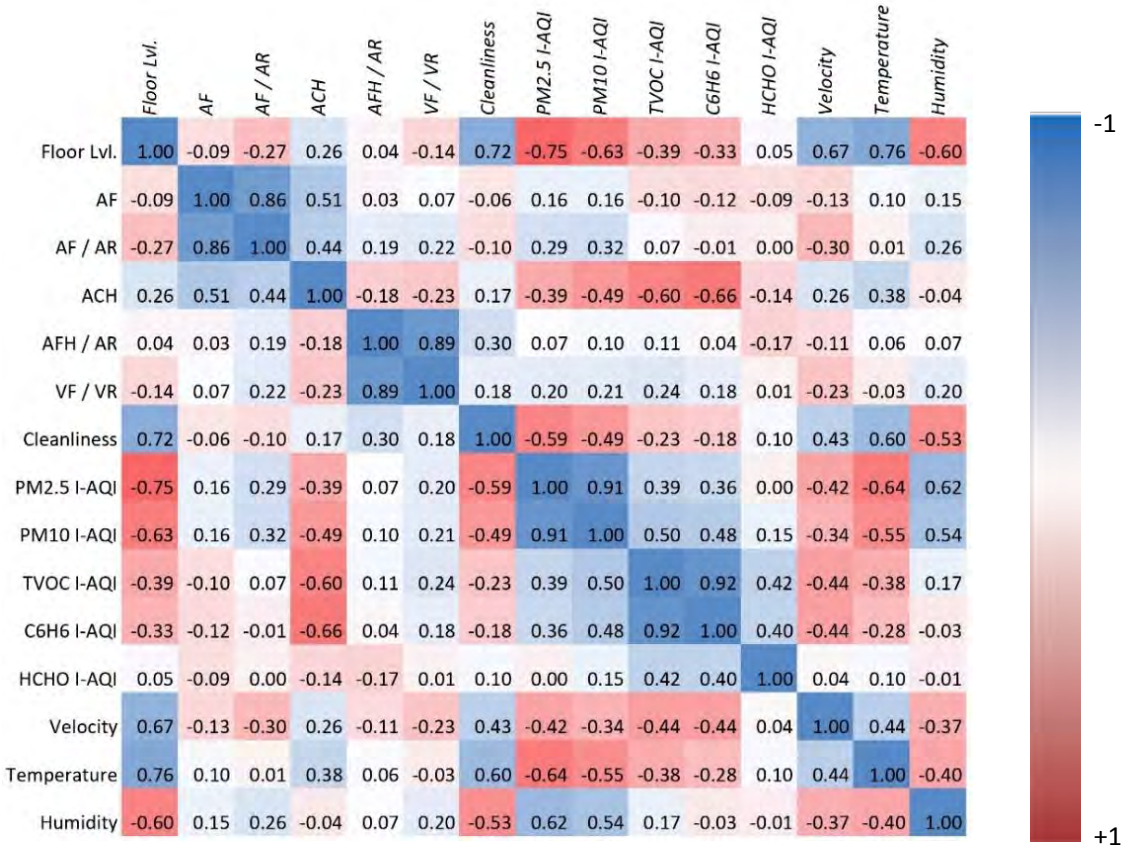

Figure 4. Seaborn Heatmap of variables (Single-side ventilated buildings)

3.2 IAQ contributory factors in naturally cross ventilated households during winter

Negative correlation with Floor Level: Similar to single-side ventilated buildings, ρ value of -0.60, -0.61, -0.13, and -0.25 are associated with PM2.5 I-AQI, PM10 I-AQI, TVOC I-AQI, and C_6H_6 I-AQI respectively.

Positive correlation with Furniture density: Furniture surface-to-room surface Ratio (A_{FH} / A_R) is also seen to be associated with IAQ of predominantly indoor pollutants with ρ value of 0.42, 0.36, and 0.31 is obtained for TVOC I-AQI, C_6H_6 I-AQI, and HCHO I-AQI respectively. Likewise, the Furniture volume to room volume Ratio (V_F / V_R) has ρ value of 0.57, 0.31, and 0.33 corresponding to TVOC I-AQI, C_6H_6 I-AQI,

and HCHO I-AQI respectively. These relations point towards furniture being a source of volatile organic compounds (VOCs) in indoor environments. VOCs are chemicals that can vaporize at room temperature and can be emitted from various sources, including furniture and furnishings.

Negative correlation with Area of Fenestrations (A_F): The ρ value of -0.58, -0.29, and -0.31 is obtained for association with TVOC I-AQI, C_6H_6 I-AQI, and HCHO I-AQI respectively.

Negative correlation with Cleanliness: Like single-side ventilated buildings, for cross-ventilated buildings the ρ value of -0.57 and -0.52 is obtained for association with PM2.5 I-AQI and PM10 I-AQI.

Negative correlation with Air Changes per Hour (ACH): The ρ value of -0.28, -0.21, and -0.28 is obtained for association with TVOC I-AQI, C_6H_6 I-AQI, and HCHO I-AQI respectively.

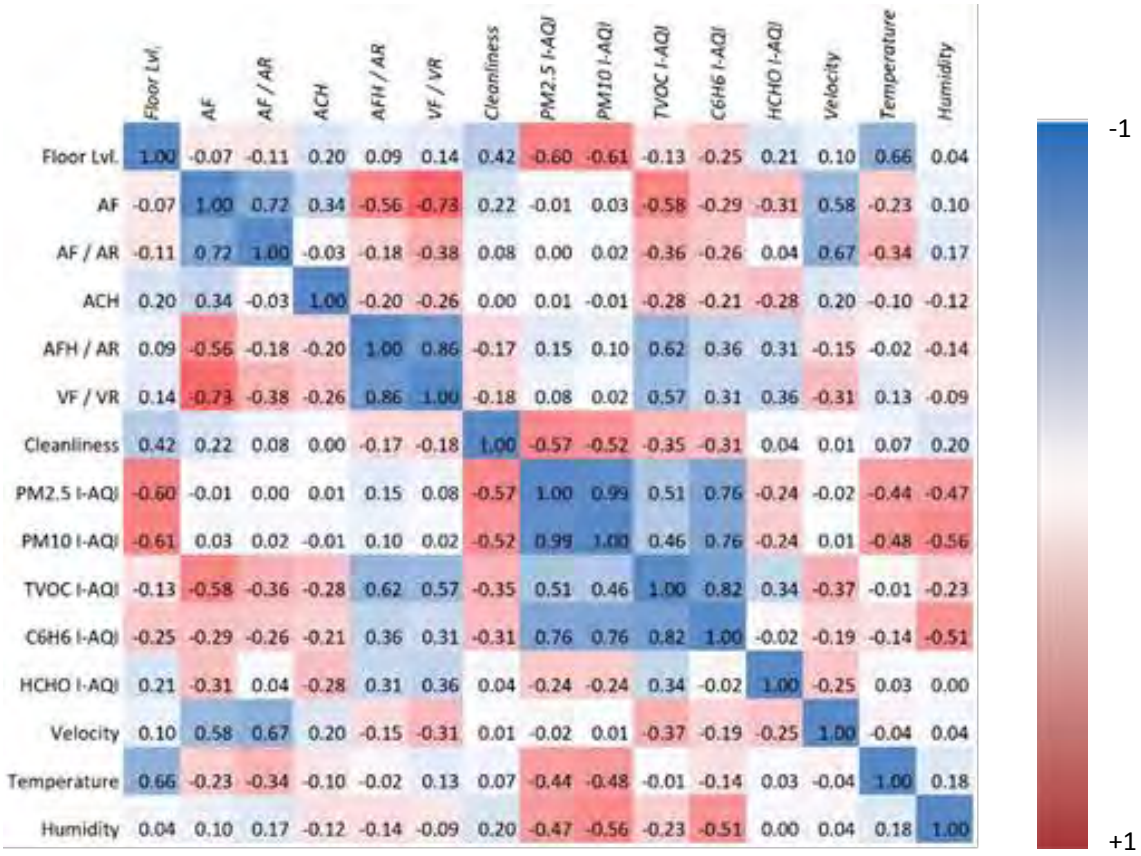

Figure 5. Seaborn Heatmap of variables (Cross ventilated buildings)

4. Results and Discussion

As per world health organisation (WHO) indoor air quality standards, the benchmark level for PM2.5, PM10, TVOC, C6H6, and HCHO are 5 µg/m3, 15µg/m3, 3 mg/m3, 0.11 mg/m3) and 0.1 mg/m3 respectively. On comparison with the WHO standards, it is observed that almost all of the households have higher PM concentration than the prescribed limits. During the winter months of December and January, a few peaks of approximately 250 µg/m3 PM2.5 and 450 µg/m3 PM10 are observed which are set to be hazardous to human health. The indoor concentration of most pollutants is found to be higher than concentrations at window level and building outdoors, which is an alarming situation for natural ventilation dependent buildings.

The correlation analysis of single-side ventilated households indicates that floor level, ACH, and cleanliness have a negative correlation with IAQ. Higher floor levels, increased ACH, and improved cleanliness are associated with lower concentrations of particulate matter and better overall IAQ. These

findings highlight the importance of considering these factors in efforts to improve indoor air quality and create healthier indoor environments. Whereas, the correlation analysis for cross-ventilated households reveal that floor level, furniture density, area of fenestrations, cleanliness, and ACH are factors that can influence indoor air quality. Higher floor levels, increased furniture density, larger window areas, better cleanliness, and higher ACH values are generally associated with improved IAQ for specific IAQ indicators. These findings highlight the importance of considering these factors when assessing and improving indoor air quality in buildings. In summary, at building design level, floor height and area of fenestrations play a crucial role in determining the IAQ of the naturally ventilated building.

5. Conclusion

Investing in the building sector to improve indoor air quality is of significant importance for the well-being of occupants and can bring about various benefits. Health and Well-being: Indoor air quality directly impacts the health and comfort of building occupants. Poor indoor air quality can lead to respiratory issues, allergies, asthma, and other health problems. By investing in measures to improve air quality, such as proper ventilation, air filtration systems, and reducing pollutant sources, occupants can enjoy a healthier and more comfortable indoor environment. Studies have shown that good indoor air quality positively affects productivity, cognitive function, and overall performance. By providing clean and healthy indoor air, occupants are likely to experience fewer sick days, improved focus, and increased productivity. Improving IAQ can have a direct impact on healthcare costs. By reducing the occurrence of respiratory problems and allergies, occupants may require fewer medical interventions and treatments, resulting in cost savings for individuals and society as a whole.

Middle-income individuals form a significant portion of the population in many developing countries. By prioritizing their well-being, governments and policymakers can stimulate economic growth and stability. Middle-income individuals often have disposable income, and when they have access to better education, healthcare, and essential services, they can contribute to increased consumption, investment, and entrepreneurial activities, driving economic development. By focusing on their well-being, policymakers can foster social cohesion, reduce inequality, and promote a more inclusive society where everyone has a fair chance to thrive. The Middle-income individuals often represent the future human capital of a nation. By investing on their built environment, well-being and health, countries can build a strong and skilled workforce capable of driving innovation, productivity, and sustainable development. Moreover, buildings with good indoor air quality are also more attractive to tenants, homeowners, and investors. Investing in air quality improvements can increase the value of a property and make it more marketable. Potential buyers and tenants are often willing to pay a premium for spaces that prioritize the health and well-being of occupants. Governments and regulatory bodies should increasingly recognize the importance of indoor air quality and enacting stricter regulations and guidelines.

6. References

ASHRAE Standard 62.2 (2016) 'Ventilation and Acceptable Indoor Air Quality in Residential Buildings', *American National Standards Institute*.

Central Pollution Control Board (2020) 'National Ambient Air Quality Status and Trends 2019', *Delhi: Ministry of Environment, Forest and Climate Change*, Retrieved from https://cpcb.nic.in/upload/NAAQS_2019.pdf

Dipanjali Majumdar, P. P. (2020) 'Managing future air quality in megacities: Emission inventory and scenario analysis for the Kolkata Metropolitan City, India', *Atmospheric Environment*, pp. 117-135.

Edwin H.W. Chan, K. L. (2008) 'Evaluation on indoor environment quality of dense urban residential buildings', *Journal of Facilities Management*, 6 (4), pp. 245-265.

Farzad Bazdidi-Tehrani, S. M. V. (2020) 'Impact of opening shape on airflow and pollutant dispersion in a wind driven cross-ventilated model building: Large eddy simulation', *Sustainable Cities and Society,* doi:https://doi.org/10.1016/j.scs.2020.102196

Government of India (2020) 'India – Air Pollution Knowledge Assessment (APnA) city program', Retrieved from *Urban Emissions*, Info: https://urbanemissions.info/india-apna/kolkata-india/

Jian Hang, Y. L. (2012) 'The influence of building height variability on pollutant dispersion and pedestrian ventilation in idealized high-rise urban areas', *Building and Environment*, doi:10.1016/j.buildenv.2012.03.023

Joanna Badach, D. V. (2020) 'A framework for Air Quality Management Zones - Useful GIS-based tool for urban planning: Case studies in Antwerp and Gdansk', *Building and Environment*, doi:https://doi.org/10.1016/j.buildenv.2020.106743

Jonathon Taylor, C. S. (2019) 'Application of an indoor air pollution metamodel to a spatially distributed housing stock', *Science of the Total Environment*, doi:https://doi.org/10.1016/j.scitotenv.2019.02.341

Junyan Yanga, B. S. (2020) 'Air pollution dispersal in high density urban areas: Research on the triadic relation of wind, air pollution, and urban form', *Sustainable Cities and Society*, doi:https://doi.org/10.1016/j.scs.2019.101941

Ministry of Statistics and Programme Implementation (2019) 'Periodic Labour Force Survey July 2017 - June 2018 Annual Report', *Delhi: National Statistical Office*, Government of India.

Mujeebu, M. A. (2019) 'Introductory Chapter: Indoor Environmental Quality', In *Indoor Environmental Quality*, pp. 1 - 13.

P.K. Srivastava, G. P. (2000) 'Volatile organic compounds in indoor environments in Mumbai, India', *The Science of the Total Environment*, 161-168.

Prashant P Bhave, N. S. (2015) 'Air Pollution and Control Legislation in India', *The Institution of Engineers (India)*, pp. 259–265.

Ritu Singhvi, N. R. (n.d.) 'Indoor Air Quality in Residential Buildings in Rajasthan, India – An Experimental Study', pp. 1-21.

Shuhan Yang, D. Z. (2020) 'Comparing impact of multi-factor planning layouts in residential areas on summer thermal comfort based on orthogonal design of experiments (ODOE)', *Building and Environment*, doi:https://doi.org/10.1016/j.buildenv.2020.107145

Smith, D. (2020) 'A Guide to Understanding Particulate Matter (PM)', Retrieved from Air Academy: https://learn.kaiterra.com/en/air-academy/particulate-matter-pm

Steigvilė Byčenkienė, M. K.-G. (2017) 'Indoor air and health - the quality of our indoor air is largely up to ourselves', *German Environmental Survey (GerES) - Indoor Air Module*.

Swanya Prabha Maharana, B. P. (2018) 'Exposure to Indoor Air Pollution and Its Perceived Impact on Health of Women and their Children: A Household Survey in a Slum of Kolkata, India', *Indian Journal of Public Health*, pp. 182-187.

The Economic Times. (2019) 'Not just outdoor, indoor air in Delhi polluted too: Study', Retrieved from *The Economic Times*: https://economictimes.indiatimes.com/news/politics-and-nation/not-just-outdoor-indoor-air-in-delhi-polluted-too-study/articleshow/71279705.cms?from=mdr

Vinita Katiyar, A. K. (2019) 'Characterization of Indoor Air Quality', *National Seminar on Spatial Dimensions of Environmental Problems and Natural Resourses Law ICSSR (IMPRESS)*, Karnal: Indira Gandi National Open University (IGNOU).

Wei Ye, X. Z. (2017) 'Indoor air pollutants, ventilation rate determinants and potential control strategies in Chinese dwellings: A literature review', *Science of the Total Environment*, pp. 696-715.

World Health Organization (2019) 'Health and sustainable development - Indoor air quality risks', Retrieved from https://www.who.int/sustainable-development/housing/health-risks/indoor-air-quality/en/

World Health Organization (2020) 'Particulate matter (PM)', Retrieved from *Air pollution*: https://www.who.int/airpollution/household/pollutants/combustion/en/

Paper Index

TRACK 2:
DECIDE jointly

Case Study Report

Assessing climate change adaptation actions for resilience building in Lagos State

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Abstract

Lagos State is exposed to signifi ant climate hazards. To reduce sensi vity, mi gate the impact, increase adapti e capacity, and create resilience, a Lagos Climate Actio Plan (CAP) was launched in 2020. The CAP has 26 prioriti ed adaptatio actio s (divided into three tim line phases: <2 years, 2–5 years, and >5 years). Leaning on the UN-Habitat Resilience Framework for Actio (RFA), this study assesses the implementatio of the adaptatio ac ons, focusing on the fi st two tim line phases. The assessment reveals how well each priority actio is performing in relatio to a partic lar RFA component (policy and legislati n, urban plans, ins tutio al set-up, fi ance, and interventio s), using a scale from 1 (weak performance) to 3 (good performance).

Keywords

Assessment, Climate change, Adaptation, Urban resilience, Lagos State

1. The Problem

It is common knowledge that extreme events will keep happening due to climate change (NPR, 2021). Lagos is vulnerable to high climate risk, due to the geographic and topographic characteristic of the State (Ministry of Environment and Water Resources, 2020). Flooding events, coastal erosion, inundati n, subsidence, extreme storms and extreme heat impacts are priority hazards of concern to the populati n, many of whom are recognized as extremely vulnerable. (Ibid.). Due to their partic lar suscepĀbility to and exposure to climate threats, the tourism, agricultural, and infrastructure sectors have also been characterised as highly vulnerable (Ibid.). Lagos' populati n, economy, infrastructure, natural resources, and politic l stability could all suĀer if certain climate concerns are not effe . vely addressed (Lagos State Resilience O ce, 2020).

To reduce sensitivity, mitigate the impact, increase adaptive capacity, and create resilience, a Lagos Climate Action Plan (CAP) was developed and launched in 2020 by the Lagos State Ministry of Environment and

Water Resources (MoE&WR) (MoE&WR, 2020). The CAP's aims align with the Paris Agreement on Climate Change goals, especially the drive to reduce the average global temperature rise to 1.5°C (United Nations Climate Change, 2015). Besides contributing to climate change mitigation by reducing emissions, the CAP also aims to enhance the resilience of Lagos's population, economy and infrastructure to the impacts of climate change.

There are 26 prioritised adaptation actions (divided into three timeline phases: <2 years, 2–5 years, and >5 years) earmarked in the CAP. The adaptation actions have been determined through their ability to combat climate impacts, risks and hazards. They lay out a thorough plan that aims to lessen sensitivity, lessen the impact, boost adaptability, and foster resilience.

To reveal how well each priority action is performing, this study assesses the implementation of the adaptation actions, focusing on the first two timeline phases: <2 years, 2–5 years. These are summed up as actions to be achieved within the next five years post-launch of the CAP (see Figure 1 below). By presenting this case study, the progress on climate change adaptation in a low- and middle-income country is revealed; the multidisciplinary and multisectoral collaboration and approaches that have influenced the success achieved in Lagos State are shown; and the strengths and weaknesses of the climate action plan are identified. Overall, the assessment of this case study is critical because it can play a crucial role in enhancing the effectiveness of climate action planning and policymaking, leading to better outcomes for both people and the planet.

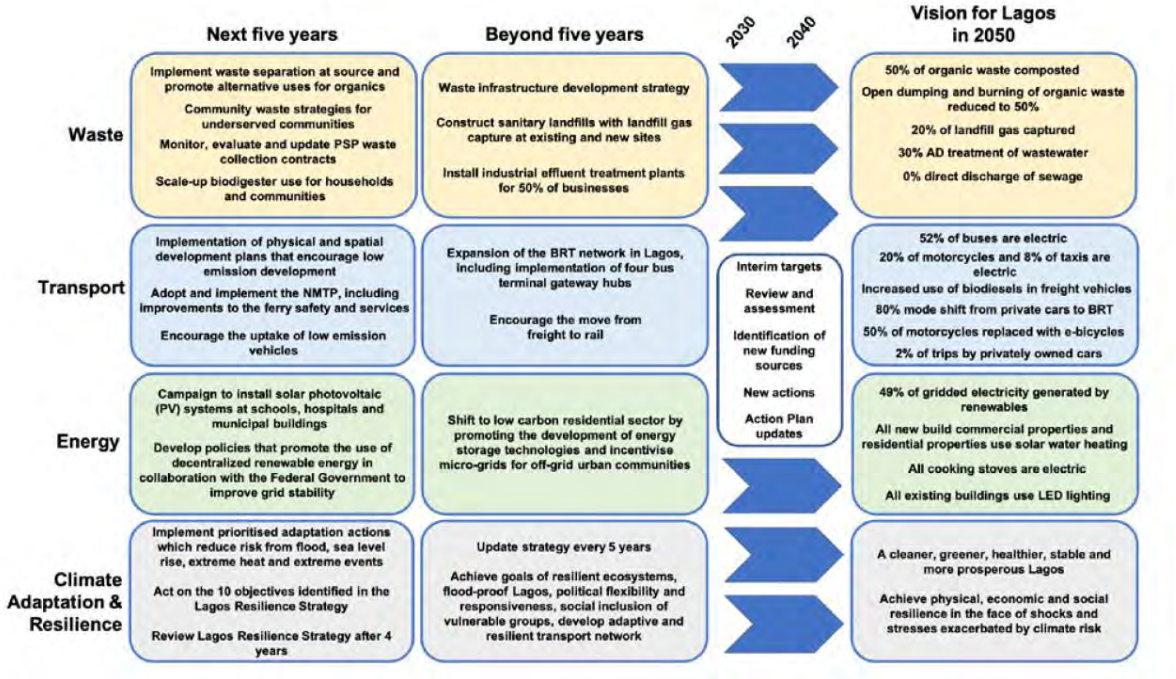

Figure 1. Summary of Lagos climate actions. Source: Lagos Climate Action Plan 2020

2. Project context

2.1. Lagos urban context

Lagos State is located in the southwestern region of Nigeria (Figure 2). The State is made up of ve (5) administrati n divisions – Ikeja, Badagry, Ikorodu, Lagos Island and Epe (jointly known as IBILE). These Āve divisions are in turn divided into 20 Local Government Areas (LGAs) and 37 Local Council Development Areas (LCDAs) (MoE&WR, 2021). Lagos State has a coastline of 180 km (MoE&WR, 2020). It is situated on a coastal plain underlain by sedimentary rocks. The land slopes gently from the interior to the sea and the terrain is predominantly at, with an average elevati n of less than 15m above sea level. Water bodies and wetlands cover over 40% of the total land area of the State, with lagoons and creeks accountin for 22% of its area. An additi nal 12% of the State is subject to seasonal Āooding (MoE&WR, 2020).

Figure 2. Boundaries within Lagos State showing 20 LGA. Source: Lagos Climate Action Plan 2020

2.2. Socio-economic context

Lagos is one of the fastest-growing cities in the world. The populati n of Lagos State is esti ated at 22 million people, which makes Lagos the 14th most populous urban area in the world (Lagos Ministry of Economic Planning and Budget, 2022). Lagos is a thriving city and home to many industries; hence the city sees a constant in ux of people in search of greener pastures, from the interior parts of the country and even from the neighbouring Republic of Benin (Okafor, 2022). However, given that more than half of Lagos's populati n lives in informal settlem nts, the city's rapid populati n has resulted in urban sprawl, the reclamati n of wetlands for housing and infrastructure, and an increase in the number of slum areas.

The rapid growth of Lagos has adverse environmental and social impacts, which the State Government is grappling with (MoE&WR, 2020). The city faces numerous challenges related to electronic waste, high traĀĀ density, plastic olluĀon, and increased security risks (ibid.). These challenges are exacerbated by low levels of advocacy, poli cal interference, poor planning and implementati n in slums, and low levels of compliance with environmental policies.

3. Project approach

The prioriĀsed adaptati n acti ns in the CAP were developed through a process of stakeholder engagement, and re ect the vision of creatin a cleaner, greener, healthier, stable and more prosperous Lagos in a changing climate. The development process also took into considerati n state resources, power and capacity to implement initiative which has ensured that the goals and objec ves are achievable and realistic within the context of Lagos. The idenĀ ed iniĀatives are a combinati n of existin and proposed policies or acti ns that will operati nalize the objecĀves of the State's CAP in the face of signi cant risk.

To successfully deliver climate adaptati n acti ns, key Lagos State Government's ministries, departments and agencies are earmarked in the CAP who are to set and review policy directi n and monitor progress; ensure accountability for realising the vision of the Plan; Ensure adequate technical and professional guidance; provide oversight to ensure resources are used e iently; promote synergies among relevant stakeholders in line with their mandates; and facilitate resource mobilisati n (MoE&WR, 2020).

4. The result of the project

Leaning on the UN-Habitat Resilience Framework for Action (RFA) (Spaliviero, et al., 2020), this study assessed the implementation of the adaptation actions earmarked in the CAP, focusing on the first two timeline phases:<2 years, and 2–5 years. The adaptation actions are assessed using the five components (policy and legislation, urban plans, institutional set-up, finance, and interventions) of the UN-Habitat Resilience Framework for Action (RFA) (see Table 1 below for details). The performance of the prioritised actions is indicated on a three-point scale (1 = weak performance; 2 = fair performance to 3 = good performance). The assessment enabled an objective evaluation of each prioritised action and systematic identification of adaptation and resilience gaps and constraints. Table 1 shows the indicators for each score of the RFA in detail, while Table 2 shows the assessment of each prioritised adaptation action of the CAP. The key achievements included in Table 2 were gathered from a series of multi-sectoral stakeholder engagements conducted as part of this assessment. These included a stakeholder workshop, focus group discussions with selected interest groups, expert interviews with various sectoral leaders, and a public survey to capture the perspectives of a cross-section of Lagos residents on the impacts of the actions. The

engagements were done over a period of twelve weeks (between August and October 2022) and established the position of the general public and sectoral experts on the progress made so far regarding the implementation of the CAP, albeit the adaptation actions are only included in this report.

RFA COMPONENTS	SCORE = 1	SCORE = 2	SCORE = 3
POLICY AND LEGISLATION	There are some relevant policies, strategies or by-laws regulating this issue, but they are rather insufficient.	This issue is taken into account, but the relevant policies and legislation should be improved.	There are policies and laws in place that adequately regulate this issue.
URBAN PLANS	> This issue is not sufficiently considered in existing urban spatial or development plan; > There are currently no valid urban plans for the city.	The existing urban plans take some aspects related to this issue into account; however, improvements are needed.	This issue is sufficiently incorporated in key urban spatial/ development plans of the city.
INSTITUTIONAL SET-UP	There is no department, specialized institution or focal person clearly assigned to manage this issue at the municipal/ local level.	One or more municipal departments, specialized institutions or focal persons are responsible for dealing with this issue, but with insufficient capacity.	Roles/responsibilities of different departments/ institutions are clearly defined for dealing with this issue at city level, with enough capacity.
FINANCE	There is very little budget allocated for managing this issue at the local level, and financial mechanisms in place are clearly insufficient.	The available budget to deal with this issue exists, but it is not clear how it is spent and the financial mechanisms in place are still weak.	The available budget allocated for this issue is sufficient and there are adequate financial mechanisms in place.
INTERVENTIONS	Very little is currently being implemented to address this issue.	There are few projects/ interventions that tackle this issue, but there is need for more.	There are sufficient/ adequate projects/ interventions planned or on-going to address this issue.

Table 1. Grading Scale for the assessment (adapted from the UN-Habitat Resilience Framework for Action (RFA). Source: Spaliviero, et al., 2020

		RFA COMPONENTS SCORE = (weak performance) ; SCORE = 2 (fair performance) ; SCORE = (good performance)					5-8 9-12 13-15	
S/N	**Adaptation action**	**Policies and legislation**	**Urban plans**	**Institutional set-up**	**Finance**	**Interventions**	**Total obtainable (15)**	**Some Key Achievements**
1	Produce a city-wide ood risk map	2	2	3	1	3	11	Lagos State Emergency Management Agency (LASEMA) has identi ed ood risk areas; and assessed and mapped vulnerability and ood risk in every part of Lagos State.
2	Strengthen the State's capacity for the collecti n, analysis and disseminati n of data	3	2	3	2	1	11	Lagos State Residents Registration Agency (LASRRA) commenced the design of new smart card for Lagos Residents and the development of online pre-enrolment website for People living with disabilities (PLwDs). LASRRA completed the deployment of Manage Engine Application for service desk, ticketing, issues resolution and knowledge bank or repository. LASRRA activated 27 Registration stations across all LGAs/LCDAs. The Office of the Civic Engagement designed, developed and upgraded LASSRA's Software to Android Platform Enrolment Application LASRRA 2.0.
3	Conduct a state-wide sea level rise vulnerability assessment	2	2	3	2	3	12	MoE&WR conducted a Lagos State Climate Risk Assessment which included the spatial assessment of vulnerability. This was launched in 2021.

Table 2: Assessment of the 8 prioritised adaptation actions of the CAP. Source: Author, 2023

		RFA COMPONENTS SCORE = (weak performance) ; SCORE = 2 (fair performance) ; SCORE = (good performance)					5-8 9-12 13-15	
S/N	**Adaptation action**	**Policies and legislation**	**Urban plans**	**Institutional set-up**	**Finance**	**Interventions**	**Total obtainable (15)**	**Some Key Achievements**
4	Community partic patory ood management	2	2	3	1	2	10	Office of Drainage Services and Water Resources (ODS&WR) has engaged in the construction of drains to de-flood communities in Ikeja LGA and Okota, Oshodi Isolo LCDA. MoE&WR embarked on sensitisation and warning campaign in four Local Government Areas (LGAs), namely Lagos Mainland, Mushin, Ibeju-Lekki and Ikorodu, with a high probability of flood risk, for the residents to be alert during the raining season. ODS&WR trained relevant stakeholders in three flood prone communities on community based participatory flood management approaches. Lagos State Government and partners of the African Development Bank Group (AfDB) implemented the innovative SLAMDAM flood management solution, which is an easily deployable water-filled flood barrier, at the Omojuwa Estate in Kosofe Local Government Area (LGA). University of Lagos Centre for Housing and Sustainable Development (CHSD), in support of Heinrich Boll Stiftung, Lagos State Resilience Office, and Ajegunle-Ikorodu Resilience Community developed a Community Resilience Action Plan.

Table 2: Assessment of the 8 prioritised adaptation actions of the CAP Continued. Source: Author, 2023

		RFA COMPONENTS SCORE = (weak performance) ; SCORE = 2 (fair performance) ; SCORE = (good performance)					5-8 9-12 13-15	
S/N	**Adaptation action**	**Policies and legislation**	**Urban plans**	**Institutional set-up**	**Finance**	**Interventions**	**Total obtainable (15)**	**Some Key Achievements**
5	Strengthen emergency response and evacuati n systems	3	3	2	2	2	12	LASEMA upgraded the emergency operation centres, and conducted sensitisation and public advocacy campaigns on climate risk and vulnerability, and conducted training of local emergency management response cadets in 57 LGAs/LCDAs, including the areas that are vulnerable to sea level rise, floods and ocean surges, landslides and coastal subsidence, storms and coastal erosion.
6	Implement one health strategy in the Lagos State Health Scheme	3	3	3	1	2	12	Lagos State Health Management Agency (LASHMA) launched the Basic Health Care Provision Fund, and organised training programmes for healthcare providers and enrolment officers on the use of the newly procured ICT platform (PROGNOSIS). The agency also launched its regulations, upgraded call centres, established Ilera Eko Kiosks and district offices, and enrolled 541,213 persons on the Lagos Health Scheme, including those in flood prone areas.
7	Scale up the implementati n of the Lagos State Special Peoples Law	2	1	3	1	1	8	Lagos State Office for Disability Affairs (LASODA) sensitised non-governmental organisations, and community-based organisations on Lagos State Special Peoples Law and inclusive Governance at the grass root. LASODA also conducted vocational training for 350 PLwDs, capacity building for social workers, parents of PLwDs, and Local Government Administration principal officers. LASODA also collaborated with financial institutions to sponsor sign

								language training for PLwDs. Lagos State Government earmarks N500m to address People Living with Disabilities.

		RFA COMPONENTS SCORE = (weak performance) ; SCORE = 2 (fair performance) ; SCORE = (good performance)					5-8 9-12 13-15	
S/N	**Adaptation action**	**Policies and legislation**	**Urban plans**	**Institutional set-up**	**Finance**	**Interventions**	**Total obtainable (15)**	**Some Key Achievements**
8	Expand the water transportati n network with increased private sector partic pati n	3	3	3	2	2	13	Launch of the Waterways Investment and Development of the Environment project. 16 new jetties were constructed, and over 12km of waterways were dredged and channelled along the Ebute Ikorodu-Ilaje-Falomo and Ilaje Bariga-Whitesand Oyingbo-Falomo ferry routes. Lagos State Government launched a mobile app for Lagos Ferry Services and eight high-capacity speedboats were added to the fleet of the Lagos State Ferry Services (LAGFERRY) and private sector operators were also licensed.

Table 2: Assessment of the 8 prioritised adaptation actions of the CAP Continued. Source: Author, 2023

4.2. Discussion of assessment of the adaptation actions

The assessment of the climate adaptation actions of the CAP indicates that there is progress in the implementation and performance of adaptation actions in Lagos, with 1 of them (Expand the water transportati n network with increased private sector parti ipati n) doing very well, 6 of them (Produce a city-wide ood risk map; Strengthen the State's capacity for the collecti n, analysis and Disseminati n of data; Conduct a state-wide sea level rise vulnerability assessment; Community Partic patory ood management; Strengthen emergency response and evacuati n systems; Implement one health strategy in the Lagos State Health Scheme) performing fairly, and 1 (Scale up the implementaĀon of the Lagos State Special Peoples Law) performing poorly.

Findings reveal that policies, legislations, plans, and institutional set-ups are in place to facilitate the implementation of the 8 adaptation actions, though the finance to implement many of the adaptation actions is weak. The finance of these 8 prioritised adaptation actions was assessed in relation to what has been allocated by the Lagos State Government in 2020, 2021, and 2022 (Lagos State Government, 2020; 2021; 2022). The Lagos State Development Plan 2012-2025 (Ministry of Economic Planning and Budget, 2013) was referenced to see how much of the adaptation actions were earmarked in the Plan.

A critical review of the assessment table shows that out of the 8 adaptation actions, 6 have so far performed fairly (score 2 = fair performance) because few projects/ interventions directly tackle these priority actions. 1 priority action has performed well (Score 3 = good performance) primarily because of good public-private partnerships, while 1 performed poorly since the launch of the CAP in 2020 (score 1 = weak performance) because of limited action to directly implement the adaptation actions.

5. Broader project impact

The general perception of the stakeholders on the impact of the 8 prioritised adaptation actions implemented across the State so far was that the government institutions are yet to include local communities in the implementation, albeit some local communities acknowledged pertinent projects. For instance, the residents of Ajegunle-Ikorodu Community, a flood-prone informal settlement, attested that the launch of the Ajegunle-Ikorodu community resilience action plan in 2020 created a pathway for engagement between them, the various Lagos State ministries, departments, and agencies, and non-state actors. The launch of the resilience action plan led to the achievement of 8 initiatives out of 15, including adding community members to the Lagos State Health Insurance Scheme, establishing an environmental committee with full women's participation, dredging the canal, upgrading existing roads, reconstruction of the community high school which was disused for over a decade due to flooding events, selection of Ajegunle Ikorodu for interventions by the Lagos State Urban Renewal agency.

Regarding the adaptation action on “Scale up the implementati n of the Lagos State Special Peoples Law”, PLwDs and other stakeholders acknowledged the state has made efforts towards the continuous training for social welfare officers and caregivers on proper handling of PLwDs, especially those in vulnerable communities such as the coastal informal and slum communities that are prone to sea level rise, ocean surges, and erosion. However, according to the stakeholders, the success of this prioritised adaptation action is still limited, stressing that an inclusive approach must be adopted for a city-wide impact.

On the producti n of a ood risk map, MoE&WR acknowledged that the producti n of that map has increased their insti uti nal capacity to plan for, respond to and recover from ood risk across the state; but then, the local communitie that were engaged opined that they have littl knowledge of this map, albeit they have over the years deployed their strategies of managing ooding events in their neighbourhoods. Experts from the private sector opined that it is important for Lagos State Government to build public trust in the insti uti nal capacity to manage climate risk in the state.

While stakeholders opined that since the launch of the CAP, the Lagos State Government has increased the capacity of the state to respond to climate hazards, they also opined that not much effort is made at the neighbourhood level. However, they acknowledged that there was room for improvement, given the growing population and unpredictable nature of the hazards.

If Lagos is really intentional about achieving a resilient ecosystem, flood-proof city, increasing insti uti nal capacity and promotin evidence-based decision-making, reducing the sensitiv ty of highly sensitive groups, increasing populati n resilience and improving adapti e capacity, and reducing climate impacts within the transport sector, the state government must localise the Lagos Climate Acti n Plan in a way that helps build trust, empowers the communities, and enables the people to collaborate effe vely with the relevant state actors, non-government organisati ns, business sector, civil society groups.

6. References

Lagos State Government (2020) Year 2020 revised budget capital expenditure. Ministry of Economic Planning and Budget. Available at: https://lagosstate.gov.ng/wp-content/uploads/2020/08/LAGOS-STATE-Y2020-REVISED-BUDGET-08.pdf (Accessed: 15 July 2023)

Lagos State Government (2021) Lagos State Citizens Budget. Ministry of Economic Planning and Budget. Available at: https://lagosmepb.org/wp-content/uploads/2021/05/Citizens-Budget-v2.pdf (Accessed: 15 July 2023)

Lagos State Government (2022) Year 2022 Citizens Budget. Ministry of Economic Planning and Budget. Available at: https://lagosstate.gov.ng/wp-content/uploads/2022/04/5.-CITIZENS-BUDGET-Year-2022-March-21-3-olayinka-310322.pdf (Accessed: 15 July 2023)

Lagos State Government (2013) Lagos State Development Plan 2012 – 2025. Ministry of Economic Planning and Budget. Available at: https://nairametrics.com/wp-content/uploads/2014/11/LAGOS-STATE-DEVELOPMENT-PLAN.pdf (Accessed: 15 July 2023).

Lagos State Ministry of Environment and Water Resources (2020) Lagos Climate Action Plan: Second Five Year Plan 2020 – 2025. Lagos: Lagos State Government.

Lagos State Ministry of Environment and Water Resources (2021) Lagos State Ministry of Environment and Water Resources. Lagos: Lagos State Government.

Lagos State Resilience Office (2020) Lagos Resilience Strategy. Lagos: Lagos State Government

NPR (2021) How climate change is responsible for more extreme weather events worldwide, NPR, 25 July. Available at: https://www.npr.org/2021/07/25/1020342829/how-climate-change-is-responsible-for-more-extreme-weather-events-worldwide (Accessed: 10 June 2023).

Okafor, C. (2022) Lagos listed as one of the fastest growing cities in the world, and a top five city in Africa, Business Insider Africa, 14 September. Available at: https://africa.businessinsider.com/local/markets/lagos-listed-as-a-fast-growing-city-in-the-world/7wh1t5e (Accessed: 10 June 2023).

Spaliviero, M., Lopes, L. F., Tomaselli, C., Rochell, K., Guambe, M., Angelone, S., Straus, F., Comba, E. (2020) City Resilience Action Planning Tool. Nairobi, Kenya: Spaliviero, M. et al., 2020. *City Resilience Action Planning Tool.* Nairobi, Kenya : United Nations Human Settlements Programme (UN-Habitat) and Sub-Regional Technical Centre for Disaster Risk Management, Sustainability and Urban Resilience (DiMSUR).

United Nations Climate Change (2015) The Paris Agreement, 12 December. Available at: https://unfccc.int/process-and-meetings/the-paris-agreement (Accessed July 1 2023).

Case Study Paper

Datafying Urban Joy

Decoding individual sentiment in agent-based modelling for the evaluation and urban environments

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Abstract

The paper explores citizen participation in a society driven by digitalisation and the gap between the cities that we want and the cities that we have. As digital culture constructs the means for us to tailor, customise, and own our digital presence, it is crucial to comprehend the transformation of our cities into adaptable environments that foster collaborative creation. Existing urban planning tools view the city from a top-down perspective and result in master plans that fail to be applicable right upon completion. Essentially, cities fail to match the adaptable and flexible nature of the current digitised urban resident. In order to bridge this divide, an agent-based model is used to evaluate urban environments based on individual sentiment derived from social media API. Through the study case of Wittenberge, Germany, the objectives and methodology of the research are examined. Utilising a range of open data sources, such as GIS layers, Census data, urban concepts, and plans, a 3D digital twin of the city is constructed. Subsequently, employing geo-tagged social media API, agents are generated, each uniquely equipped with personal goals, agendas, and inclinations derived from keywords that signify opinion lexicon. The agents embody four distinct personality types, each playing a vital role in the urban context. Operating within a 20-minute walking radius, their "life satisfaction score" serves as an indicator of their capacity to fulfil their daily requirements and preferences within the designated study area. The analysis of three aspects is facilitated through the utilisation of urban data: the demographic composition of urban residents, their subjective evaluations of their present circumstances, and the areas in which urban interventions are needed to improve the urban quality of life. Consequently, informed by these insights, strategic interventions can be implemented to effectively address their needs and enhance their overall life satisfaction within the urban environment.

Keywords

Data-based urban design, Citizen participation, Digital culture, Agent-based modelling, Social media sentiment analysis, Co-creation in cities

1. Introduction

Through an examination of historical precedents in human settlements and observation of their commonalities, it becomes evident that the fundamental objective of urban formations has consistently revolved around fulfilling the essential requirements of inhabitants, encompassing elements of security, sustenance, and the cultivation of spiritual focal points. Throughout history and up to contemporary times, cities have served as tangible embodiments of essential human needs, with urbanisation emerging in response to the demand for diversified economic prospects, enhanced availability of public

infrastructure, and the facilitation of social connections (Steele, 1981). Evolving gradually and over time, cities cultivate a heightened sense of communal belonging and place attachment (Scannell and Gifford, 2010) which have been associated with enhanced psychological well-being, reduced crime levels, and heightened citizen involvement and active participation. (Stedman, 2003)

"In his interview for the publication 'Handmade Urbanism' (Rosa & Weiland, 2013, p.202), Wolfgang Nowak, Director of the Alfred Herrhausen Society, the International Forum of Deutsche Bank, observes that contemporary cities no longer prioritise the needs of human beings but primarily serve as apparatuses for profit generation. In order to counteract this phenomenon, the planning process necessitates a diverse range of inputs that extend beyond the perspectives of architects and investors. Nowak contends that active involvement of the communities slated to inhabit these spaces is imperative for successful outcomes.

As explored by Edward Glaeser in the book "*Triumph of the City: How Our Greatest Invention Makes Us Richer, Smarter, Greener, Healthier, and Happier*," cities have transformed from being "economic engines" in the 19th century to acting as "consumer cities" nowadays, measured by quantifiable metrics of "a quality of life". Gleaser argues that urban residents will migrate to locations that offer abundant and varied amenities, even at the cost of higher living expenses and lower wages, in the quest for a "higher quality of life". "When a city has high housing prices relative to income [levels] you can bet that there is something nice about that place" (Glaeser, 2011, p. 130)

During the COVID-19 pandemic, our living environments experienced additional strain as the functional requirements of our daily lives became reliant on virtual representations within the confines of our homes. The use of virtual meetings as a replacement for work-related conferences among surveyed US adults has risen to 31% in 2020 from 13% in 2019. Similarly, 59% of surveyed US adults used virtual meetings to connect with friends and family during the first year of the pandemic, rising from 21% in 2019. (Pew Research Center, 2021) Moreover, there has been a substantial increase in the number of active users and the volume of content generated on social media platforms. (Pew Research Center, 2021)

When examining the integration of digitalisation within the urban context and considering the limitations of current smart-city initiatives, an important question arises regarding the potential forms and inclusivity of digital urbanism projects. New media allows citizens increased participation in the design and development processes undergoing in their cities. (De Lange & De Waal, 2013) Current digital platforms, including social media, online forums, and crowdsourcing platforms, provide methods for citizens to convene, share information, and express their perspectives. (Cardullo & Kitchin, 2019) However, data extraction and aggregation as part of smart-city projects facilitate concerns around surveillance and the commodification of urban space. (Kitchin, 2013) Despite data being available publicly to be accessed by citizens, it is being produced, maintained by and targeted at urban elites. And despite being marketed as "citizen-focused" platforms aimed at enhancing social rights and the common good, smart urbanism promotes technological advancement at the expense of privacy, security and data governance (Deakin, 2013), further marginalising certain groups from urban governance procedures. (Zandbergen & Uitermark, 2019).

In order to begin developing valuable and socially beneficial digital urban solutions, it is imperative to explore the integration of digital technologies into urban environments at the local level (Shaw & Graham, 2017) - and to follow suit with the premise of the internet to increasingly overcome the contrails of distance and time (Staab, 2019) - on the immediate level.

The mere existence of data collection mechanisms is insufficient to catalyse transformative change. It is crucial to devise supplementary response mechanisms that facilitate the simulation and validation of conclusions deduced from the perpetually expanding database. By seamlessly integrating these complementary mechanisms, policymakers and urban planners can adeptly leverage the potential of data

to inform decision-making processes and drive substantive urban interventions, thereby a landscape of urban development and management that is informed by empirical evidence.

2. Methodology

Technological advancements have simplified the capability to engender "virtual replicas" of spatial environments, encompassing comprehensive depositories of various quantifiable data and information. However, the predominant paradigms surrounding the essence of the 'smart city' often disregard the paramount significance of human agency in the pursuit of technological efficiency. Digital urbanism, as manifested in the context of technology-driven smart city initiatives, is undergoing a process of depoliticisation, reducing urban development into an issue of technical services and infrastructure. This process is shaping digitised cities as "software-sorted geographies," (Graham 2005, 2008) where software is the principal driving force of urban development, overpowering the needs of the citizens. Furthermore, according to Kitchin, Lauriault, and McArdle (2015), the discourse around smart cities has framed distinctive urban issues as universal technological problems, to be solved by scalable digital means, thus further marginalising local concerns and specific needs of communities, thereby further reinforcing prevailing power dynamics. Furthermore, the discourse on smart-urban regeneration has exhibited a concerning inclination to perceive the city as an empty and malleable space to be dissected and reconfigured. These perspectives overlook the intricate interplay of social, political, and economic dynamics that contribute to the formation and functioning of established urban environments. By advocating for the adoption and integration of digital technologies in urban areas, these viewpoints disregard the broader implications digital interventions may have on the overall urban fabric. (McFarlane and Söderström, 2017) Furthermore, under the premise of making human life in smart cities more efficient, sustainable and liveable, the initiation of smart city projects has been serving as a marketing strategy to attract investors and new businesses in developing metropolitan centres. This reliance on big-tech and private sector actors has been creating cities where the need of the investor is put before the need of the citizen, and conditions where data privacy is jeopardised in favour of surveillance and control. (Graham and Marvin, 2001)

Study area

The further elaborated case study of Wittenberge, Germany, serves as a completed exemplification situated within a broader research framework. The case study critically investigates the aims and approach of an urban analysis model intended for integration into ongoing research endeavours.

Figure 1: Aerial image of Wittenberge, retrieved from Google Earth

Wittenberge, located in the Prignitz district of Brandenburg, Germany, is a town with a population of 16,837 as of December 31st, 2022. Situated on the northeastern bank of the Elbe River, Wittenberge occupies a strategic position halfway between Hamburg and Berlin [Figure 1]. With origins dating back to the medieval period, the city experienced steady development and growth, particularly after becoming the site of the Singer sewing machine factory in 1903. However, during the German Democratic Republic (DDR) era, the population remained relatively stable, and a substantial decline was observed following the reunification of East and West Germany in 1990 [Figure 2]. Without significant modifications to the urban landscape of Wittenberge, a further decline in population is anticipated [Figure 3].

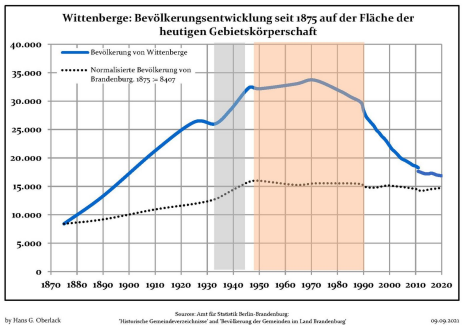

Figure 2: Population in the state of Brandenburg, Hans G. Oberlack, Amt für Statistik Berlin-Brandenburg, 09.09.2021

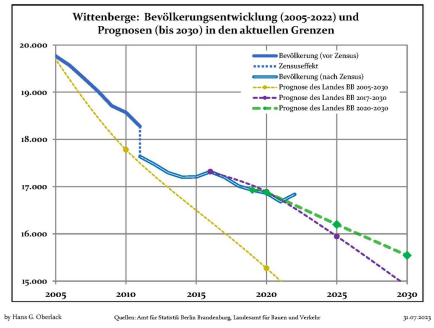

Figure 3: current population trends (2005-2021) and forecasts (until 2030), Hans G. Oberlack, Amt für Statistik Berlin-Brandenburg, 15.08.2022

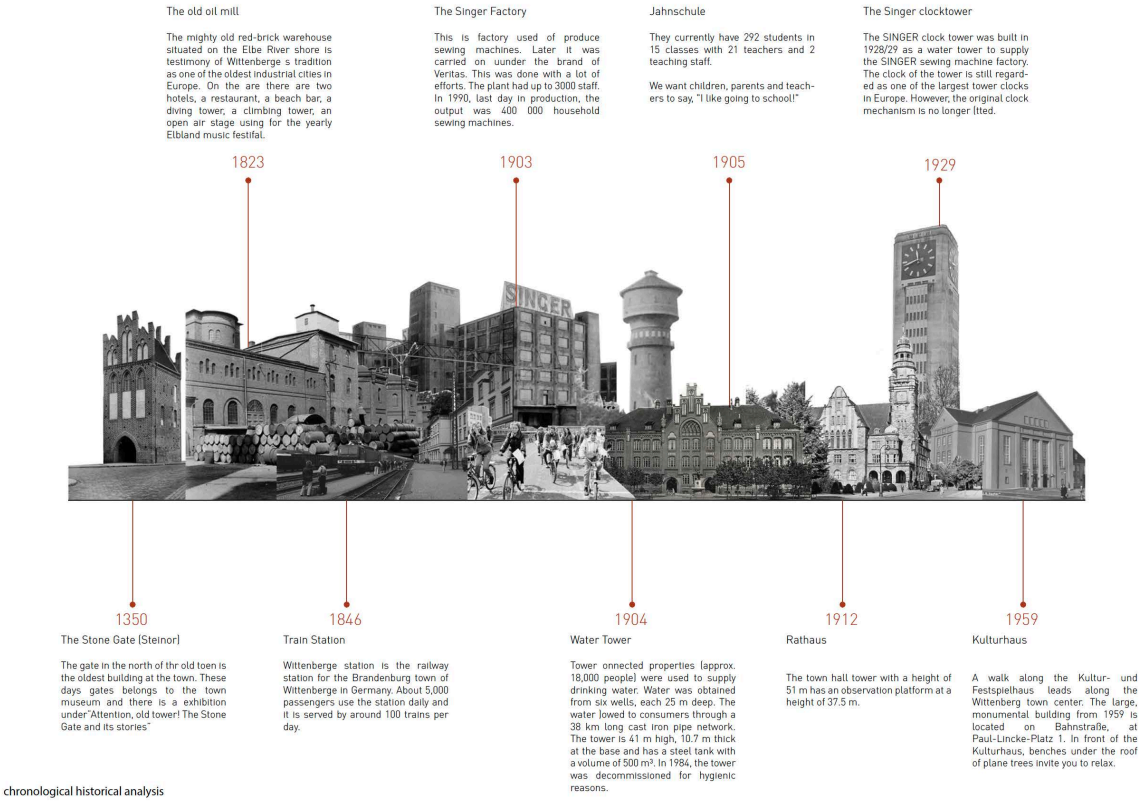

Figure 4: Notable buildings in Wittenberge situated on the timeline. Created by Julia Barashkov and team, based on data and source imagery from the City Museum of Wittenberge.

For the analysis of the study case, spatial data was collected and compiled from GIS layers and Open Street Maps metadata. Given the relatively compact size of the town, a comprehensive examination of its entire municipal area was conducted, offering a macroscopic perspective on the urban fabric. The collected spatial data was categorised and compartmentalised based on its respective metadata. This data was then utilised to construct a 3D digital representation of the study case using Rhinoceros 6.0 and Grasshopper software. Furthermore, amenities within the town were mapped, taking into account their corresponding walking distance radii for comprehensive assessment [Figures 6-10].

STREETS	BUILDINGS	USE	PUBLIC	FUTURE
Street curves	Building curves	Amenities in buildings	Open public spaces	Construction sites curves
Street types	Building height	Publicly accessible functions	Public and private education facilities - both plot data and building data	Planned building curves
Pedestrian paths	Number of floors	Privately owned businesses and offices		Planned building heights
Public transport routes	Number of housing units			Amenities in planned buildings

Figure 5: collected metadata for study case assessment. Created by Julia Barashkov

Figure 6: Wittenberge train station and a 20 minute walking distance radius, equal to approximately 800 m. Created by Julia Barashkov sing retrieved GIS spatial data and metadata

Figure 7: Bus stops across Wittenberge and a 10 minute walking distance radius, which is equal to approximately 400 m. Created by Julia Barashkov using retrieved GIS spatial data and metadata

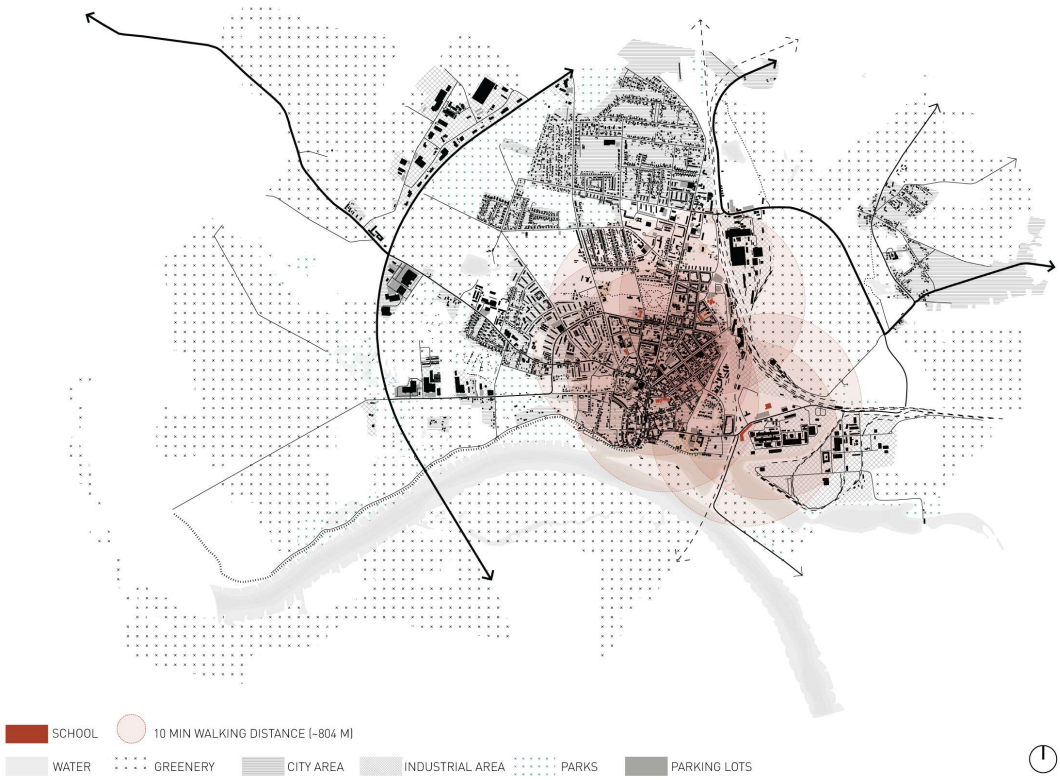

Figure 8: A mapping of schools in Wittenberge and 10 minute walking distance radius, which is equal to approximately 400 m. Created by Julia Barashkov using retrieved GIS spatial data and metadata using building use = school OR amenity = school

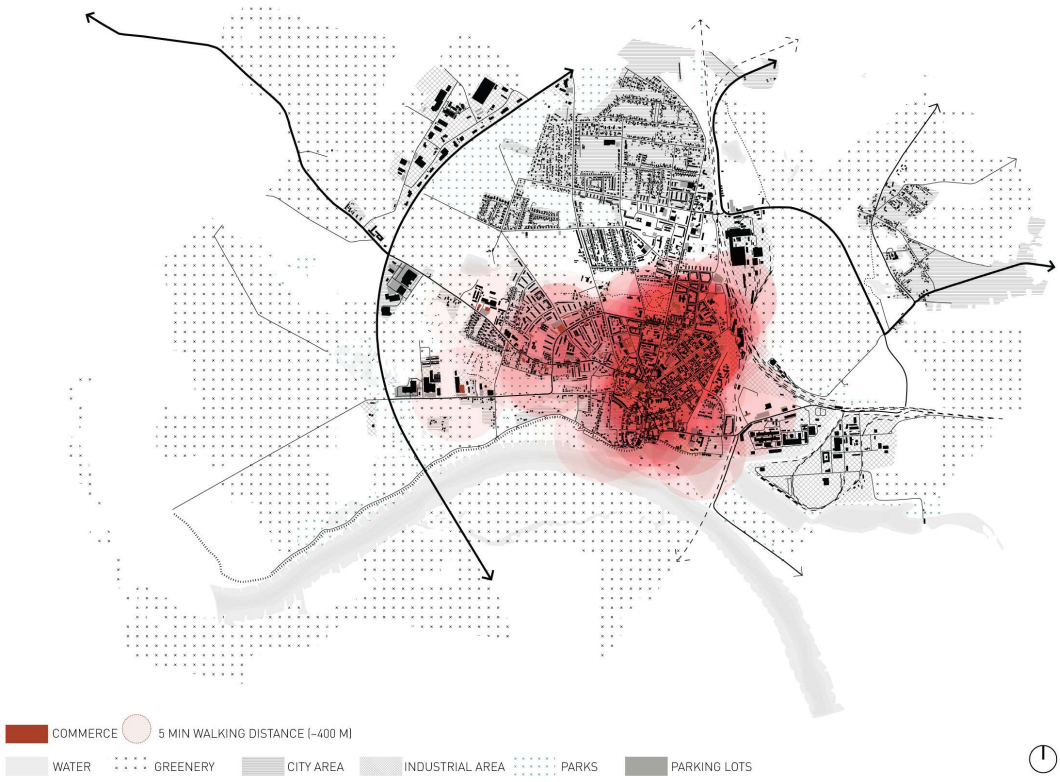

Figure 9: A mapping of commercial facilities in Wittenberge. Created by Julia Barashkov using retrieved GIS spatial data and metadata using a clustering of metadata [see figure — bellow].

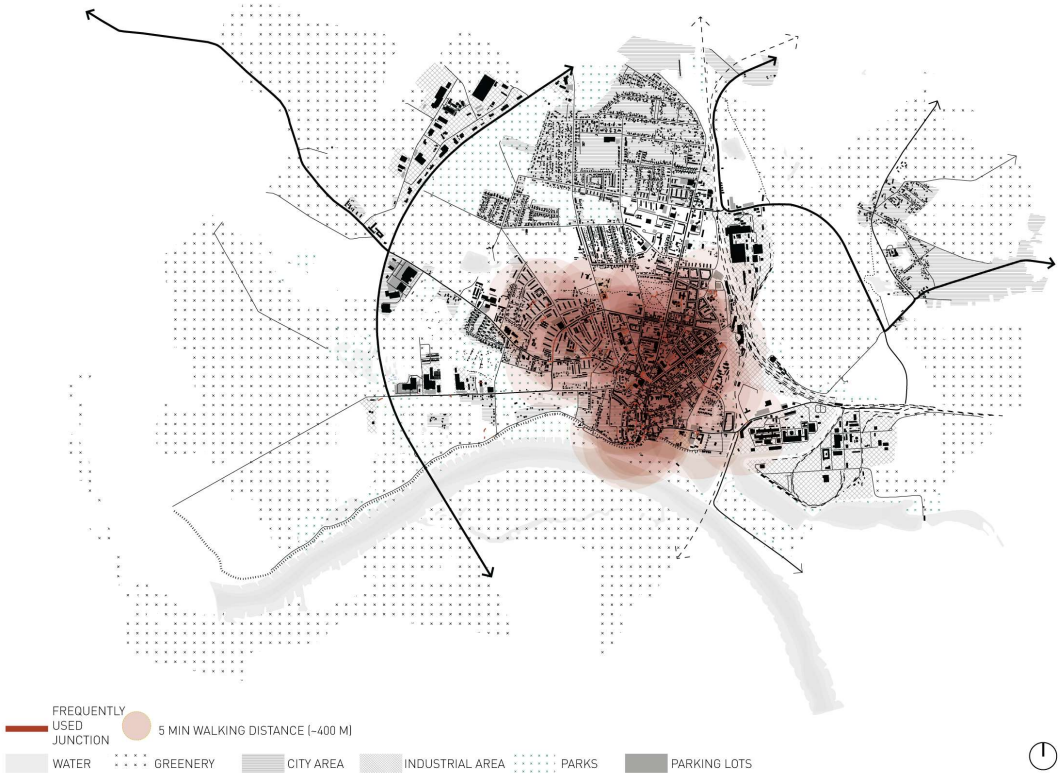

Figure 10: A superposition of amenities and walking distance radiuses to locate "hotspots" of usage. Created by Julia Barashkov

Methodology for agent creation

Agents were generated using the Instagram API, specifically focusing on data from November 2021. A total of 100 Instagram posts that were geotagged to Wittenberg, Germany, were retrieved and subjected to detailed analysis based on a systematic approach. [figure 12] Initially, the geolocation data of the content was verified and placed on a city map to establish its spatial context. [figure 11] Subsequently, the content of each image was examined to identify the specific location depicted, allowing for the completion of any missing spatial data in the 3D model. Furthermore, the colour scheme employed in the images was extracted and recorded. Lastly, the captions and associated hashtags were analyzed for sentiment lexicon, employing a keyword search methodology [figure 13], clustering posts that contained sentiment-related words and subsequently dissecting the captions to identify underlying subtext and contextual nuances.

Figure 11: 50/100 inspected instagram posts on a map of Wittenberge. Created by Julia Barashkov.

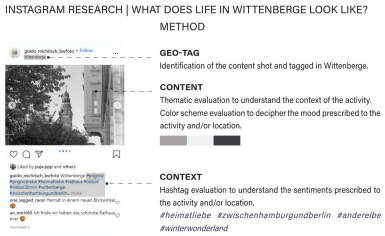

Figure 12: Instagram post evaluation. Created by Julia Barashkov.

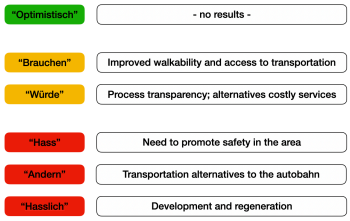

Figure 13: sample keywords searched for in analysed instagram captions. Created by Julia Barashkov.

The sentiment analysis output was subsequently cross-referenced with the geographical location data of the post and thereafter incorporated into the Rhinoceros and Grasshopper model as a point cloud infused with metadata that indicates the assigned sentiment. Further details regarding this process can be found in Figure 14 as presented below.

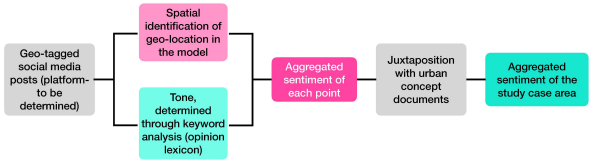

Figure 14: Method for sentiment mapping. Created by Julia Barashkov.

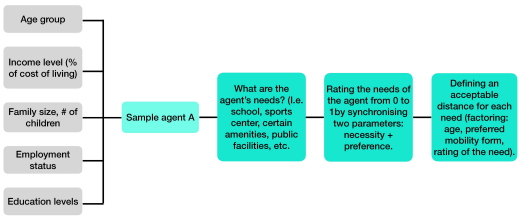

Figure 15: sample agent formation. Created by Julia Barashkov

The development of an agent-based simulation model requires the generation of four distinct agent types, each assigned with cultural identifiers that align with the analysis of census data and reports from municipal officials regarding their desired target groups and populations. In order to effectively analyse societies through algorithms, cultural identifiers are viewed and utilised as curves of descriptive characteristics. Through the mapping of the city and the analysis of empirical data of its residents - such as age groups, income levels, family sizes, employment statistics and income levels, and median levels of education [figure 15] - lies the potential to integrate various layers of identity signifiers. Contrary to the previously oversimplified categorisation of individuals into a single culture which has proved problematic, and led to the development of Social Identity Theory (SIT) by Straub et al. (2002). This theoretical framework presents an approach to identifying, integrating, measuring, and aggregating diverse

influences, and highlights the adaptability of operationalised culture. Rather than assuming homogeneity of social groups, operationalised culture recognises individual markups, providing an alternative narrative to previous categorisation methods.

A discussion with city officials in Witenberge has made clear that the city's target population for urban regeneration are three sectors of the existing population: teenagers, who lack resources for self-development, employment and cultural enrichment; young adults and especially young parents, who move back to their home town after having children; and the former employees of the now-closed Singer factory who have struggled to find meaningful employment after the factory has shut its doors and have been living on unemployment benefits and then retirement payments ever since[1]. To define agents for the subsequent agent-based simulation, the aggregated Instagram API was classified into corresponding age groups, and activities were extracted from the images posted. Another target groups that the city officials have introduced are the types of residents they seek to attract - educated and employed young adults and young families, working in high-skilled positions. The city perceived its selling point to be the convenient positioning between Hamburg and Berlin, on the route of the ICE express train running between those cities. However, urban joy and the acceptance of one's living space lie in entirely different factors. (Montgomery ,2013; Cao, 2016; Lauwers et al. ,2021, Müller et al., 2023)

Figure 16: Agents signified highly-specific population groups generated for the study case of Wittenberge. Created by Julia Barashkov

Methodology for agent-based simulation

Urban user satisfaction

Urban user satisfaction extends beyond mere contentment with services and amenities provided within one's vicinity. Rather, it encompasses various factors such as neighbourhood characteristics, perceptions, and residential satisfaction to form a comprehensive metric for life fulfilment. The mix of land use, density, and street connectivity in urban areas significantly impacts life satisfaction, making it crucial to

[1] informal interview conducted with Christian Fenske, the former chair of the Construction and Economic Development Committee of the City of Wittenberge, conducted on the 8th November 2021.

consider the distance that residents are willing to travel to meet their needs. As noted by Cao (2016), connectivity and land use mix play a decisive role in determining urban life satisfaction.

The threshold between "satisfied" and “dissatisfied”

Previous studies exploring the effect of urban environments on mental health and overall life actualisation noted accessibility to resources, alignment with individual and community-based needs, and the incorporation of marginalised groups through participatory processes as driving forces in urban mental health. (Lauwers et al., 2021; Müller et al., 2023).

Existing tools such as the StadtRaumMonitor, which was developed in Scotland in 2015 and was adapted in the year 2019 for the use of the Federal Center for Health Education in Köln, Germany, measure the following parameters in their urban survey: walkability & cycle-ability; access via public transport; availability of parking spaces; quality of open green spaces; visual aesthetic factors; cleanliness; perceived safety; access to daily services and needs; access to health care and social facilities; availability of housing options; access to occupation opportunities and career advancement; access to leisure activities; access to social meeting points; a sense of belonging and the ability to have one’s voice heard and make a difference in the urban realm as decisive factors.[2] These metrics were researched further in the book "The Happy City" by Charles Montgomery (2013), which discusses the science behind the happiness of urban residents.

The plethora of information available regarding the qualifications of pre-existing cities and urban environments prompts the question of how digital fast urban prototyping and data-based simulation can be utilised to integrate these parameters into the planning stages. By doing so, we can ensure that we are making informed decisions that take into account the unique characteristics and needs of each city. To analyse and quantify the movement patterns of the agents designed for this study case, the trademarked toolkit of “Walk-score” was employed. A “walk score” is a mapping tool that assigns values between 0 and 100 to measure the walkability of any address. Points are awarded based on the distance to amenities in each category. Walk Score also measures pedestrian friendliness by analysing population density and road metrics such as block length and intersection density.[3]

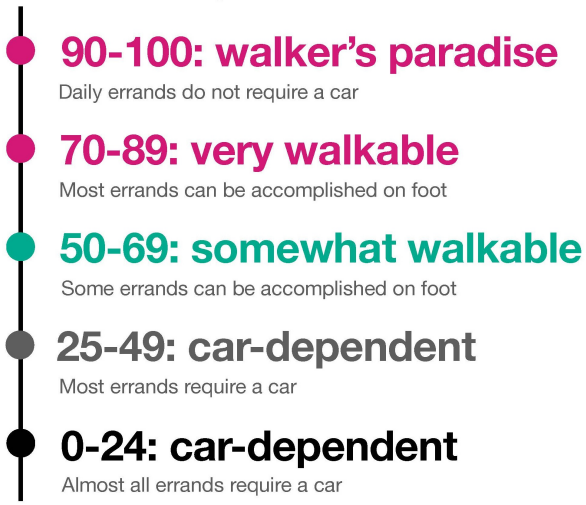

Figure 17: “Walk score” walkability levels. Created by Julia Barashkova, on the basis of data retrieved from the “walk score” official website.

[2] retrieved from the StadtRaumMonitor website, available at: https://stadtraummonitor.bzga.de/#srmbackgrnd accessed on August 1, 2022

[3] retrieved from the Walk Score official website, available at https://www.walkscore.com accessed on 07.06.2021

In the realm of urban planning, there exists a crucial need to incorporate an array of data sources into the decision-making process. To achieve this, a pedestrian movement simulation graph was weighted using the sentiment data derived from the social media keyword analysis, which then influenced the movement preferences of the agents. The simulation's objective was transformed from merely seeking the shortest available path to prioritising the most joyful available path, thereby enhancing the overall experience for pedestrians.

“The shortest path” VS. “The joyful path”

Jan Gehl (2010) defines a joyful urban experience as one in which "people enjoy spending time in a city, feel comfortable and safe, and are able to engage in social interactions and other activities that enrich their lives”. Prioritising pedestrian movement, Gehl suggested widening the sidewalk, adding public seating and greenery, while also fostering places for public interaction. Pleasing urban environments encourage metropolitan residents to spend more time in them and take longer routes when reaching their destinations. Streets carry within them value and meaning, which influence pedestrian movement, and by analysing streets according to their connectivity, centrality and accessibility, ABM simulations provide insight into the spatial organisation of the city. (Jiang et al., 2014) By incorporating aesthetic and social elements into ABM simulations of pedestrian movement, we can create more accurate and nuanced models of urban behaviour in urban environments, taking into account weighted decision-making patterns.

Although agent-based modelling (ABM) is commonly utilised to calculate optimal routes between two locations, several strategies have been devised to integrate subjective elements into ABM simulations. In this study, the technique employed involves the integration of "preference maps" into ABM simulations. These maps assign greater values to specific attributes of the urban environment, signifying their desirability. Consequently, agents are programmed to prioritise routes with higher rankings, even if they are longer or less direct. This approach has been recognised for its efficacy in enhancing the precision of the model when predicting human behaviour and decision-making tendencies. (Kaviari et al., 2016)

In the study case, the agents undertook trips of up to 10 minutes in each direction, taking into account the average walking speed of a male adult, which is estimated to be 1.15 m/s, while carrying baggage (Mohamad et al., 2018)

A pedestrian movement model was developed for the agents "Felix and Sophia," representing the desired population groups that the city aims to attract. The model incorporated various metrics to guide their movement patterns and preferences within the urban environment. These metrics were derived from the spatial data obtained during the 3D reconstruction and analysis of the study case. The walkability metric enabled the agents to choose specific spatial elements based on factors such as proximity, accessibility, and connectivity. Additionally, preferences were assigned to different areas, weighting the graph with preferred routes to guide the agents' movement. This allowed the agents to prioritise certain areas over others, considering factors such as amenities, aesthetics, or other desired attributes. Furthermore, a rating system was implemented for amenities, indicating their popularity or significance within the agents' preferences. Ratings were determined by the number of posts showcasing the respective amenities divided by the total number of posts assigned to each agent. Through these metrics, the pedestrian movement model simulated the agents' behaviours and decision-making patterns, providing insights into their movement choices and preferences within the urban environment.

Element	Walkable?	Preferred?	Rating
Sidewalks	Yes	Yes	
Squares	Yes	Yes	
Indoor spaces	No	Yes	
Bodies of water	No	Yes	
Roads	Yes (to allow crossing of roads)	No (this agent has a small child, and prefers safer routes farther away from car traffic)	
Pedestrian paths	Yes	Yes	
Restaurant	Yes	Yes	5%
Bank	Yes	No (preferring online banking)	0%
Post office	Yes	No (preferring digital communication)	3%
Theatre	Yes	No (no cultural signifiers for theatre identified during the analysis)	0%
School	Yes	No	0%
Arts Centre	Yes	Yes	5%
Bicycle Parking	Yes	Yes (preferring sustainable modes of transportation)	4%
Supermarket	Yes	Yes	7%
Bar / Pub	Yes	Yes	6%
Local stores	Yes	Yes	2%
Doctors	Yes	No	0%
Fast food	Yes	No	0%
Cinema	Yes	Yes	3%
Cafe	Yes	Yes	10%

The pedestrian movement simulation originated from one of the newer developments in the city, specifically targeted towards attracting new tenants. The simulation considered a maximum travel time of a 20-minute round trip, encompassing the journey from home to the destination and back. The findings of the simulation revealed that the agents Felix and Sophia had a range of options available to them within their designated area. They had access to 28 dining establishments, a single option for nightlife, 32 local shopping options, and 8 social, public, or cultural facilities to frequent. However, when evaluating their overall satisfaction with the urban area, calculated based on a median between their walk score and the percentage of daily needs met, the agents' satisfaction score was 20.15 out of 100. This score indicates that a significant portion of their needs is not fulfilled within their walkable radius of a 20-minute round trip.

Figure 18: analysis of existing amenities for the sample agents Felix and Sophia. Executed in Rhinoceros and Grasshopper using agent based simulation of pedestrian movement. Created by Julia Barashkov

3. Results and Discussion

3.1. Why is "the joyful path" important?

Incorporating the notion of joy in the urban experience is crucial for fostering vibrant, liveable, and sustainable cities. Previous research has examined and identified spatial guidelines that contribute to self-reported emotional well-being. For instance, a study conducted by Yang et al. (2023) investigated the emotional reactions to spatial decisions surrounding subway stations in Nanjing, China. The findings revealed that less enclosed public spaces (characterised by a lower ratio of distance to height), open spaces, and visually appealing elements all enhanced emotional well-being in the otherwise congested and dynamic environment of a subway station. By considering mobility hubs as microcosms for pedestrian movement in urban settings at large, these findings can be extrapolated to explore other typologies as well. Another study, conducted by van der Berg et al. (2010), surveyed approximately 4500 Dutch respondents to assess the influence of green spaces in mitigating stressful life events. The research demonstrated a reverse correlation between the amount of green space within a short walking distance of participants' homes and the relationship between stressful life events and their health consequences. In essence, the experience of joy in our daily lives positively impacts emotional well-being and overall

health. By incorporating spatial strategies that promote joy and well-being, urban planners and designers can play a vital role in creating more resilient and healthier urban environments and communities.

Research conducted by Mouratidis (2021) has yielded significant insights into the creation of urban environments that promote high levels of self-reported subjective well-being. The study highlights several crucial tools that contribute to this pursuit, including the integration of urban nature, the provision of accessible public spaces and facilities, the promotion of active travel and public transport, the utilisation of technology to enhance inclusiveness, the maintenance of urban upkeep, the reduction of noise levels, the creation of aesthetically pleasing environments, and the addressing of socio-spatial inequalities. Moreover, the research emphasises the active involvement of the community in the planning process and underscores the importance of evidence-based urban policies, interdisciplinary knowledge transfer, and the measurement of planning outcomes. These findings align with the broader understanding that enjoying one's urban environment is essential for promoting social interaction, community building, and a sense of belonging (Carr, 1993). By incorporating evidence-based planning, cities can create environments that foster positive social interactions and strengthen the fabric of their communities. The emphasis on data-driven approaches further accentuates the importance of informed decision-making and the effective implementation of strategies aimed at enhancing subjective well-being in urban contexts.

3.3. Limitations and biases

Several limitations and biases in the research necessitate discussion and potential addressing in future research endeavours. Firstly, the reliance on social media as a primary source for data collection and the generation of agent personas introduces inherent exclusions of fundamental population groups within the scope of the study. Notably, this approach overlooks small children who lack access to mobile phones, elderly populations, individuals with disabilities who do not utilise mobile phones or engage in content production on social media platforms, individuals facing financial constraints that impede their access to mobile phones or the internet, and those who deliberately opt out of engaging with social media platforms altogether, just to name a few. Recognising and addressing these exclusions is critical to ensure a more comprehensive and representative understanding of urban dynamics and the experiences of diverse populations. Future research should explore alternative methods and sources to capture the perspectives and experiences of these marginalised and underrepresented groups, thereby enhancing the validity and applicability of the findings in relation to the broader urban context.

Secondly, it is important to acknowledge that the decision-making pattern of the agents was consciously constructed by the author of this paper, based on the author's own decision-making sequence. This design choice introduces a potential limitation in terms of the generalisability and applicability of the model to different population groups. It is crucial to recognise that diverse population groups are likely to exhibit distinct decision-making patterns and preferences, which may deviate significantly from those observed in the constructed model. Therefore, the predictability level of the model may be compromised when applied to real-life scenarios involving different individuals or groups. Future research should consider incorporating a broader range of decision-making patterns and preferences, derived from empirical data or representative samples, to enhance the model's accuracy and validity in capturing the complexities of decision-making processes in diverse urban contexts.

To incorporate subjective factors from diverse stakeholders, a comprehensive data collection approach encompassing both qualitative and quantitative methods should be employed. Qualitative insights can be gathered through interviews conducted with selected focus groups, enabling a deeper understanding of individuals' decision-making processes and the multitude of factors influencing their choices. Drawing on the work of Wolek et al. (2021), potential survey questions have been identified to elicit valuable information from participants:

1. What are the primary considerations for you when selecting a route in the city? (e.g., distance, safety, landmarks, aesthetics, etc.)

2. How do you weigh the importance of these factors in your decision-making process?
3. Are there specific types of environments (e.g., busy streets, quiet parks, bustling marketplaces) that you tend to prefer or avoid when navigating the city?
4. Do time constraints impact your preferences for certain environments?
5. To what extent do social and cultural factors influence your decision-making process when navigating the city? Could you provide examples of these factors?
6. Do you tend to follow habitual or routine paths in your navigation, regardless of other factors?
7. How significant is the presence of clear and legible signage for you when navigating the city?
8. Have you encountered situations where you had to alter your route due to unexpected circumstances (e.g., construction, crowds, safety concerns)? How did you make that decision?
9. How frequently do you consult maps or other wayfinding tools while navigating the city?
10. How do you balance the desire for efficiency, such as taking the shortest route, with the inclination for exploration and discovery in the urban environment?
11. Have you ever deliberately chosen a longer route due to the aesthetic qualities or other appealing attributes of the environment?

By employing this mixed-methods approach, researchers can gain comprehensive insights into the complex interplay between subjective factors and decision-making processes in urban navigation. These findings contribute to a deeper understanding of individuals' preferences and inform the development of more nuanced and user-centric urban planning strategies.

Moreover, it is imperative to critically examine the implications and reliability of model results when integrating them into urban decision-making processes. The dawn of the internet introduced a paradigm known as "Code is Law," asserting the priority of mathematical algorithms in the digital realm, detached from human judgment (Lessig, 1999). However, the increasing dominance of media giants such as Facebook, Google, and Amazon raises concerns about issues such as mass surveillance, biased machine learning, algorithmic decision-making, economic vulnerabilities, and political unrest (Klein, 2007). Additionally, the jurisdictional challenges associated with internet-related malware and misconduct transcend the legal systems of individual countries or states (Sttab, 2021; Johnson et al., 2004; Froomkin, 2015). These concerns become particularly salient when code is granted the power to shape physical alterations in public spaces, giving rise to questions about the ownership of urban space, the accountability of coded decisions, and the role of democratic processes in monitoring and regulating these decisions. The debate extends to considerations of private versus public control over urban spaces and the need for mechanisms to ensure democratic oversight in the face of algorithmic decision-making (Sttab, 2021). These critical issues highlight the importance of careful scrutiny and ethical evaluation of code-driven interventions in the urban realm, in order to safeguard public interests, uphold democratic values, and address the potential social, cultural, and political implications of such technological transformations.

There is an inherent challenge to perceive and predict the effects of new tools and developments on societal structures. Technological advancements exert dual effects on our lives, encompassing both conscious recognition of our needs and expectations, as well as cultural developments and underlying pressures that operate at a subconscious level. Furthermore, these influences vary among different age groups and backgrounds. When faced with the unprecedented, Zuboff (2019) argues that we interpret and assess it based on the tools and frameworks available to us, drawing comparisons to past situations and established structures. Consequently, our judgments are shaped by two factors. Firstly, our current understanding of the future is inherently limited, impeding accurate predictions of the tool's potential

consequences. Secondly, future users of the tool will possess a restricted comprehension of its implications for their lives.

4. Conclusion

The main findings of this study highlight the importance of understanding decision-making patterns in order to build agents that accurately capture the behaviours of various stakeholders. Real-life pedestrians consider multiple factors when selecting their routes, including distance to the destination, perceived safety of the route, pedestrian traffic levels, and the aesthetic qualities of the environment. Furthermore, social and cultural factors play a significant role in decision-making processes. It is evident that the human demeanour is complex and multifaceted, highlighting the value of understanding decision-making patterns beyond immediate needs.

Demographic factors, such as age and gender, also influence decision-making patterns. For example, older pedestrians may be more sensitive to environmental factors such as sidewalk width and slope. These factors must be considered when developing models and interventions aimed at enhancing the pedestrian experience.

In addition, the study accentuates the transformative nature of technological development and the need to consider the long-term effects of proposed urban developments. While it may be challenging to predict these effects at present, it is essential to take a cautious and forward-thinking approach to ensure the potential impacts are adequately considered.

The findings of this study contribute to both theory and practice by providing insights into decision-making patterns and the complex interplay of factors that influence pedestrian conduct. This understanding can inform the design of urban environments and interventions that prioritise the needs and preferences of pedestrians. Furthermore, it accentuates the need for ongoing research and exploration of the long-term consequences of technological advancements on human behaviour and society as a whole.

5. References

Cao, X. (. (2016). How does neighborhood design affect life satisfaction? Evidence from Twin Cities. Travel Behaviour and Society, 5, 68-76. https://doi.org/10.1016/j.tbs.2015.07.001

Cardullo, P., & Kitchin, R. (2019). Being a 'citizen' in the smart city: Up and down the scaffold of smart citizen participation in Dublin, Ireland. GeoJournal, 84(1), 1-18.

Carr, S., Francis, M., Rivlin, L. G., & Stone, A. M. (1993). Public Space. Cambridge University Press.

Deakin, M. (2013). *Smart Cities: Governing, Modelling and Analysing the Transition*. Routledge.

Froomkin, A. M. (2015). The law of the horse: What cyberlaw might teach. Kentucky Law Journal, 103(3), 465-494.

Gehl, J. (2010). Cities for People. Island Press.

Graham, S., & Marvin, S. (2001). Splintering Urbanism: Networked Infrastructures, Technological Mobilities and the Urban Condition. London, UK: Routledge.

Graham, Stephen. (2005). Software Sorted Geographies. Progress in Human Geography. 29. 10.1191/0309132505ph568oa.

Jiang, Bin & Claramunt, Christophe. (2004). Topological Analysis of Urban Street Networks. Environment and Planning B: Planning and Design. 31. 151-162. 10.1068/b306.

Johnson, D. G., Crawford, K., & Palfrey, J. G. (2004). Intellectual property and the internet. Annual Review of Law and Social Science, 133-174.

Kaviari, F., Mesgari, M. S., Seidi, E., & Motieyan, H. (2019). Simulation of urban growth using agent-based modeling and game theory with different temporal resolutions. *Cities*, *95*, 102387. https://doi.org/10.1016/j.cities.2019.06.018

Kitchin, Rob. (2013). The real-time city? Big data and smart urbanism. GeoJournal. 79. 1-14. 10.1007/s10708-013-9516-8.

Kitchin, Rob & Lauriault, Tracey & McArdle, Gavin. (2015). Knowing and governing cities through urban indicators, city benchmarking and real-time dashboards. Regional Studies, Regional Science. 2. 6-28. 10.1080/21681376.2014.983149.

Klein, N. (2007). The Shock Doctrine: The Rise of Disaster Capitalism. Macmillan.

de Lange, M. and de Waal, M. (2013) "Owning the city: New media and citizen engagement in urban design", First Monday, 18(11). doi: 10.5210/fm.v18i11.4954.

Lauwers, L., Leone, M., Guyot, M., Pelgrims, I., Remmen, R., Van den Broeck, K., Keune, H., & Bastiaens, H. (2021). Exploring how the urban neighborhood environment influences mental well-being using walking interviews. *Health & Place*, *67*, 102497. https://doi.org/10.1016/j.healthplace.2020.102497

Lessig, L. (1999). Code and other laws of cyberspace. New York: Basic Books.

McFarlane, C., & Söderström, O. (2017). On alternative smart cities. City, 21(3-4), 312–328. https://doi.org/10.1080/13604813.2017.1327166

Mitchell, J.A., Thomson, M. and Coyne, R.P. (2017) *A guide to citation*. *E-book library* [online]. Available at: https://www.mendeley.com/reference-management/reference-manager (Accessed: 10 September 2016)

Mohamad Ali, Mohd Firdaus & Abustan, Muhammad Salleh & Abu Talib, Siti & Abustan, Ismail & Abd Rahman, Noorhazlinda & Gotoh, Hitoshi. (2018). A Case Study on the Walking Speed of Pedestrian at the Bus Terminal Area. E3S Web of Conferences. 34. 01023. 10.1051/e3sconf/20183401023.

Montgomery, C. (2013). Happy city: transforming our lives through urban design. First edition. New York, Farrar, Straus and Giroux.

Mouratidis, K. (2021). Urban planning and quality of life: A review of pathways linking the built environment to subjective well-being. *Cities*, *115*, 103229. https://doi.org/10.1016/j.cities.2021.103229

Müller H, Rehn-Groenendijk J and Wasmer A (2023) Small-scale urban design interventions: A framework for deploying cities as resource for mental health and mental health literacy. Front. Psychol. 14:1112209. doi: 10.3389/fpsyg.2023.1112209

Pew Research Center. (Spetember, 2021). *The Internet and the Pandemic.* Available at: http://www.pewresearch.org (Accessed on: 26 November 2022)

Pew Research Center. (April, 2021) *Social Media Use in 2021*. Available at: https://www.pewresearch.org/internet/wp-content/uploads/sites/9/2021/04/PI_2021.04.07_Social-Media-Use_FINAL.pdf (Accessed on: 27 November 2022)

Rosa, M. L., & Weiland, U. (2013). *Handmade Urbanism: Mumbai - São Paulo - Istanbul - Mexico City - Cape Town From Community Initiatives to Participatory Models*. Berlin, Boston: JOVIS Verlag GmbH.

Scannell, L., & Gifford, R. (2010). Defining place attachment: A tripartite organizing framework. Journal of Environmental Psychology, 30(1), 1-10. https://doi.org/10.1016/j.jenvp.2009.09.006

Scott, Allen. (2012). Triumph of the City: How Our Greatest Invention Makes Us Richer, Smarter, Greener, Healthier, and Happier – By Edward Glaeser. Economic Geography. 88. 97-100. 10.2307/41474071.

Shaw, J., & Graham, M. (2017). An Informational Right to the City? Code, Content, Control, and the Urbanization of Information. Antipode, 49(4), 907-927. https://doi.org/10.1111/anti.12312

Staab, Philipp. (2019). Digitaler Kapitalismus. Markt und Herrschaft in der Ökonomie der Unknappheit, Suhrkamp, Berlin 2019.

Staab, A. (2021). Cybercrime. In International Encyclopedia of Comparative Law (pp. 1-16). Springer.

Stedman, Richard. (2003). Is It Really Just a Social Construction?: The Contribution of the Physical Environment to Sense of Place. Society &Natural Resources. 16. 671-685. 10.1080/08941920309189

Steele, F. (1981). The Sense of Place; CBI Pub. Co.: Boston, MA, USA.

Straub, Detmar & Loch, Karen & Evaristo, J. & Karahanna, Elena & Srite, Mark. (2002). Toward a Theory-Based Measurement of Culture. JGIM. 10. 13-23. 10.4018/jgim.2002010102.

Troy B.N. (2015) 'Harvard citation rules' in Williams, S.T. (ed.) *A guide to citation rules*. New York: NY Publishers, pp. 34-89.

van den Berg AE, Maas J, Verheij RA, Groenewegen PP. Green space as a buffer between stressful life events and health. Soc Sci Med. 2010 Apr;70(8):1203-10. doi: 10.1016/j.socscimed.2010.01.002. Epub 2010 Feb 12. PMID: 20163905.

William, S.T. (eds.) (2015) *Referencing: a guide to citation rules*. New York: My Publisher

Wolek M, Suchanek M, Czuba T. Factors influencing walking trips. Evidence from Gdynia, Poland. PLoS One. 2021 Aug 4;16(8):e0254949. doi: 10.1371/journal.pone.0254949. PMID: 34347818; PMCID: PMC8336852.

Yang, L., Zhu, Y., Chatzimichailidou, M. *et al.* Assessing human emotional responses to the design of public spaces around subway stations: a human factors research. *Urban Des Int* (2023). https://doi.org/10.1057/s41289-023-00219-y

Zandbergen, Dorien & Uitermark, Justus. (2019). In search of the Smart Citizen: Republican and cybernetic citizenship in the smart city. Urban Studies. 57. 004209801984741. 10.1177/0042098019847410.

Zuboff, Shoshana. (2019). The Age of Surveillance Capitalism: The Fight for a Human Future at the New Frontier of Power. PublicAffairs. p.12

Authorship contribution statement

Julia Barashkov carried out this study through conceptualisation, methodology development, conducting formal analysis, carrying out investigations, visualising the data, and writing the original draft. Additionally, Julia Barashkov completed the revision and editing of the manuscript.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

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Case Study Report

Competition-based Approach to Climate Action:

#CircularCityChallenge, A Competition for Teenagers

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Abstract

The world faces climate change caused by environmental degradation and ecosystem collapse. Cities play a vital role in addressing these challenges, and circular urban development, in the form of "circular cities," is becoming increasingly popular as a way to achieve sustainable development. The CircularCityChallenge, building on fundamentals of circular cities and approaches in education for sustainable development, is a competition that targets young people aged 14-18, encouraging them to submit their ideas for a circular future in their own environments and simultaneously educating them about sustainable development. The challenge offers an innovative example of a participatory platform that is structured on a five-step process, in which young people would be getting familiar with the (1) circular city concept, (2) critical thinking, (3) system thinking, (4) pluralistic thinking, and (5) creative thinking. Encouraging networking and providing approaches for networking, the challenge potentially creates a liaison between local government/businesses and young people, and the fresh ideas and approaches that young people bring to the table carry the potential to inform local governments/businesses about local urban development needs, allowing them to collaboratively build circular futures for cities.

Keywords

circular cities, education for sustainable development, young people, climate action, sustainable development, competition-based approach

1. Introduction

Cities provide habitats for billions of Earth dwellers, over 60% of the world's population. Cities also consume 60-80% of the world's resources and produce 50% of global waste due to their linear approach to urban resources (Camaren and Swilling, 2012). This makes cities a significant contributor to atmospheric warming and environmental degradation, putting them at the forefront of the global climate emergency. Cities have two central systems linked to each other and contribute to both waste and sustainable futures (Prendeville et al., 2018; Gravagnuolo et al., 2019; Williams, 2022): procurement and social. Procurement involves the production of goods and services by good providers like in the food and fashion industries and service providers like local governments. Social systems refer to communities, citizens (also called users) together with their skills and urban lifestyles, including consumption behaviors. Sustainable procurement alone is insufficient for cities, which also need a corresponding shift in community-led change, as enhanced community resiliency and adaptation is a more beneficial investment in sustainable futures than pursuing the ultimate goal of sustainability (Callaghan and Colton, 2008).

Therefore, it is urgent that cities take action to transition to more sustainable modes of urban existence by creating resilient communities.

Creating resilient communities requires advancing citizens' skills and capabilities to ensure the survival of both places and people through the sustainable transition in climate action (Dale and Newman, 2006). Sustainable transition in climate action has emerged in cities in the form of various city models, such as carbon-zero cities (Kennedy and Sgouridis, 2011), eco-cities (Tang et al., 2022), and smart cities (Chen, 2023). Recently, "urban circularity" (Marin and De Meulder, 2018, p. 1) or "urban circular development" (Williams, 2021, p. 1) in the form of circular cities has emerged as a promising approach, introducing a new set of individual and collective skills that accompanied with urban circular actions: loop (RE-actions), regenerate, and adapt, as well as localize, substitute, and share (Williams, 2019). The familiarity of citizens with those actions not only brings out empowerment through gaining the necessary knowledge, values, and skills to advance sustainable development but also supports Sustainable Development Goal #11, which aims to create sustainable cities and communities (UN, 2015).

Circular urban development in the form of circular cities conceptually adopts circular economy principles to transform linear city systems into circular ones, offering a way to experiment with urban circular actions to address the problems in sustainable development. However, there is limited empirical evidence to validate the concept of circular cities internationally. While circular development potentially intends to create equal opportunities and benefits for all actors, it can, in practice, exacerbate existing inequalities (Williams, 2021). An emphasis is needed within urban circular development on creating fair procedures and aiming at fair outcomes for everyone. Additionally, community-led circular development initiatives hold significant potential for transformation, as they can drive changes in city systems, leading to more resilient and circular communities. Therefore, creating resilient communities requires the enhancement of citizens' competency in several different ways of thinking allocated under circular thinking: (1) critical thinking for recognizing urban problems caused by linear approaches, (2) system thinking for identifying related actors in the problem and solution, (3) pluralistic thinking for creating fair procedures and outcomes for all related actors, and (4) creative thinking for experimenting with urban circular actions. And these thinking approaches are commonly adopted in Education for Sustainable Development.

Education for Sustainable Development (ESD) is a crucial platform for promoting circular development, especially for young people, who are the future of nations. ESD aims to enhance young individuals' comprehension of the multifaceted aspects of sustainability, including social, environmental, and economic factors, and to help them understand the impact of their choices and actions on global sustainability (UNESCO, 2020). However, the content of ESD needs updating to include new means of sustainability, such as circular development. It is vital to introduce circular development and its aspects in upper secondary education through ESD since upper secondary education points out a threshold for individuals before starting higher education and then a career. Enhancing young people's capacity for circular thinking allows them to explore their interests and passions in fields that contribute to sustainable futures. This can also help young people enhance their independence and responsibility as they navigate global issues in adulthood. Developing capacities for circular thinking, design, and actions is also a matter of value change, as values are primarily shaped during childhood, adolescence, and early adulthood through the influence of parents, neighbors, friends, and schools (Scharfbillig et al., 2021). As a result, it is crucial to impart the necessary values and capacities to the secondary school age group for sustainable transition.

2. #CircularCityChallenge

Responding to the global climate action and building on the conceptual framework that combines urban circular development and education for sustainable development, the #CircularCityChallenge aims to provide young people (14-18 years old) with a platform for amplifying their voices to encourage them to become sustainability and circularity ambassadors for older generations by stepping forth with their ideas addressing sustainability issues in their cities. The challenge will collect submissions from young people starting in September 2023. The submissions will be judged by a committee of experts in circularity and education for sustainable development based on the four criteria given below, and during the final event, the winners will be awarded, and their participation will be celebrated.

1. UNDERSTANDING URBAN CIRCULARITY: How well does the team display a basic understanding of circularity and the circular economy within complex urban systems of production and consumption?
2. UNDERSTANDING INTER-CONNECTIVITY: How well does the team understand of general landscape (key actors, organizations, initiatives), determine who needs to be involved, map the relationships, roles, and information flow in the system, identify opportunities to build new relationships, and explore other parts of the system?
3. SEEING OPPORTUNITIES FOR CIRCULARITY: How well does the team represent the problem in their environment and address this problem, establish objectives through cooperation, and find ways to achieve those objectives via circular actions?
4. CONVINCING THE JURY ABOUT THEIR ANALYSIS AND PROPOSAL: How well does the team present their overall analysis, which includes the problem, actors, cooperation, and their final proposal for the problem they defined?

The #CircularCityChallenge adopts the competition-based approach that is proven successful in motivating students and increasing their learning performance (Burguillo, 2010). By doing that, the challenge aims to develop the capacity of young people in circular thinking to help them to effect meaningful and positive change in their urban environments. The #CircularCityChallenge is a competition bringing together young people from different communities, countries, languages, and demographics to encourage them to collaborate with their peers and to think about climate change and environmental degradation. The goal is not just to find solutions but also to inspire young individuals to communicate, plan, and make a difference in their daily lives. Thus, the challenge empowers and instills a sense of agency in young people while equipping them with the necessary skills to navigate and tackle 21st-century challenges beyond upper secondary education. Ultimately, the objective is to help students gain an understanding of the complicated and controversial issues surrounding climate change and environmental degradation.

Additionally, by its ready package that includes necessary tools for both young people and teachers/facilitators, the challenge provides a stand-alone educational method to be utilized in upper secondary schools in teaching circularity and sustainability more broadly. The intended learning outcomes of the challenge are **(1)** gaining a basic understanding of circularity and the circular economy within complex urban production and consumption systems, **(2)** being empowered with systemic and critical

thinking, and encouraging them to reflect on how to assess information better and challenge un-sustainability, and **(3)** developing competencies related to project management, teamwork and communication, digital information and data literacy, problem-solving, and social responsibility.

The toolbox of #CircularCityChallenge contains five-step-instruction manuals designed especially for young people called 'the logbook' and for teachers/facilitators called 'the guidebook,' and a set of toolkits. The toolbox is formatted for both manual and digital use, depending on the availability of technological instruments. First, the logbook is an essential tool for helping participants keep track of their progress in preparation to submit their ideas for the competition. The logbook is divided into five steps **(Table 1)**, and each step is divided into five sections that are explained below:

1. **First Reminders:** Before starting the step, the logbook provides reminders to ensure participants /young people are well-prepared for the step.
2. **Tasks and Questions:** This section contains tasks and questions related to the step.
3. **Inspirational Material:** The QR code provides access to further knowledge and the toolkit provided online.
4. **Blank Space:** This space is for notes and sketches. There are also more blank pages at the end of the logbook if needed.
5. **Second Reminders:** After completing the step, the logbook provides reminders to ensure participants/young people have finished it completely.

Table 1: Challenge steps. Source: #CircularCity Challenge Participant Logbook

STEP #1	**INTRODUCTION** introduces the six urban circular actions with which cities worldwide experiment to mitigate issues caused by unsustainable production and consumption of goods, food, and energy: (1) Looping, (2) Regeneration, (3) Adaptation, (4) Localization, (5) Substitution, (6) Sharing.	**AIM** Enhancing the knowledge of urban circular actions
STEP #2	**IDENTIFY YOUR CHALLENGE** encourages participants/young people to ask critical questions to identify sustainability issues, such as waste production, in their settings, such as "What is the impact of waste on the environment and human health?" and "What are the underlying causes of waste production?"	**AIM** Enhancing critical thinking
STEP #3	**POSITION YOURSELF** challenges participants/young people to explore the system around the issue by defining the actors (including themselves) who might be affected by the waste, who might be contributing to it, and who might have a role to play in reducing it, also encourages participants/young people to categorize defined actors based on the power and information they hold in taking action and their relationship to their defined challenge and to identify connections and relationships between these groups.	**AIM** Enhancing system thinking
STEP #4	**ENVISION CIRCULAR FUTURES** encourages participants/young people to imagine a better way, rewrite the rules, reshape the system, and imagine if this new system would eliminate waste, circulate products and materials, and regenerate nature. This step specially asks participants/young people to approach key people in their imagined system and expand their network.	**AIM** Enhancing pluralistic thinking

STEP #5	**DEVELOP YOUR INITIATIVE** leads participants/young people creatively to think and design their circular idea responding to defined challenges. They are asked to demonstrate (action-based presentation) or suggest a scenario (plan-based presentation) to present their ideas and submit them via the submission portal of #CircularCityChallenge in any format, including videos, poster presentations, reports, and so on.	**AIM** Enhancing creative thinking

Second, the guidebook is an indispensable tool for teachers/facilitators who want to help young people/their students develop critical, system, pluralistic, and creative thinking skills while encouraging them to think about sustainability challenges in their settings. The guidebook follows the same five-step layout with the same order as the logbook and provides teachers/facilitators with step-by-step instructions specific to the tasks of each step on how to guide young people/their students. For example, for STEP #5, the guidebook includes techniques to kindle creative thinking in young people/participants, such as mind mapping, visualization, and role-playing. Third, a set of toolkits is accessible online via the QR codes in the logbook and guidebook for young people/participants and teachers/facilitators. Via the codes, participants and facilitators can access a collection of books, articles, videos on circular knowledge, and instructions on existing methods that can be utilized in each step to supplement the process whenever needed.

3. Potential Contributions of #CircularCityChallenge

The #CircularCityChallenge showcases an alternative approach to collaborative urban planning, aimed at creating circular cities as a means of sustainable development in climate action. Its focus on young people's participation also highlights their forgotten critical role in climate action. More importantly, the challenge points out the need to enhance citizens' capabilities to company local government responses to climate action.

The #CircularCityChallenge offers a competition-based approach to participation, allowing young people to challenge themselves, their cities, and the linear system through their circular ideas for their urban environments. The challenge not only brings institutional innovation regarding participation in urban planning and young people's agency but also potentially provides fresh ideas and approaches to urban circularity that local governments and businesses can adopt in climate action.

The #CircularCityChallenge enhances the multi-perspective approach to urban planning by providing a stand-alone collaborative platform that can be used by governmental and non-governmental organizations, such as local governments, foundations, and NGOs interested in collaborative urban planning and design for creating sustainable futures. Moreover, the #CircularCityChallenge methodologically and knowledge-creation-wise contributes to policy-making in both education and urban development. It localizes the sphere of transformation in urban settings, focusing on the knowledge and skill development of citizens for more resilient communities. This process enhances the adaptability of citizens and enlarges the concept of a pluriform society, potentially explaining the interconnectedness of cities' actors. Thus, the challenge facilitates a shift from the position of young people as outside observers of a system to change agents within the systems of cities.

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5. References

Burguillo, J.C., 2010. Using game theory and Competition-based Learning to stimulate student motivation and performance. Comput. Educ. 55, 566–575. https://doi.org/10.1016/j.compedu.2010.02.018

Callaghan, E.G., Colton, J., 2008. Building sustainable & resilient communities: a balancing of community capital. Environ. Dev. Sustain. 10, 931–942. https://doi.org/10.1007/s10668-007-9093-4

Camaren, P., Swilling, M., 2012. Sustainable, Resource Efficient Cities - Making it Happen! United Nations Environment Programme, Kenya.

Chen, C.-W., 2023. Can smart cities bring happiness to promote sustainable development? Contexts and clues of subjective well-being and urban livability. Dev. Built Environ. 13, 100108. https://doi.org/10.1016/j.dibe.2022.100108

Dale, A., Newman, L., 2006. Sustainable Community Development, Networks and Resilience. Environments 34.

Gravagnuolo, A., Angrisano, M., Fusco Girard, L., 2019. Circular Economy Strategies in Eight Historic Port Cities: Criteria and Indicators Towards a Circular City Assessment Framework. Sustainability 11, 3512. https://doi.org/10.3390/su11133512

Kennedy, S., Sgouridis, S., 2011. Rigorous classification and carbon accounting principles for low and Zero Carbon Cities. Energy Policy 39, 5259–5268. https://doi.org/10.1016/j.enpol.2011.05.038

Marin, J., De Meulder, B., 2018. Interpreting Circularity. Circular City Representations Concealing Transition Drivers. Sustainability 10, 1310. https://doi.org/10.3390/su10051310

Prendeville, S., Cherim, E., Bocken, N., 2018. Circular Cities: Mapping Six Cities in Transition. Environ. Innov. Soc. Transit. 26, 171–194. https://doi.org/10.1016/j.eist.2017.03.002

Scharfbillig, M., Smillie, L., Mair, D., Sienkiewicz, M., Keimer, J., Pinho, D.S.R., Vinagreiro, A.H., Vecchione, E., Scheunemann, L., 2021. Values and Identities - a policymaker's guide. Publ. Off. Eur. Union, JRC126150. https://doi.org/10.2760/349527

Tang, W., Niu, Z., Wei, Z., Zhu, L., 2022. Sustainable Development of Eco-Cities: A Bibliometric Review. Sustainability 14, 10502. https://doi.org/10.3390/su141710502

UN, 2015. Sustainable Development Goals.

UNESCO, 2020. Education for Sustainable Development: A Roadmap, Education 2030. United Nations Educational, Scientific and Cultural Organization (UNESCO), France.

Williams, J., 2022. Circular cities: planning for circular development in European cities. Eur. Plan. Stud. 0, 1–22. https://doi.org/10.1080/09654313.2022.2060707

Williams, J., 2021. Circular Cities: What Are the Benefits of Circular Development? Sustainability 13, 5725. https://doi.org/10.3390/su13105725

Williams, J., 2019. Circular cities. Urban Stud. 56, 2746–2762. https://doi.org/10.1177/0042098018806133

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Planning for Metropolitan Areas – Ensuring Better Spatial Planning and Service Delivery Outcomes for Chennai Metropolitan Area

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Abstract

! YŜúN2LJ2ťúI·yˇNŜƎλ2yˇKI·ă ăŜØŜNlI·t dzNōI·yˇIּyŘ NdzNlI·t Ŏ2yáúλúdzŜyűăΣ øKλŎK ōè ØλNúdzŜ 2Ŧ ōŜλyƎ λyˇűKŜ ØλŎλyλűè 2Ŧ űKŜ Ŏ2NŜ ŎλúèּI·NŜ ŜĚLJŜNΛŜyŎλyƎ ŘŜY2ƎNlI·LJKλŎ ƎN2øűKΣ ăLJI·úλIּt ŜĚLJI·yăλ2yˇIּyŘ ŜŎ2y2YλŎ ŘŜØŜf2LJYŜyűΦ ¢KŜ ŦI·ăú LJI·ŎŜ 2Ŧ ƎN2øűK 2Ŧ YŜúN2LJ2ťúI·yˇŎλúΛŜă I·yŘ űKŜΛN LJŜNΛπdzNōI·yˇIּNŜI·ă I·yŘ űKŜ NŜădztűλyƎ ăLJI·úλIּt űNI·yãŦ2NYI·úλ2yˇλă 2yŜ 2Ŧ űKŜ Y2ăú ăúNΛ¶λyƎ ŦŜI·údzNŜă 2Ŧ LyŘλI·Ωă dzNōI·yˇăŎŜyI·NΛ2Φ ¢KŜăŜ KI·ØŜ NŜădztűŜŘ λyˇλyŎNŜI·ăŜŘ LJNŜăădzNŜ 2yˇűKŜ ŜyØΛN2yYŜyűIּt NŜă2dzNŎŜă ădzŎK I·ă fIּyŘ I·yŘ ø I·úŜN Φ a2NŜ I·yŘ Y2NŜ tI·yŘ λă ōŜλyƎ LJdzű dzyŘŜN ōdzλťűπdzLJ λyˇűKŜ YŜúN2LJ2ťúI·yˇIּNŜI·ăΦ CdzNúKŜNΣ űKŜ I·ŎŎ2YLJI·yêλyƎ ŜŎ2y2YλŎ ŘŜØŜf2LJYŜyűă λyˇLJŜNΛπdzNōI·yˇIּNŜI·ă λă ŎNŜI·úλyƎ I· ăúN2yƎ LJdzff Ŧ2NŎŜΣ y2ű 2yfè Ŧ2N űKŜ LJ2LJdztI·úλ2yˇŦN2Y I·Ř22λyλyƎ Řλăú¼Ŏűăōdzű I·fă2 Ŧ2N ŦI·N 2ŦŦ I·NŜI·ă λyˇ2úKŜN LJ22NŜN ăúI·úŜă 2Ŧ úKŜ Ŏ2dzyúN¼è Φ tN2ØλŘλyƎ Ŧ2N ŘI·λfè yŜŜŘă I·yŘ ăŜNØλŎŜ NŜIjdzλNŜYŜyűă 2Ŧ úKλă I·ŘŘλúλ2yIּt LJ2LJdztI·úλ2yˇIּyŘ Ŝyãdz¼yƎ ăëăúŜYI·úλÔ LJfIּyŷλyƎ ōŜŎ2YŜă I· ŎKI·ftŜyƎŜ ŦŽN YŜúN2LJ2ťúI·yˇIּNŜI·ăΦ /I·ŭŜN¼yƎ ú2 úKŜ øI·ŭŜN ŘŜYI·yŘă 2Ŧ űKλă ŜØŜNπλyŎNŜI·ăλyƎ LJ2LJdztI·úλ2yˇ λă I·fă2 ōŜŎ2YλyƎ dzyãdzăúIּλyIּōfŜΦ ² λűK λyŎNŜI·ăλyƎ ŎfλYI·ŭŜ ØI·N¼I·ōλťλúè I·yŘ 2ŎŎdzNNŜyŎŜă 2Ŧ ŜĚúNŜYŜ ŜØŜyűă ădzŎK I·ă Ŧf22ŘăΣ NŜăLJ2yãλōfŜ YIּyIּ·ƎŜYŜyű 2Ŧ úKŜăŜ NŜă2dzNŎŜă KI·ă ōŜŎ2YŜ ŜØŜyˇY2NŜ NŜfŜØI·yúΦ ¢KŜ ăúdzŘè ø2dztŘ λŘŜyűλŦè űKŜ úNI·yãŦ2NYI·úλ2yã I·yŘ ăúNŜăăŜă λyˇűKŜăŜ NŜă2dzNŎŜă IּyŘ K2ø úKŜè I·NŜ dzyŜIjdzI·ffè ōŜλyƎ I·LJLJ2Núλ2yŜŘ ōŜúøŜŜyˇűKŜ Ŏ2NŜ ŎλúèּŦ /KŜyŷIּλ IּyŘ λúă LJŜN¼dzNōI·yˇI·NŜI·ăΦ

Keywords

tŜNλdzNōI·yΣ YŜúN2LJ2ťúI·yˇƎ2ØŜNyIּ·yŎŜΣ øI·úŜN ădzLJLJfèΣ LJfI·yŷλyƎ

1. Introduction

Cities have long been seen as having far reaching developmental impact not only for itself but also for its surroundings, both immediate and distant. Coupled with globalization this specific form of rapid urbanization is resulting in the complex process of 'Peri-Urbanization' on the peripheries of the large developing metropolises in developing countries.

Peri-urban has been defined differently by different scholars but there are certain aspects which come out very clearly while defining a peri-urban area. As a place, peri-urban area lies outside the municipal boundary but can be considered as an extension of the cities they surround. As a process, it undergoes continuous transformations with respect to physical, socio-demographic, economic, and environmental aspects. As a concept, it is a dynamic mixed space with both urban and rural settlement and activities being carried. (Based on study of Mc Gee 1991, Narain 2010, Dupont 2005, Kundu et al. 2002, Moench and Gyawali 2008, Webster 2002, Marshall et al., 2009, Shaw 2005, Arabindoo 2005, Rohilla 2005, Cadene 2005, Oliveau 2007, Aguilar 2008).

The fast pace of growth of metropolitan cities and their peri-urban areas and the resulting spatial transformation is one of the most striking features of India's urban scenario. In addition to this the accompanying economic developments in peri-urban areas is creating a strong pull force, not only for the population from adjoining districts but also for far off areas in other poorer states of the country. Providing for daily needs and service requirements of this additional population and ensuring systematic planning becomes a challenge for metropolitan areas.

A metropolitan region has several urban and rural constituents, which by virtue of being in the vicinity of the core city are experiencing demographic growth, spatial expansion and economic development. The core city has been the primary reason for these transformations. However, these transformations are both positive as well as negative for the peri-urban areas. The positive ones being, greater economic opportunities, better connectivity with the core and access to many higher order services located in the core city. The negative ones are, greater exploitation of environmental resources like water and land in peri-urban areas, rapid unplanned development in peri-urban areas, stress on already existing service provision and infrastructure and declining political representation. These negative transformations result in various conflicts and contestations between the core city and the peri-urban areas. This calls for taking a look at the peri-urban areas from a spatial equity. State or the government has an important role to play as far as addressing these negative outcomes of peri-urbanization are concerned, in particular the provision of services such as water and sanitation and bringing about planned development of these areas. Peri-urban areas thus entail a greater role for the state to manage, facilitate and regulate the increasing physical, demographic and economic developments.

2. Methodology

The paper starts with introducing the study area and looking at some of the physical transformations taking place in peri-urban areas of Chennai city. This has been carried out with the help of maps sourced from Bhuvan portal and existing master plans of Chennai Metropolitan Area (CMA). It discusses the institutional set-up in CMA and simultaneously takes up the discussion on differential access to services and resources in the periurban metropolitan area. This has been studied through primary data collected through household surveys for the four selected periurban settlements (micro-case study areas), namely, Thiruvottiyur Municipality (which was later annexed to the Corporation of Chennai in 2012), Anakaputhur Municipality, Thirumazhisai Town Panchayat and Irungattukottai Village (adjacent to Chennai Metropolitan Area boundary). The concept of a peri-urban area is very dynamic and what is rural today might be peri-urban in times to come. Taking cue from this Irungattukottai was selected from beyond the existing limits of Chennai Metropolitan Area. The Census of India, 2011 identifies it as part of the Chennai Urban Agglomeration. Land from this village was acquired for developing the SIPCOT (State Industries Promotion Corporation of Tamilnadu Ltd.) Industrial Park. Finally, the last section deals with strategy building and way forward.

3. Chennai Metropolitan Area and Transformations in its Periurban Areas

The Chennai Metropolitan Area (CMA) comprises of the city of Chennai and contiguous area around it. It has a population of 4.6 million (Census, 2011). It was notified in 1974. It extends over 1189 Sq.km. CMA comprises of Chennai City and areas to an extent of 376.58 Sq.Km. in Kancheepuram District and 639.39 sq.km. in Thiruvallur District. According to 2001 Census, 38.6 percent of the population of Kancheepuram District and 57.5 percent of the population in Thiruvallur District live within CMA. Chennai city which was earlier comprised of only the District of Chennai, after the expansion of city limits in 2012 also includes parts of Thiruvallur and Kancheepuram districts. The outlying area consists of one cantonment, 16 Municipalities, 20 Town Panchayats and 213 Village Panchayats in 10 Panchayat Unions. In December 2011 the limits of Chennai city was increased to annex certain municipalities, town panchayats and villages from the adjoining districts of Thiruvallur and Kancheepuram after which the outlying or peri-urban area of Chennai city consists of 1 cantonment, 11 municipalities, 8 town panchayats, and 181 villages arranged in 10 Panchayat Unions. This is also one form of spatial transformation taking place around metropolitan cities.

Some other types of physical transformations in peri-urban areas include change in built-up and land use. Built-up area has been continuously increasing over the periods from 1973 to 1980 to 1991 and 2006 (refer map 1). Taking the built-up together it accounts for 83.17 percent in 2006 as against 71.62 percent in 1973 for Chennai city. As far as the rest of CMA is concerned, the built up comprised 13.69 percent in 1973, this increased to 29.17 percent in 2006. Thus, there was almost a 50 percent increase in built up space over the 33 year period in peri-urban Chennai. Water bodies on the other hand, have registered a decline during the same period. The built-up growth has followed the transportation spines emanating from Chennai city in 1973. However, from 1991 onwards more and more areas towards the south and west of Chennai city have experienced rapid increase in built-up. Once again this coincides with the post-liberalization period, when the mega cities underwent rapid economic and spatial transformation.

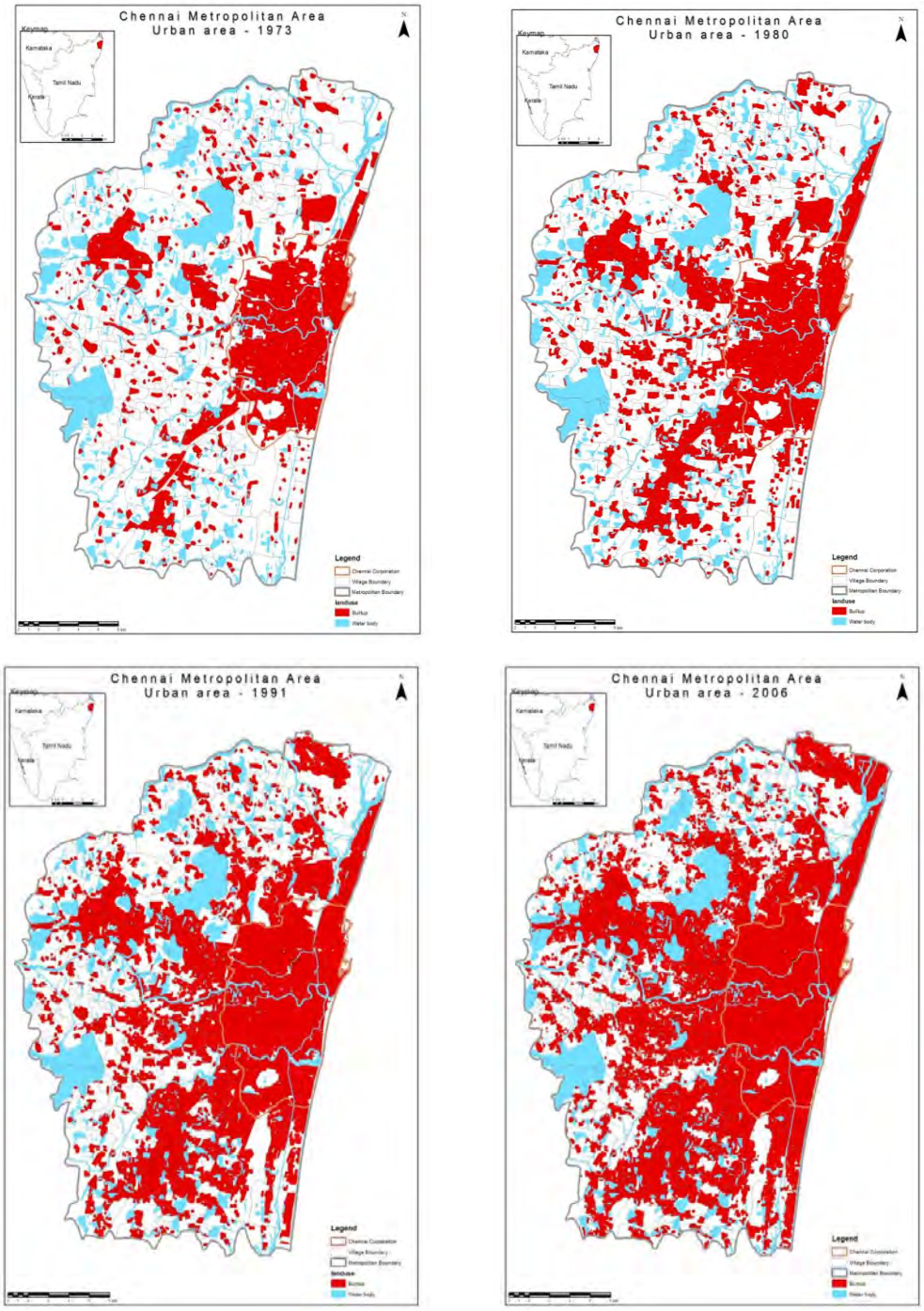


Figure 1. Changes in Built-up Area and Water Bodies for CMA 1973, 1980, 1991, 2006 Source: Bhuvan and author's own analysis

From 1973 to 2006 there has been a drastic fall in land under agriculture from 80,000 hectares in 1973 to just about 12,000 hectares in 2006, whereas the land under industrial use has increased from around 5,000 hectares in 1973 to around 8,000 hectares in 2006 (refer figure 1). The reason for the drastic fall in agriculture is the fact that farmers have discontinued farming due to easy access to other employment opportunities in the core city as well as the peri-urban areas and also that selling water from their agricultural fields earns them more than what they used to get from cultivating their fields (Primary survey, June 2014). Panchayat Unions have experienced the most radical fall in agricultural land and the increase in industrial land is also the highest for them. It can thus be said that the peri-urban areas have become part of 'city dynamics' over this 33 year period and more so in post-1991 scenario.

The institutional landscape in CMA is as per constitutionally prescribed ULB structure with the municipal bodies at the top. Besides the hierarchy of municipal bodies including municipal corporations (Chennai Municipal Corporation (CMC)) and other municipalities, there are corresponding urban and rural local bodies in town panchayats and village panchayats. The rest of the institutions, especially parastatals such as Chennai Metropolitan Development Authority (CMDA), the planning authority in CMA and Chennai Metropolitan Water Supply and Sewerage Board (CMWSSB) appear to be the institutional responses to the metropolitan scale of challenges in CMA. In addition to these, there are other agencies and line departments conventionally entrusted with provision of various services. A metropolitan region thus holds many different territorial and functional entities.

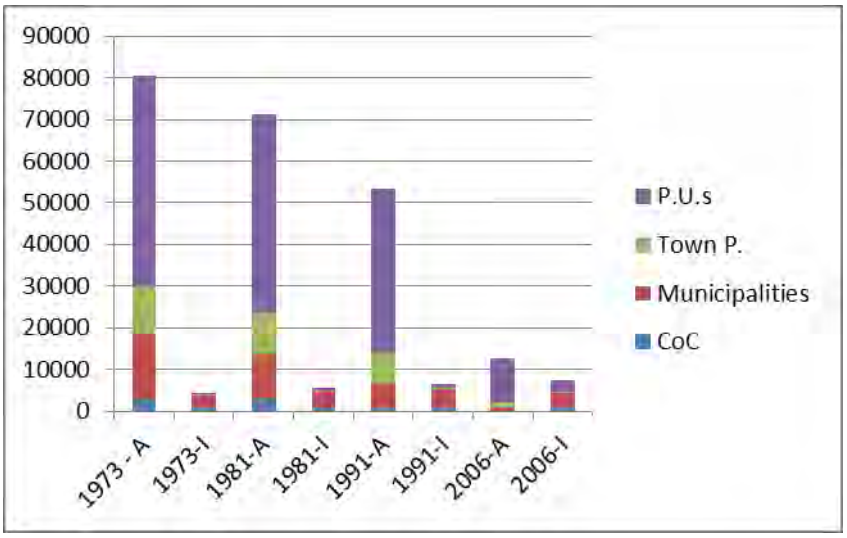


Figure 2. Area under Agricultural (A) and Industrial (I) Land Uses for Panchayat Unions (P.U), Town Panchayat, Municipalities and Chennai Corporation, 1973-2006. Source: Unpublished data from CMDA and own analysis

3.1. Growth of Census Towns

As per Census 2001, Chennai Urban Agglomeration included 56 towns/cities. This number has increased to around 90 in Census 2011. The increase has been mostly by addition of Census Towns (30) and outgrowths (10). These census towns are administratively still rural and thus are not equipped enough to deal with the rapid spatial and economic transformations taking place within them. They don't have the resources or capacity to cater to the increase in population being experienced by them. The maximum number of census towns have come up in the Sriperambudur Taluk to the west of Chennai city, which is becoming the industrial hub of CMA.

3.2. Changes in Land Use and Its Impact on Chennai Metropolitan Area

Chennai Metropolitan Area experienced major transformation in the Land Use for its periurban areas. The land under agriculture reduced from around 75 percent to just about 12 percent, indicating the pressures exerted on land as a resource. This also highlights the conflicts in use of land when it comes to built up versus agriculture uses (refer Figure 3 and 4).

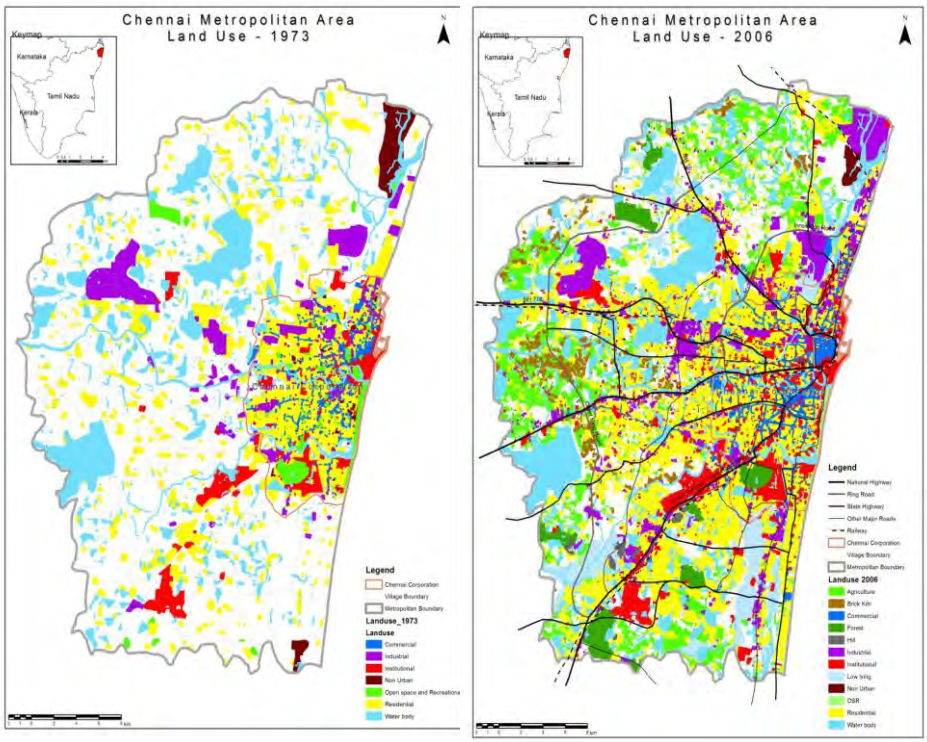
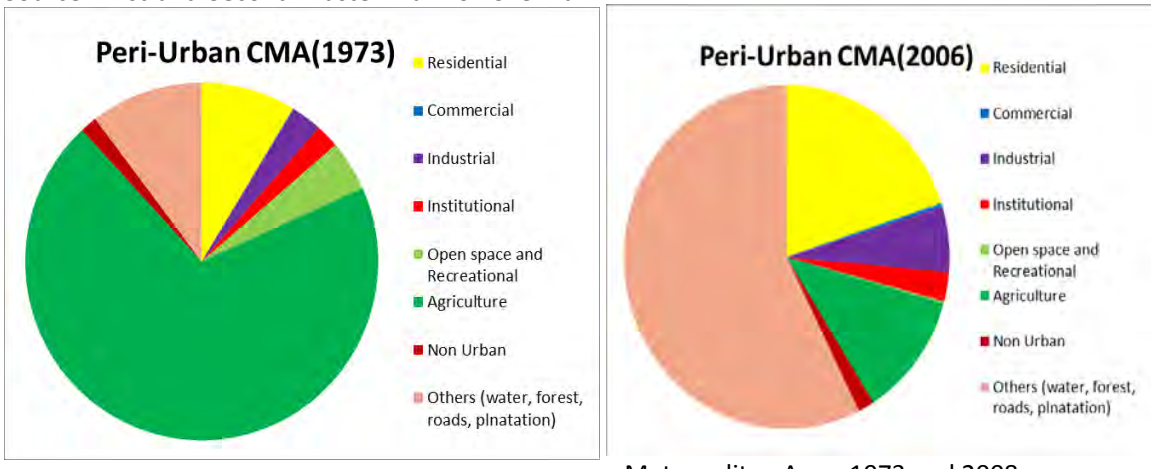


Figure 3. Land Use for Chennai Metropolitan Area, 1973 and 2006
Source: First and Second Master Plan for Chennai



Metropolitan Area, 1973 and 2008

Figure 4. Land Use for Periurban Areas of Chennai Metropolitan Area, 1973 and 2006
Source: First and Second Master Plan for Chennai Metropolitan Area, 1973 and 2008 and Author's own analysis

3.3. Water Resource and Its Spatial Distribution in CMA

Chennai city has always been water scarce area due to lack of any perennial river in its vicinity and a limited period of rainfall due to north-east monsoon. Thus, Chennai corporation (and not the entire CMA) has always depended on multiple sources of water for catering to the city of Chennai which is the sixth most populated city in India (Census of India, 2011). It still depends on at least four large reservoirs (Poondi, Puzhal-Red Hills, Chembarambakkam and Cholavaram), at least three river systems (Kaveri, Krishna and Palar), two desalination plants at Minjur (100 MLD) and Nemelli (100 MLD) (with two more being at various stages of planning and execution) and several hundreds of groundwater aquifers across the city and in its hinterlands (refer Figure 5).

These various sources of water in the periurban areas of CMA and beyond are serving the city of Chennai and its ever growing population and even catering to the demand from industrial establishments in CMA. Only around 6.8 percent of the total water being sourced by these multiple sources is being supplied to the peri-urban settlements in CMA. This is despite the fact that CMWSSB (Chennai Metropolitan Water Supply and Sewerage Board) is supposed to supply water to the entire CMA as per its statute (refer Figure 6). If we look at the water that is being supplied for industrial use, it comes to almost 5.3 percent. Further it has been found that almost 60 percent of the water used in CMA comes from sources other than the public system (Ruet et al., 2002). Thus the conflicts and contestations with respect to accessing water are several in the peri-urban areas of CMA.

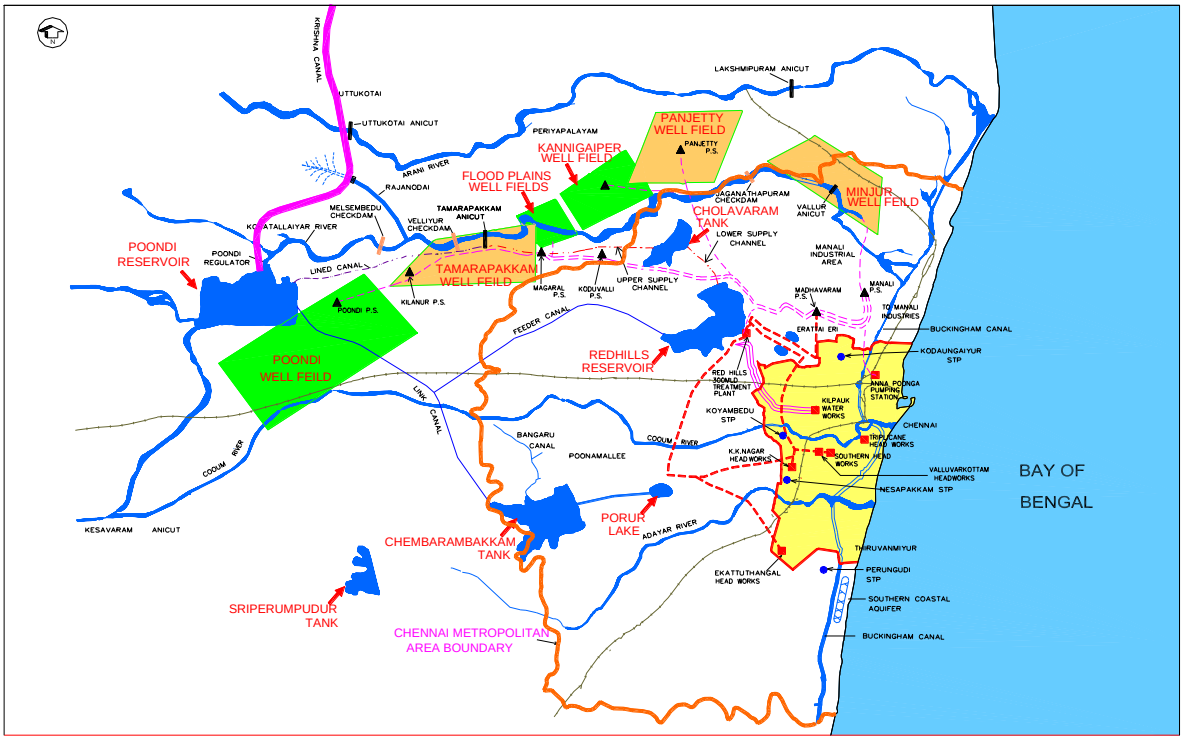


Figure 5. Various Sources of Water in CMA and Outside Its Boundary. Source: Unpublished Map from CMWSSB

Water Sourcing	Quantity (in mld)
Redhills to Kilpauk WTP	150.75
Redhills to Puzhal WTP	100
Redhills to Surapet WTP	8
Chembarambakkam WTP	120
Veeranam	180
Wellfield	15
Porur to KK Nagar	2
South coastal aquifer	4
Desalinated Water from Minjur	80
RO plants	0.25
Total	660

Water supply distribution	Supply (in mld)
City supply through pipeline	565
City supply through tanker lorries	15
Industrial supply	35
Bulk consumers & local bodies	45
Total	660

Figure 6. Sources of Water and Water Supply in CMA, 2016. Source: Unpublished Data from CMWSSB

4. Micro-case Studies in Chennai Metropolitan Area and Delivery of Services

The status of delivery of services in peri-urban areas has been studied through primary data collected for the four selected periurban settlements, namely, Thiruvottiyur Municipality (which was later annexed to the Corporation of Chennai in 2012), Anakaputhur Municipality, Thirumazhisai Town Panchayat and Irungattukottai Village (adjacent to Chennai Metropolitan Area boundary). Around one percent sample was taken from each settlement, but for Irungattukottai thirty households were surveyed as the one percent sample size was too less.

4.1. Water

The situation of availability of water in all the micro-case study areas is very dismal. The supply of tap water is being carried out by the municipal authority in Anakaputhur, by the town panchayat in Thirumazhisai, by municipality earlier and now by CMWSSB in Thiruvottiyur and by TWAD Board (Tamil Nadu Water Supply and Drainage Board) in Irungattukottai (refer table 2). All the households in these areas are dependent upon multiple sources of water such as tap water, bore well, tanker water and packaged water for their day-to-day needs (refer table 1).

Table 1 Sources of Water Being Used in Selected Case Study Areas, 2014

Municipality/ Town Panchayat/village	Sources of Water being used
Anakaputhur	Borewell, piped water supply, tankers (98percent have all)
Thiruvottiyur	Borewell (100percent), Common taps/handpumps (30percent), Piped Water Supply (16percent)
Thirumazhisai	Tanker (59percent), Borewell (40percent), Piped water supply (28percent) [only 16 percent have more than one source]
Irungattukottai	Borewell, Tanker

Source: Primary Survey, June 2014

Anakaputhur has bore wells, well and piped water supply sources. In Thiruvottiyur all households have borewells and common taps provided by the municipality is an important additional source. In Thirumazhisai tanker water supply by local government is an important source of water supply (table 1).

Table 2 Piped Water Supply in Selected Case Study Areas, 2014

Municipality/ Town Panchayat/village	Percentage of houses having piped water supply
Anakaputhur	68 (Municipal water supply)
Thiruvottiyur	30 (now CMWSSB, earlier municipality)
Thirumazhisai	27 (Town Panchayat in coordination with TWAD)
Irungattukottai	TWAD – no piped water supply

Source: Primary Survey, June 2014

The provision of piped water supply is also the highest in Anakaputhur municipality at 68 percent followed by Thiruvottiyur and Thirumazhisai (table 2). Irungattukottai village has no provision for piped water supply. When asked whether water being supplied by government is sufficient for daily needs, more than 69 percent households in all the selected local bodies felt that it was not sufficient or it just met the necessary needs such as cooking and drinking (Table 3). Another issue relating to this that is observed is that all the surveyed households stored water for use. By doing this a lot of wastage of water happens as compared to a situation when water is supplied regularly.

Table 3 Sufficiency of Water Being Provided by Government Sources for Daily Needs, 2014

Municipality/ Town Panchayat/village	Percentage of household saying no or that only necessary demands being met
Anakaputhur	80
Thiruvottiyur	69
Thirumazhisai	70
Irungattukottai	65

Source: Primary Survey, June 2014

It was also seen that there was overarching dependence on packaged drinking water for Anakaputhur (75 percent) and Thiruvottiyur (79 percent) (refer table 4). Whereas, the low income and far off areas of Thirumazhisai and Irugattukottai have relatively less dependence on packaged water for drinking. The issue of brackish underground water was a major problem in Thiruvottiyur as it is located along the coast. The problem in Thiruvottiyur thus gets further complicated because the other areas still have some dependence on open wells and borings.

Table 4 Percentage of Households Using Other Paid Sources of Water Supply, 2014

Municipality/ Town Panchayat/village	Percentage of households purchasing packaged water for drinking
Anakaputhur	75
Thiruvottiyur	79 (brackish water being a major issue)
Thirumazhisai	45
Irungattukottai	22

Source: Primary Survey, June 2014

Chennai Metropolitan Area has a major issue when it comes to frequency and duration of water supply. Anakaputhur and Thiruvottiyur, both have institutional tap water supply only once a week for a duration of 2 hours. These areas have heavy dependence on tanker water supply. The situation for Thiruvottiyur was the same in the pre-annexation scenario as well as per 90 percent population. Thirumazhisai has everyday supply of water by municipal pipelines for one or two hours. Irungattukottai also has everyday supply of water in community taps located in the village (refer table 5).

Table 5 Frequency and Duration of Piped Water Supply, 2014

Municipality/ Town Panchayat/village	Frequency and duration of piped water supply
Anakaputhur	Once a week and two hours a day
Thiruvottiyur	Once a week and two hours a day
Thirumazhisai	Everyday
Irungattukottai	Every day through community taps

Source: Primary Survey, 2014

Quality of water being supplied by government sources is better in the nearby municipalities as compared to the far off ones. In Anakaputhur and Thiruvottiyur more than 82 percent households found the quality to be good (refer table 6).

Table 6 Quality of Water Being Supplied By Government Sources, 2014

Municipality/ Town Panchayat/village	Percentage of households saying it is good or average
Anakaputhur	82
Thiruvottiyur	83
Thirumazhisai	60
Irungattukottai	58

Source: Primary Survey, 2014

The dependence on packaged drinking water is high for Anakaputhur (78 percent) and Thiruvottiyur (79 percent) which are closer to CMC and have higher household incomes as compared to the other two local bodies (refer table 7)

Table 7 Dependence on Packaged Drinking Water, 2014

Municipality/ Town Panchayat/village	Percentage of households with dependence on packaged drinking water
Anakaputhur	78
Thiruvottiyur	79
Thirumazhisai	45
Irungattukottai	12

Source: Primary Survey, 2014

Almost 25 to 50 percent of the total household income is spent on accessing water from sources other than government (refer table 8). Fifty percent households in Anakaputhur and 61 percent in Thiruvottiyur spent 25 to 50 percent of their total household expenditure on these other sources of water. There is lesser expenditure on these other sources in Thirumazhisai and Irungattukottai.

Table 8 Percentage of Total Household Expenditure on Other Sources of Water, 2014

Municipality/ Town Panchayat/village	Percentage of total household expenditure on other sources of water
Anakaputhur	50 percent households with 25 to 50 percent expenditure
Thiruvottiyur	61 percent households with 25 to 50 percent expenditure
Thirumazhisai	26 percent households with 25 to 50 percent expenditure
Irungattukottai	12 percent households with 25 to 50 percent expenditure

Source: Primary Survey, 2014

Grievance redressal mechanism exists in all the selected urban and rural local bodies. However, less than 32 percent of households in these areas found it to be useful in all the case study areas (refer table 9).

Table 9 Usefulness of a grievance redressal mechanism for water supply, 2014

Municipality/ Town Panchayat/village	Percentage of households saying it is useful
Anakaputhur	30
Thiruvottiyur	31
Thirumazhisai	31.8
Irungattukottai	15

Source: Primary Survey, June 2014

As already seen in chapter 3 and 4 there is a multiplicity of state institutions supplying water in Chennai Metropolitan Area. Nevertheless, it is found that more than 81 percent of households in all the selected local bodies wanted that any government institution should only be made responsible for supplying water to them (refer table 10 below).

Table 10 Percentage of Households Wanting Government Agency to Supply Water to them, 2014

Municipality/ Town Panchayat/village	Percentage
Anakaputhur	95
Thiruvottiyur	91
Thirumazhisai	81
Irungattukottai	91

Source: Primary Survey, June 2014

Various reasons have been cited by the respondents in the four micro-case study areas for choosing the government agencies over private ones. The main reasons that are given are regularity of water supply, greater access to water, better quality of water and reduced expenditure on water being consumed (refer table 11).

Table 11 Reasons for Supporting Government Supply, 2014

Municipality/ Town Panchayat	Major Reasons

Anakaputhur	Regularity/greater access to water, good quality
Thiruvottiyur	Regularity/greater access to water, less expenditure on water
Thirumazhisai	Reduced bill
Irungattukottai	greater access to water, good quality

Source: Primary Survey, June 2014

Regarding the preference of people with respect to the state agencies supplying water in Chennai Metropolitan Area, namely, CMWSSB, TWAD or local body, it came out that the town panchayat of Thirumazhisai and Irungattukottai village have much greater support for CMWSSB. More than 90 percent of households surveyed in these areas support CMWSSB (refer table 12). Anakaputhur and Thiruvottiyur, on the other hand, did not have any specific preference between the municipal body supplying water or the CMWSSB (refer table below). After annexation of Thiruvottiyur in corporation of Chennai, new pipeline for water supply is being laid for the entire area as a project under Detailed Development Plan.

Table 12 Percent of Households with Preference for CMWSSB, 2014

Municipality/ Town Panchayat	Percentage of households supporting CMWSSB
Anakaputhur	40
Thiruvottiyur	30
Thirumazhisai	90
Irungattukottai	93

Source: Primary Survey, June 2014

4.2. Sanitation

Anakaputhur had all the households with toilet facility. Thiruvottiyur had 99 percent households with toilet facility (refer table 13). 29 percent of these have sewerage line connection as well which have been laid after CMWSSB took over. The other local bodies just have septic tanks for the toilets. However, Thirumazhisai has only 84 percent households with toilets. The main problem is in Irungattukottai where only 15 percent households have toilet facility in their premises. When the multinational company of Hyundai acquired land in this area they provided the households with community toilets. Yet, these toilets do not have tap water connections which makes it more of a token initiative on part of the company.

Table 13 Percent of Households Having Toilet Facility within Their Premises, 2014

Municipality/ Town Panchayat/village	Households having toilet facility (in Percent)
Anakaputhur	100
Thiruvottiyur	99
Thirumazhisai	84
Irungattukottai	15 (rest have community toilets)

Source: Primary Survey, June 2014

Gound water and wells are the main sources of water supply in the toilets for Anakaputhur and Thiruvottiyur (refer table 14). This is so because the frequency of tap water supply is very dismal in these areas. For Thirumazhisai, tap water supply also features as one of the sources because as given in table 5, frequency of tap water supply is every day for the 28 percent households that have access to tap water.

Table 14 Source of water for Toilets, 2014

Municipality/ Town Panchayat/village	Source of water for households having toilet facility
Anakaputhur	Ground water and wells (100 percent)
Thiruvottiyur	Ground water and wells (88 percent), tankers (12 percent)
Thirumazhisai	Ground water and wells (60 percent), tankers (27 percent), tap (17 percent)
Irungattukottai	Community taps (100 percent)

Source: Primary Survey, 2014

Almost 99 percent of surveyed households in Anakaputhur, Thiruvottiyur and Thirumazhisai have toilets in their houses. Thiruvottiyur is the only local body, though now it is a ward in corporation of Chennai after annexation, which has 31percent households with sewage outlet. The Detailed Development Plan for provision of sewerage network has already been worked out for Thiruvottiyur and some areas have already been connected to the sewer line.

4.3. Planning and Role of State in Service Provision

Chennai Metropolitan Development Authority is responsible for preparing plans for the metropolitan region. The town planning departments in the local bodies have no role to play in the plan being prepared by CMDA. Neither do they have the finance nor the capacity. More than 81 percent households in the selected case study areas have no ideas about any spatial plan being prepared for their area (refer table15 below).

Table 15 Awareness of Households about Spatial Plan Being Prepared, 2014

Municipality/ Town Panchayat	Percentage of households not aware
Anakaputhur	90
Thiruvottiyur	81
Thirumazhisai	98
Irungattukottai	99

Source: Primary Survey, June 2014

In Thiruvottiyur and Anakaputhur, which are adjacent to old Chennai city limits, more than 90 percent households want to be part of any such spatial planning process being undertaken for their area. However, in Thirumazhisai town panchayat only around 38 percent households want to be part of such plan making process. The reason cited is that they feel that there is no use of being part of any such spatial plan making process (refer table 16 below).

Table 16 Percentage of Households Saying They Would Want To Be Part of Such Plan Making Process, 2014

Municipality/ Town Panchayat	Percentage
Anakaputhur	100
Thiruvottiyur	90
Thirumazhisai	38
Irungattukottai	35

Source: Primary Survey, June 2014

In all the micro-case study areas almost 84 percent or more population have seen/met their councillors/sarpanch (refer table 17 below).

Table 17 Percentage of households that had seen/met their councillor/ sarpanch, 2014

Municipality/ Town Panchayat	Percentage of households saying yes
Anakaputhur	97
Thiruvottiyur	92
Thirumazhisai	84
Irungattukottai	100

Source: Primary Survey, June 2014

When asked about the frequency of the visits of the councillor the percentage of households from14 percent to 33 percent in the case study areas say that the councillors come only once in five years (refer table 18 below). In case of Thiruvottiyur 50 percent of households also said that the councillors visited more often in the pre-annexation scenario. This brings out the fact that representation was better in the period when they were not annexed. This becomes more important in the scenario where the percentage of households which say that they want to be part of the spatial plan making process is also high.

Table 18 Frequency of Visit by Councillor, 2014

Municipality/ Town Panchayat	Percentage of households saying the councillor comes only once in five years
Anakaputhur	24
Thiruvottiyur	33 (in pre-annexation scenario 50percent say the councillors visited more often)
Thirumazhisai	14
Irungattukottai	-

Source: Primary Survey, June 2014

When asked whether the household's suggestions get incorporated by the councillors/ sarpanch it comes out that only Thiruvottiyur is performing well with 89 percent households saying yes (refer table 19). In

case of Irungattukottai village it is the lowest and people in the village say that the previous Sarpanch's wife is the current sarpanch and it is actually her husband who manages all the affairs.

Table 19 Percentage of Households which Say That Their Suggestions Get Incorporated by the Councillors, 2014

Municipality/ Town Panchayat	Percentage of households saying yes
Anakaputhur	54
Thiruvottiyur	89
Thirumazhisai	49
Irungattukottai	39

Source: Primary Survey, June 2014

The respondents were also asked about the improvements that are required in their town or village or ward. The issues which came out very predominantly in all the case studies is that water, sewerage and road need to be improved upon. Water is the most pressing demand followed by sewerage and roads (refer table 20).

Table 20 Improvements Required in Your Ward/Town

Municipality/ Town Panchayat	Issues
Anakaputhur	Water, sewerage, road
Thiruvottiyur	Water, sewerage, road
Thirumazhisai	Water, sewerage, road
Irungattukottai	Water, sanitation

Source: Primary Survey, June 2014

Water, pollution and overcrowding, due to migration, have emerged as the most important issues in these areas. These are issues which result in conflicts amongst the various local bodies and also are the transformations that are going on in the peri-urban areas. It is in this context that role of the state assumes great importance. Distance from the core city is also a consideration when one looks at the access to services. The heavy dependence on private and informal sources of water also got established from the primary survey. However, if we consider the case of Thirumazhisai town panchayat the picture looks different. The town panchayat has been efficiently supplying water to its residents and has a system of tankers as well as piped water supply which cater to the area. This proves the point that equity aspect can be addressed in a fragmented governance system. However, most of the respondents also wanted to be a part of the corporation of Chennai and be served by a parastatal agency like CMWSSB. Annexation of Thiruvottiyur was also taken very positively by its residents. Thus, a combination of state agencies which consider the equity aspect as well as the economy, efficiency and cooperation aspect needs to be designed for a metropolitan region. The upcoming sections try to come up with a model of governance which takes into account all these drawbacks and issues in a metropolitan peri-urban area.

5. Strategy for Metropolitan Governance and Planning and Way Forward

Transformations are taking place in peri-urban areas. These areas are not economically and institutionally well placed to deal with these transformations. It is thus required that some sort of arrangement is developed so that these peri-urban areas can address the challenges that they face due to the rapid transformations being experienced by virtue of their location near a metropolitan city.

To start with, it is required that the metropolitan areas have some autonomy from the state control so that their development can be guided by forces of economy and decision by the citizens of the peri-urban areas. For better coordination amongst the local bodies, given the fact that the metropolitan areas are large entities and have multiple jurisdictions, some metropolitan level governing authority can be brought in place. However, the local bodies in the peri-urban areas should have enough say in the matters concerning their fate as far as service delivery, environment, use of land and economic development is concerned. Complete functional fragmentation might thus not work well with jurisdictional fragmentation and some level of coordination is desirable for metropolitan regions.

However, this does not mean that one has to go back on the issue of functional decentralization as enshrined in the 73rd and the 74th Constitutional Amendment Acts. The local bodies should have functional as well as financial autonomy. However, there is a lot of disparity when it comes to financial status of these local bodies because of which the level and quality of service provision varies from settlement to settlement. The metropolitan level body, in this case the CMWSSB, should be made responsible for easing out these inequalities by way of facilitating equitable levels of service delivery in the peri-urban areas. Thus, the sourcing, treatment, laying of network and distribution at local body level should be given to CMWSSB (refer figure 7). TWAD should be limited to areas outside CMA. The local bodies need to be made responsible for local distribution of water within the local body jurisdiction and also try to reduce the dependence of households on other informal sources, such as ground water and tankers. Continuous monitoring by the citizens through e-participation should also be encouraged by the local body and CMWSSB (refer figure 7).

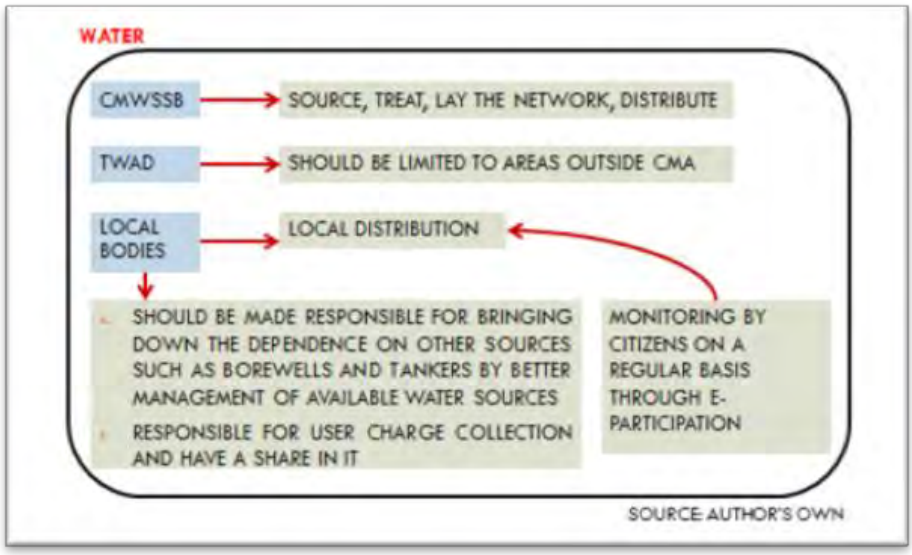


Figure 7 Model for Provision of Water and Sanitation in Metropolitan Areas – CMA. Source: Author

As far as planning is concerned, MPC should be set-up in these areas with enough power to enforce plan making in the various constituent local bodies of the peri-urban areas as well as the core city (refer figure 8). This again requires political will and autonomy of the MPC. The metropolitan planning authorities in

metropolitan cities can exist and function as a support to the MPC as far as overseeing, compiling and implementation of plans is concerned. If a metropolitan level planning body, like the CMDA has to remain true to its central tasks, it cannot be overwhelmed by this "default planner" responsibility. Hence, the capacity and responsibility for spatial planning should be developed at the local body level in the metropolitan. The metropolitan development authority, in this case the CMDA, can also provide financial support and capacity building at the local body level. The responsibility for plan making will lie with the local bodies and they will in turn make use of e-community as a platform to get inputs from the citizens on efficient planning (refer figure 8).

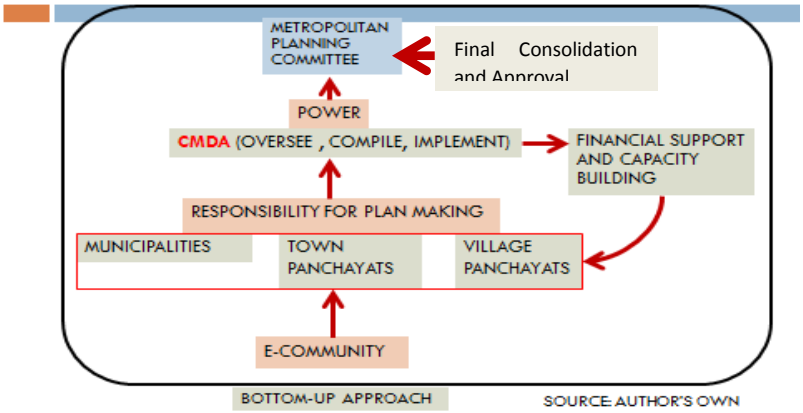


Figure 8 Model for Planning in Metropolitan Areas – CMA. Source: Author

References

Arabindoo, P. (2005), "Examining the peri-urban interface as a Constructed Primordialism" in Peri-Urban Dynamics: Population, Habitat and Environment on the Peripheries of Large Indian Metropolises – A review of concepts and general issues. CHS Occasional Paper No.14, New Delhi, Centre de Sciences

Cadene, P. (2005), "Dynamics of peri-urban areas: from the French case to the developing countries", in Peri-Urban Dynamics: Population, Habitat and Environment on the Peripheries of Large Indian Metropolises – A review of concepts and general issues. CHS Occasional Paper No.14, New Delhi, Centre de Sciences Humaines

Dupont, V. ed., (2005): Peri-Urban Dynamics: Population, Habitat and Environment on the Peripheries of Large Indian Metropolises – A review of concepts and general issues. CHS Occasional Paper No.14, New Delhi, Centre de Sciences Humaines

Kundu, A, B K Pradhan and A Subramaniam (2002): 'Dichotomy or Continuum: Analysis of Impact of Urban Centres on Their Periphery', Economic and Political Weekly, December 14, pp 5039-46.

Marshall, F. et al., (2009), STEPS Working Paper 35, Brighton: STEPS Centre

Mc Gee T.G. (1991), "The Emergence of Desakota Regions in Asia. Expanding a Hypothesis" In: Ginsburg NJ, Koppel B, Mc Gee TG (eds) The Extended Metropolis. Settlement Transition in Asia. University of Hawaii Press, Honolulu: 3-26.

Moench, M. and Gyawali, D. (2008), "Desakota: Reinterpreting the Urban-Rural Continuum" Accessed on 24 January 2012 at:https://www.espa.ac.uk/files/espa/Final%20Report%20Desakota%20Part%20II%20A%20Reinterpreting%20Urban%20Rural%20continuum_0.pdf

Narain, V. (2010), 'Periurban water security in a context of urbanization and climate change: A review of concepts and relationships', Peri Urban Water Security Discussion Paper Series, Paper No. 1, SaciWATERS.

Oliveau, Sebastian (2005): Peri-urbanization in Tamil Nadu: A Quantitative Approach. CHS Occasional Paper No.15, New Delhi, Centre de Sciences Humaines

Rohilla, S. (2005), "Defining 'Peri-urban' – A review", in Peri-urban dynamics: population, habitat and environment on the peripheries of large Indian metropolises- A review of concepts and general issues. CHS Occasional Paper No.14, New Delhi, Centre de Sciences Humaines.

Ruet. J.. Saravanan. V, S. & Zérah. M-H. (2002). The Waterand Sanitation Scenario in Indian Metropolitan Cities. Centre de Sciences Humaines, New Delhi, Occasional Paper.

Shaw, A. (2005), "Peri-Urban Interface of Indian Cities Growth, Governance and Local Initiatives", Economic and Political Weekly, pp. August 2008, 129-136

Webster, D. (2002), "On the Edge: Shaping the Future of Peri-urban East Asia", The Asia Pacific Research Center.

Research Paper

Structuring the Complexity of Positive Energy District with cognitive maps

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Abstract

The concept of a Positive Energy District (PED) has emerged as a promising solution to mitigate the environmental impact of urbanization. PEDs aim to generate more energy than they consume by integrating renewable energy sources, energy-efficient buildings, and sustainable transportation systems. However, designing and implementing a PED is a complex and multi-dimensional task that involves various stakeholders and requires a holistic approach. This paper proposes the use of cognitive maps and stakeholders' analysis to structure the complexity of PEDs. Cognitive maps are a visual representation of the cause-and-effect relationships among the elements of a system. In the context of PEDs, cognitive maps can help to identify the key factors that influence the energy balance of the district. The construction of cognitive maps involves the participation of stakeholders, who provide their expertise and knowledge about the system. By integrating the different perspectives of stakeholders, cognitive maps can offer a comprehensive view of the PED. The use of cognitive maps in PED design can help create more effective positive energy districts. Cognitive maps can help identify available energy sources, energy consumers, and potential renewable energy producers, as well as identify areas of the city with greater opportunities for the installation of renewable energy generation facilities. In addition, cognitive maps can facilitate communication among the various stakeholders involved in the creation of PEDs, thereby improving collaboration and the effectiveness of the project.

Keywords

Cognitive maps; Positive Energy District (PED); Stakeholders Analysis; Decision Support System(DSS), Fuzzy cognitive maps.

1. Introduction

The European Union has placed the reduction of CO2 emissions on cities and their related systems. Cities account for over 50% of the world's population, 80 % of global GDP, two-thirds of global energy consumption, and over 70% of global annual carbon emissions. These factors are expected to increase significantly in the coming decades: it is predicted that by 2050 more than 70% of the world's population will live in cities, resulting in a massive growth in demand for urban energy infrastructure. Climate action in cities is essential to achieve ambitious net-zero emission targets. In this respect, it is well known that in the coming years, urban development will have to shift from simple building solutions to positive energy districts and neighborhoods (Becchio *et al.*, 2020). With the new Horizon Europe research and innovation plan [2], Europe aims to strongly address several global challenges affecting our cities and society: health and safety, digitization, energy, and climate change in the first place (Guarino *et al.*, 2022). PEDs fall into this category. In recent years, to support the urban energy transition, the concept has become even more ambitious, moving from high-efficiency to zero-emission buildings. Subsequently, by including energy sharing, waste heat recovery, electric mobility, and energy storage, the goal of a broad implementation of

zero-emission neighborhoods has been achieved, or even better PEDs are envisaged (Guarino *et al.*, 2022). In this regard, we introduce the concept of complexity, applied to PEDs and their development at the urban level, by analyzing the stakeholders involved and identifying the structure of the process and how it is articulated in order through cognitive maps.

2. Context of the research

2.1. Features of PED

Research all around the world is still struggling to find a unique definition for PEDs. From an energy-focused perspective, a PED is seen as an energy self-sufficient and carbon-neutral urban district. Indeed, positive energy means that energy districts also play an important role in producing excess energy using renewable energy sources and feeding it back into the grid (Bossi, Gollner, and Theierling, 2020). However, widening the perspective, it is expected that PEDs will increase the quality of life in European cities, help achieve the COP21 goals, and improve European capabilities and knowledge to become a global model (Derkenbaeva *et al.*, 2022). Moreover, considering the keen interest of the European Commission to deliver at least 100 PEDs by 2050 and the current situation of European cities (IEA, 2020), it is necessary to address this concept not only for new areas of urban development and the construction of new buildings and neighborhoods but especially for the redevelopment of the existing building stock (Derkenbaeva *et al.*, 2022). The discussion on how and where to define the boundaries of these entities is still open and conclusions may differ depending on whether one considers physical limits and management aspects or those related to the overall energy balance and energy carriers, ranging therefore from local to regional scale (Bossi, Gollner and Theierling, 2020; Niu and Zhang, 2023). The discussion also often starts from the local dimension of city blocks, up to the urban dimension. In this regard, some interesting research on existing tools to support decision-making toward climate neutrality in cities and districts has been already carried out (Suppa, Cavana, and Binda, 2022). In an attempt for extreme simplification, it can be said that PEDs must strike an optimal balance between energy efficiency, energy flexibility, and local energy production (European Commission, 2022) in turn also achieving integrated sustainability based on environmental, economic, and social features.

2.2. Stakeholders involved.

For a Positive Energy District (PED) several stakeholders such as cities and public bodies, industry and business, research and academia, citizens and civic society, private and professional stakeholders, and citizens play a central role in the energy transition. Satisfying outcomes of Positive Energy Buildings/Districts requires the involvement of a wide range of different stakeholders right from the beginning. Therefore, increasing the knowledge of PEB, public communication, dissemination and public engagement among the public is vital.

2.3. Concept of complexity

The term “complexity” used by academics is a narrower concept than is employed by practitioners; in fact, certain context-related aspects that practitioners point to as being complex are identified by academics as complicated (Baccarini, 1996). This is because theoretical complexity focuses on emergence, uncertainty, nonlinearity, and interdependence among the elements present in a project. Purposes of this case study, we do not distinguish between the terms “complex” and “complicated” – following the common usage employed by several authors (Volpe, 2015). Complexity will impact project goals and objectives, project planning and organization as well as staff recruitment requirements. (González-Varona *et al.*, 2023)indicate that complexity in the project context has become the focus of attention for several reasons: (a) it impacts the way the project is planned, executed, and controlled; (b) it can hinder the identification of goals and objectives; (c) it also influences how the project is organized as well as the skills required by workers; (d) it

can impact project objectives (scope, time, cost, risks, etc.). According to (Baccarini, 1996), one definition of project complexity is that it consists "of many varied interrelated parts". He advocated implementing it in terms of the differentiation and interdependency of varied elements (González-Varona *et al.*, 2023). In their paper (Baccarini, 1996), identified two dimensions of project complexity: structural complexity and uncertainty. In addition, structural complexity has two sub-dimensions: the number and interdependence of project elements, such as tasks, specialists, and components. He also proposed two sub-dimensions of the uncertainty dimension: uncertainty in goals and means(Baccarini, 1996). Structural complexity is the easiest for practitioners and researchers to identify and increases with size, variety, breadth of scope, level of interdependence between people or tasks, pace, or variety of work to be done. Interdependence between people or tasks, pace, or variety of work to be done, number of locations and time slots, work to be done, the number of locations and time zones. The existence of strict deadlines, e.g., closing of a construction site, or opening of an infrastructure, is a source of complexity because it leads to an increase in the pace of work and stress of the people involved (Geraldi and Söderlund, 2018).

3. Methodology

Cognitive maps are a visual representation of the cause-and-effect relationships among the elements of a system(Kok, 2009). Cognitive maps have been used widely in political science, urban management, organizational analysis, and decision-making(Kosko, 1986). In political science and urban management, the cognitive map approach has been to discover the belief systems of political leaders and policymakers. In organizational analysis and decision-making, cognitive maps have been used mainly to analyze the organizational decision-making process(Papageorgiou *et al.*, 2017).

3.1 Cognitive Maps

Cognitive maps usually consist of variables and causal relations among them. In the cognitive map arrows interconnect variables. The direction of arrows means the direction of causal influence. The signs attached to the head of arrows indicate the polarity of the causal relations. If two variables are connected by an arrow causes an increase/decrease in the variable at the head of the arrow. With the variables and causal relations embedded in the cognitive map, one can see the emergent perceptual structure. The perceptual structure can then be analyzed to identify the perceptual bases of policy or urban measures adopted by policy-urban actors. Policymakers or urban managers define policy problems and chalk out measures based on their perception of the real world. In this respect, cognitive maps are directly related to the cognitive aspect of policymaking.

3.2 Cognitive Maps as a tool for structuring the complexity of a PED.

In the context of PEDs, cognitive maps can help to identify the key factors that influence the energy balance of the district. The construction of cognitive maps involves the participation of stakeholders, who provide their expertise and knowledge about the system. By integrating the different perspectives of stakeholders, cognitive maps can offer a comprehensive view of the PED.

4. Results and discussion

4.1 Stakeholders' Analysis

The relevance of different stakeholders involved in the project gives a clear idea of is very complex the question. As we can see in (Figure 1) the players are divided into the public and private spheres, which have power and influence that varies depending on what stage of the project you are in. Below based on the typical construction site phases I propose an analysis of the different stakeholders involved in the different project phases: Urban planning phase, Integrated build design process, Construction phase and its

management, Operation phase, and Building operation process. For our context, the Urban planning phase is more interesting and more important because, by the literature review, we had understand that is the more complex part of the process(De Sousa *et al.*, no date; Mosannenzadeh *et al.*, 2017; Bottero *et al.*, 2021; Dell'Anna *et al.*, 2023).

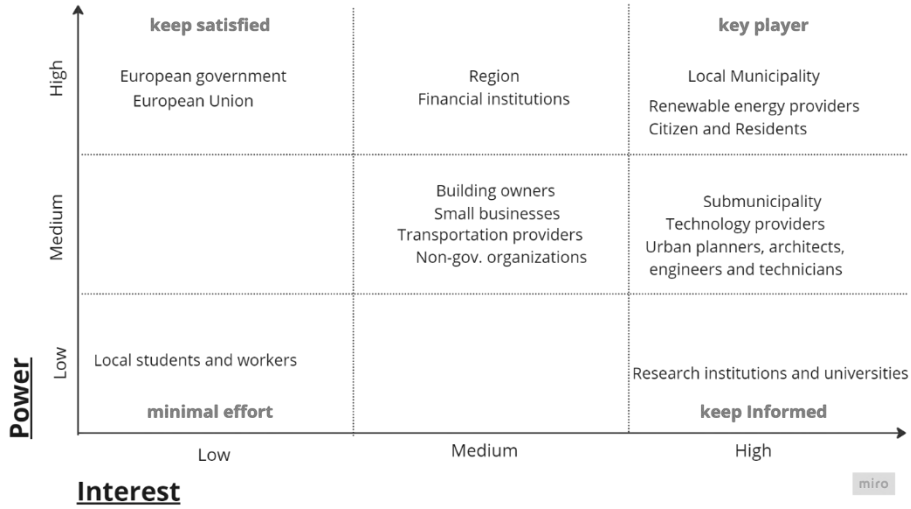

Figure 1: Stakeholders analysis in the power and interest grid used to identify key stakeholders, and their influence in terms of power and interest. Source: drawn by the authors.

The urban planning phase is composed of citizens, citizen groups, NGOs, authorities, municipalities, tenants, owners, Economic Chambers, Labour Chambers, construction companies, politicians, utilities urban planning departments, architects and energy planners, engineers and designers of energy companies, developers, consultants, land owners, water companies, environmental protection agencies as well as building owners and users.

4.2. Cognitive map of a PED: structuring the complexity

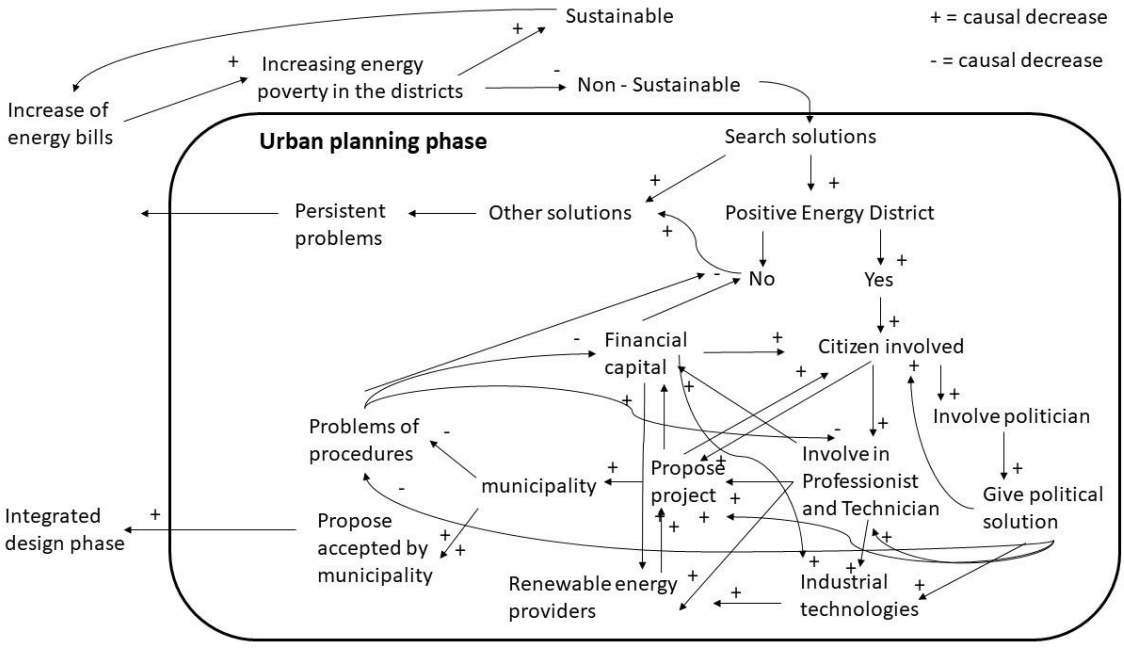

Figure 2: Cognitive map of a Positive Energy District in the Urban planning phase

As can be seen in figure 2, analyzing the main actions that occur in the spatial and urban planning phase involving stakeholders, one can realize how easy it is to see the relationships and their negative or positive causality with cognitive maps. We would have had to write pages and pages just to explain how complex the relationship between citizens, administrations, and professionals involved is, whereas with cognitive maps it is possible to clearly represent how much impact the hierarchy of actions that occur in a multistakeholder decision-making process has. With this scheme, it becomes apparent that the financial aspect, especially in a multi-stakeholder context, is the predominant one and has the capacity to block the development of PED.

5. Conclusion

About the cognitive maps, we can say that is one the best solutions useful for analyzing the complexity from a multistakeholder perspective. Local circumstances and practices also vary, depending on whether the related operations (e.g. energy, water) are private companies or municipally owned ones. In addition, land ownership has a great impact. Another factor influencing stakeholder composition is whether the project is a new construction or the refurbishment of an old building. The involvement of appropriate moderators or mediators to bring about consensus solutions. Also, international collaboration with other cities through city networks or cooperation initiatives would add benefits. A collaborative governance model is imperative to connect different stakeholders and align their interests and priorities. In such a model, an establishment of shared values and a common vision among stakeholders could be achieved, aiming at finding the synergies and unlocking the co-benefits of multiple stakeholders. For the success of PEDs, it is of great importance to ensure the commitment of the people through an open process and broad stakeholder engagement when developing a cities or region's strategy. Further officials should raise the awareness of all stakeholders and educate them on all energy efficiency. Municipalities can support building designers from the beginning through other means than mandating or encouraging PEDs in urban plans: providing practical guidance, initiating discussions, organizing energy nights, bringing stakeholders together, offering one-stop-shop models for project owners and construction firms to launch awareness-raising campaigns, and disseminate knowledge.

For the development of PED, at the national level, it is important to define the general framework and minimum standards. As the general framework is set there, the government must be active in this. In addition to legislating, the national and regional governments have the main financial resources to support the massive deployment of PEBs. Therefore, national-level financing and incentivization schemes play a vital role in encouraging energy-efficient (even positive energy) buildings and districts.

6. References

Baccarini, D. (1996) 'The concept of project complexity—a review', *International Journal of Project Management*, 14(4), pp. 201–204. Available at: https://doi.org/10.1016/0263-7863(95)00093-3.

Becchio, C. *et al.* (2020) 'Integrated Assessments and Energy Retrofit: The Contribution of the Energy Center Lab of the Politecnico di Torino', in G. Mondini et al. (eds) *Values and Functions for Future Cities*. Cham: Springer International Publishing, pp. 365–384. Available at: https://doi.org/10.1007/978-3-030-23786-8_21.

Bossi, S., Gollner, C. and Theierling, S. (2020) 'Towards 100 positive energy districts in europe: Preliminary data analysis of 61 European cases', *Energies*, 13(22). Available at: https://doi.org/10.3390/en13226083.

Bottero, M. *et al.* (2021) 'Decision making in urban development: The application of a hybrid evaluation method for a critical area in the city of Turin (Italy)', *Sustainable Cities and Society*, 72, p. 103028. Available at: https://doi.org/10.1016/J.SCS.2021.103028.

Dell'Anna, F. *et al.* (2023) 'Supporting sustainability projects at neighbourhood scale: Green visions for the San Salvario district in Turin guided by a combined assessment framework', *Journal of Cleaner Production*, 384, p. 135460. Available at: https://doi.org/10.1016/J.JCLEPRO.2022.135460.

Derkenbaeva, E. *et al.* (2022) 'Positive energy districts: Mainstreaming energy transition in urban areas', *Renewable and Sustainable Energy Reviews*, 153, p. 111782. Available at: https://doi.org/https://doi.org/10.1016/j.rser.2021.111782.

European Commission (no date) *SDGs*. Available at: https://www.spglobal.com/esg/about/index (Accessed: 21 April 2023).

Geraldi, J. and Söderlund, J. (2018) 'Project studies: What it is, where it is going', *International Journal of Project Management*, 36(1), pp. 55–70. Available at: https://doi.org/10.1016/J.IJPROMAN.2017.06.004.

González-Varona, J.M. *et al.* (2023) 'How public funding affects complexity in R&D projects. An analysis of team project perceptions', *Journal of Business Research*, 158, p. 113672. Available at: https://doi.org/10.1016/J.JBUSRES.2023.113672.

Guarino, F. *et al.* (2022) 'State of the Art on Sustainability Assessment of Positive Energy Districts: Methodologies, Indicators and Future Perspectives', in J.R. Littlewood, R.J. Howlett, and L.C. Jain (eds) *Sustainability in Energy and Buildings 2021*. Singapore: Springer Nature Singapore, pp. 479–492.

IEA (2020) *CO2 emissions in MT by sector, World 1990-2018. , https://www.iea.org/data-and-statistics.*

Kok, K. (2009) 'The potential of Fuzzy Cognitive Maps for semi-quantitative scenario development, with an example from Brazil', *Global Environmental Change*, 19(1), pp. 122–133. Available at: https://doi.org/10.1016/J.GLOENVCHA.2008.08.003.

Kosko, B. (1986) 'Fuzzy cognitive maps', *International Journal of Man-Machine Studies*, 24(1), pp. 65–75. Available at: https://doi.org/10.1016/S0020-7373(86)80040-2.

Mosannenzadeh, F. *et al.* (2017) 'A case-based learning methodology to predict barriers to implementation of smart and sustainable urban energy projects', *Cities*, 60, pp. 28–36. Available at: https://doi.org/10.1016/J.CITIES.2016.07.007.

Niu, C. and Zhang, W. (2023) 'Causal effects of mobility intervention policies on intracity flows during the COVID-19 pandemic: The moderating role of zonal locations in the transportation networks', *Computers, Environment and Urban Systems*, p. 101957. Available at: https://doi.org/10.1016/j.compenvurbsys.2023.101957.

Papageorgiou, E.I. *et al.* (2017) 'A concept reduction approach for fuzzy cognitive map models in decision making and management', *Neurocomputing*, 232, pp. 16–33. Available at: https://doi.org/10.1016/J.NEUCOM.2016.11.060.

De Sousa, L. *et al.* (no date) *iGUESS-A web based system integrating Urban Energy Planning and Assessment Modelling for multi-scale spatial decision making*. Available at: http://www.iemss.org/society/index.php/iemss-2012-proceedings.

Suppa, A.R., Cavana, G. and Binda, T. (2022) 'Supporting the EU Mission "100 Climate-Neutral Cities by 2030": A Review of Tools to Support Decision-Making for the Built Environment at District or City Scale', in O. Gervasi et al. (eds) *Computational Science and Its Applications – ICCSA 2022 Workshops*. Cham: Springer International Publishing, pp. 151–168.

Volpe, R. (2015) 'Urban Energy Mapping through the Implementation on Complex Networks', *Energy Procedia*, 82, pp. 863–869. Available at: https://doi.org/10.1016/J.EGYPRO.2015.11.828.

Research Paper

Research on low-carbon renewal strategy of large-scale residential communities from the perspective of “climate positive”

a case study of Huilongguan Street area in huitian area

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Abstract

As cities grow, climate change becomes one of the major issues facing the world. As large residential communities are important exploration areas and urban residents gathering places in the healthy climate plan initiated by C40, how to update them with low carbon to cope with climate change and rapid urbanization has become an important issue. From the perspective of "Climate Positive", the research object is based on the area of Huilongguan Street in the Huitian area of Beijing, the largest residential community in Asia, and summarizes community problems based on environmental characteristics, including road system, spatial structure, and public services. Based on this, a low-carbon renewal strategy at the macro, meso and micro levels is proposed, including the construction of a road network system with a complete system and dense density; Improve the public transportation system and build a diversified and multi-level public service facility system; Build a slow travel system that connects multiple living places to reduce carbon emissions. In order to promote carbon emission reduction in urban communities, mitigate climate change, and provide new ideas for improving the environmental quality and quality of life of residents in large residential communities.

Keywords

Climate positive, large residential community, low-carbon renewal

1. Introduction

Climate change is becoming an important issue facing the world. In the 2016 Paris Agreement, controlling greenhouse gas emissions became the consensus of all countries[1]. In 2020, China officially proposed the "dual carbon" development goal, and reducing urban carbon emissions has become an important starting point for achieving the "dual carbon" goal. In 2021, the State Council commissioned the Action Plan for Peaking Carbon Emissions before 2030, which clarifies that economic and social development is based on green and low-carbon development. The 26th session of the United Nations Climate Change Conference in 2021 urgently called for unified action to combat climate change. Urban renewal initiatives have become mainstream. Cities are the most human-intensive regions, accounting for 75% of global greenhouse gas emissions[2]. China's CO2 emissions from 287 cities above the prefecture level account for 58% of China's total. 84%, and more than 80% in cities and towns [3].

In 2020, China's urbanization rate has reached 63.9%, and in the same year, the Fifth Plenary Session of the 19th Central Committee of the Communist Party of China clearly proposed the strategic deployment of "implementing urban renewal actions", and the urban development model changed from "incremental expansion" to "stock renewal". In June 2022, the Ministry of Housing and Urban-Rural Development and the National Development and Reform Commission issued the Notice on Printing and Distributing the Implementation Plan for Carbon Peaking in the Field of Urban and Rural Construction, which further clarifies the guiding ideology of "taking green and low-carbon development as the guide, promoting urban renewal actions and rural construction actions, accelerating the transformation of urban and rural construction methods, and improving the quality of green and low-carbon development". Therefore, low-carbon urban renewal will become an important issue to cope with climate change and rapid urbanization. The construction of green and low-carbon communities is one of the important parts of building a green and low-carbon city [4].

As the largest residential community in Asia, the Huitian area of Beijing is representative, so some of the neighborhoods are used as the research object to study how to renew the community from the perspective of "Climate Positive". Therefore, based on the characteristics of the built environment and climate environment, including wind environment, thermal environment, architecture, road network and public space, and investigating and interviewing the needs of local residents, the lack of public service facilities, the serious problems of work-housing balance, less green space in parks, road network density and road width were summarized. Based on this, a three-level low-carbon renewal strategy is proposed.

2. A way to respond to climate change from the perspective of " Climate Positive "

At the end of the 20th century, the practice and research of low-carbon communities began abroad, such as Hammarby Lake City, Sweden[5]; The BedZED, UK, known as the Zero Carbon Community [6]; The Freiburg solar community, known as the carbon-negative community, is [7]. Low-carbon community practices have also promoted a range of technical and theoretical innovations[8][9]. China's exploration of low-carbon renewal of settlements is gradually advancing, but it is not yet mature[10].

The continuous increase in carbon emissions has caused a huge threat to the global ecological environment, and reducing carbon emissions is a focus issue of concern to all countries in the world[11]. In order to address climate change, in 2005, the then mayor of London initiated the establishment of the Urban Climate Leadership Alliance, or C40, a non-governmental international organization composed of major cities in the world, aiming to halve carbon emissions by 2030 and explore a path to the Paris Agreement[4]. The climate is derived from C40's 2009 initiative with the Clinton Climate Initiative (CCI) and the U.S. Green Building Council[12], which aims to offset or absorb some carbon emissions on top of achieving the goal of carbon neutrality in response to the dual challenges of rapid urbanization and climate change.

Rapid urbanization has also exacerbated climate change and increased carbon emissions. There is no direct relationship between cities and carbon emissions, but are related to carbon emissions through intermediary factors [13], including city scale[14], energy transmission[15], urban land use (density and mixed land use, etc.) [16], climate and urban heat island effect[15][16][17], transportation energy consumption[18], carbon sink and carbon capture[19].

Carbon emissions are mainly concentrated in cities, so cities are the main places to achieve green and low-carbon development. As the basic unit of the city, the community is the main place of people's life, and it is also an important place to form a simple and moderate, green and low-carbon, civilized and healthy lifestyle, and the main space to promote carbon emission reduction and mitigate climate change in urban communities. Therefore, from the perspective of "Climate Positive", Longzeyuan Street in the Huitian area of Beijing, the largest residential community in Asia, is the research object, and based on the characteristics of the built environment and climate environment, the community environment is understood by investigating and interviewing the needs of local residents.

3. Environmental characteristics of the area of Huilongguan Street in the Huitian area of Beijing

Located between the North 5th Ring Road and the North 6th Ring Road, Huitian area covers an area of 62.8 km2 and has a population of 796,000, which is an important expansion area extending from the central urban area along the central axis to the north, and is a concentrated bearing area for the functional relief of the central city. As the largest residential community in Asia, the early development and construction of the Huitian area provided a large number of affordable housing for Beijing's local low- and middle-income people and immigrants[20].

Urban spatial structure and road network are the mainstay of urban development, directly related to people's production and life, therefore, reasonable determination of regional spatial layout and reasonable road network design is of great significance to reduce carbon emissions and build low-carbon cities. For residents living in Longzeyuan Street in the Huitian area of Beijing, the largest residential community in Asia, it is necessary to meet not only their living needs, but also the needs of transportation, medical care, greening and other aspects. Therefore, public service facility planning is also essential [21].

3.1. Macro level, road analysis, land use layout

3.1.1 Road analysis

Huilongguan Street area is located in Changping District, Beijing, is part of Huitian area, Huitian area is located between the North 5th Ring Road, North 6th Ring Road, belongs to Changping District, is an important expansion area extending from the central urban area along the central axis to the north, is a centralized bearing area for the function dredging of the central city, is an important node area of the northern green corridor and ventilation corridor, and is an important hub area connecting Zhongguancun Science City and Future Science City. There is a Beijing-Tibet Expressway on the west side of the site, and the interior is divided into north and south parts by Huilongguan Street. There are many secondary trunk roads in the site, and there are very few branch roads. Although there are parking spaces on both sides of

the road, they are still insufficient, and there are cases where motor vehicles occupy non-motorized lanes, and there are cases where pedestrians walk on non-motorized lanes.

Figure 1 Current situation road analysis. Source: Author drawing.

3.1.2 Land use layout

Part of the Huitian area, the site is a reservoir of talent and labor, providing living space for the surrounding major functional areas. On the land, the residential function is the mainstay, and commercial facilities and public relations service facilities are arranged along the street.

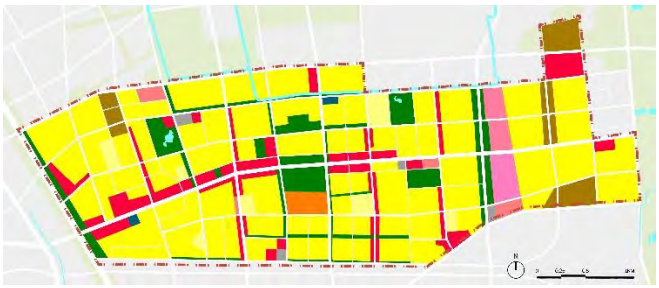

Figure 2 Current land layout. Source: Author drawing.

3.2. Meso-level, public transportation and public facilities

3.2.1 Public transportation

Line 8 and Line 13 pass through the subway within the site, and the Changping Line passes near the site. The bus line network can basically cover the entire site, and it leads to all directions, which shows that the bus network is relatively developed.

Figure 3 Analysis of current subway lines. Source: Author drawing.

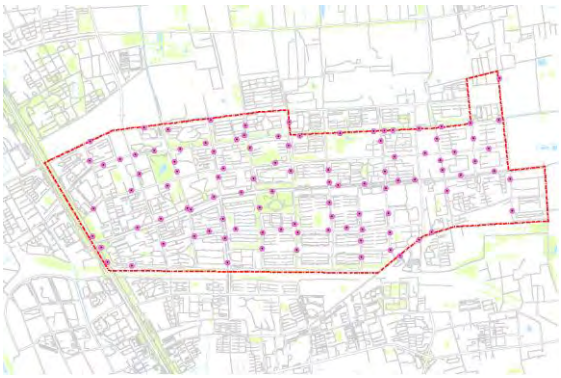

Figure 4 Analysis of current bus stops. Source: Author drawing.

3.2.2 Public Facilities

There are 3 middle schools, 7 primary schools and kindergartens in the site; The site includes Longze Garden, Huoying Street Office, Longze Garden of Beijing Municipal Public Security Bureau, Huoying Police Station Branch, and some neighborhood committees of communities; Beijing Changping District Library Huoying Street Branch, Changping District Library (Huilongguan First Branch), and some libraries in the community, cultural facilities are insufficient; There are many hospitals in the site, including first-level hospitals, tertiary hospitals (Jishuitan Hospital, Kyoto Children's Hospital, Beijing Changping District Hospital of Integrated Traditional Chinese and Western Medicine), and some community health service stations, with sufficient medical resources; Most of them are community-level elderly care service stations and nurseries, and there is a lack of elderly care facilities; Commercial facilities are mainly distributed around Hualian Huilongguan Shopping Center and Beidian Times Square on the west side. The infrastructure conditions in the region are weak, most of the sewer pipe network is a combination of rain and sewage, the overflow phenomenon is prominent in some parts of the rainy season, and there are many water accumulation points on the road, which on the one hand affects traffic and causes greater safety hazards on the other hand.

Figure 5 Distribution of current primary schools. Source: Author drawing.

Figure 6 Distribution of current elderly care facilities. Source: Author drawing.

Figure 7 Distribution of current medical facilities . Source: Author drawing.

Figure 8 Distribution of current kindergartens. Source: Author drawing.

Figure 9 Distribution of current secondary schools. Source: Author drawing.

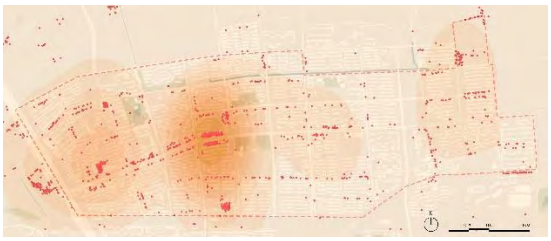

Figure 10 Distribution of current commercial facilities. Source: Author drawing.

3.3. Micro level, slow traffic analysis

3.3.1 Slow traffic

The non-motorized roads in the site are very perfect, except for a few roads without non-motorized roads, there are basically them, and a relatively complete bicycle slow travel system has been formed. Bicycle rental sites are more evenly distributed in the venue, but from field research, it is found that most people use shared bicycles, and few people rent cars at bicycle rental points. There is also a dedicated bicycle path on site.

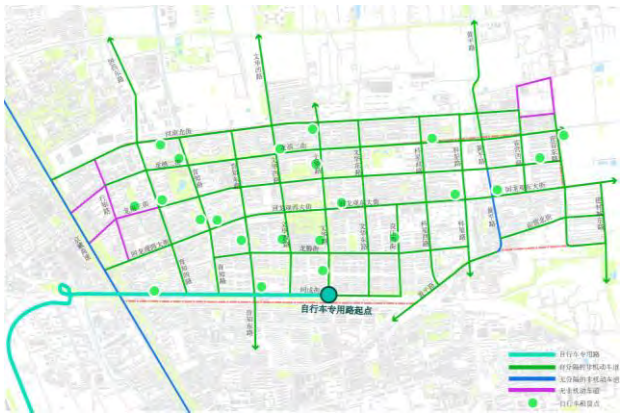

Figure 11 Analysis of current slow traffic. Source: Author drawing.

Overall, there are the following problems: insufficient capacity to support transportation and municipal infrastructure; The proportion of land gaps for medical, cultural and elderly care facilities is large; The slow travel system is not perfect. According to the Climate Positive Framework published by the C40 Alliance, the purpose of the Climate Positive Plan is to explore the development path of environmental sustainability and economic growth. Based on this, a low-carbon renewal strategy in two dimensions is proposed, including the carbon emission reduction strategy of "building a 15-minute low-carbon living circle, road system, and slow travel system" and the strategy of "building a park green space system" to increase carbon sinks.

4. Low-carbon renewal strategy of Huilongguan Street area based on the perspective of positive climate

4.1. Build a well-structured and dense road network system to advocate green travel

Strategy 1: Regional interconnection, breaking administrative segregation, and building an integrated road transportation system. Strategy 2: Add the connecting lines on both sides of the Beijing-Tibet Expressway and Metro Line 13 to smoothly connect the functions of the two sides. Advocate green travel, take advantage of the opportunity of the renovation of the existing suburban railway of the Northeast Ring Line, strengthen the relationship between the Huitian area and key functional areas such as Zhongguancun Science City, Future Science City, Wangjing, and CBD, and balance the relationship between employment and housing in the Huitian area on a larger scale. Increase industrial land, improve the relationship between employment and housing, and realize local employment. Strategy 3: Encrypt the branch road network, open up microcirculation, build a complete road transportation system, and balance the relationship between employment and housing on a larger scale.

4.2. Build a diversified and multi-level public service facility system and improve the public transportation system

Strategy 1: Prioritize high-quality resources to supplement the allocation of public service facilities, and establish a public service facility system that meets the convenience, fairness, diversity, safety, and livability of early childhood education, learning and education, housing and housing, and support for the weak. Strategy 2: Layout major public service facility centers along the public service facility belt, mainly including regional commercial centers and regional cultural and sports centers (Huilongguan Sports and Cultural Park). The facility network is basically formed, and some node facilities are lacking, and it is urgent to break through the blockage, improve the system, and improve the overall support capacity

through meridian dredging, detail update and repair. Strategy 3: Combined with the No. 13 capacity expansion and promotion, set up a site micro-center to achieve integrated development.

4.3. Build a slow travel system that connects multiple living places to reduce carbon emissions

Strategy 1: Implement the relevant requirements of Changping District's slow travel system planning, and build a complete network of internal and external connectivity, continuous and diverse pedestrian and bicycle transportation systems. Strategy 2: Connect the main public service facilities through the slow corridor to achieve the walking out of the main body within 1 km, the bicycle traffic out of the main body within 1-5 km, and the "walking + bus" or "bicycle + bus" travel mode of more than 5 km. Strategy 3: Strengthen the slow-moving traffic links between the region and the green spaces of the central axis and improve the accessibility of country parks; At the same time, it is connected to the main work places of the surrounding residents, providing diversified options for commuting.

5. Conclusion

Climate change has become one of the major issues facing the world, and how to update large residential communities as an important exploration area and urban residents in the climate plan launched by C40 has become an important issue. From the perspective of "Climate Positive", taking the Huilongguan Street area in the Huitian area of Beijing, the largest residential community in Asia, as the research object, based on environmental characteristics, including road system, spatial structure and public services, this paper proposes a low-carbon renewal strategy at the macro, meso and micro levels, in order to promote carbon emission reduction in urban communities, mitigate climate change, and provide new ideas for improving the environmental quality and quality of life of residents in large-scale residential communities.

6. References

Ou J, Liu X, Wang S, et al. Investigating the differentiated impacts of socioeconomic factors and urban forms on CO2 emissions: Empirical evidence from Chinese cities of different developmental levels [J].Journal of Cleaner Production, 2019, 226(20): 601-614.

IPCC (Intergovernmental Panel on Climate Change).Climate Change 2007: Synthesis Report[R].2007.

QIU Baoxing. Urban Development Research,2009,16 (8): 1-6.

Enlightenment of Climate Positive Action to Chinese Low Carbon Urban Renewal :A Case Comparison of Barangaroo, Sydney and Elephant Park, London

WILLIAMS J. Lost in translation: translating low carbon experiments into new spatial contexts viewed through the mobile transitions lens[J]. Journal of Cleaner Pro‐duction. 2017, 169: 191-203.

CHANCE T. Towards sustainable residential communities; the Beddington Zero Energy Development(BedZED)and be‐yond[J]. Environment and Urbanization.2009, 21(2): 527-544.

FREYTAG T, GÖSSLING S, MÖSS‐NER S. Living the green city: Freiburg's Solarsiedlung between narratives and practices of sustainable urban development[M]. Local Environment, 2014.

BENITES H S, OSMOND P, ANGELAR. Developing low-carbon communities with LEED-ND and climate tools and policies in São Paulo, Brazil[M]. Journal of Urban Planning and Development,2020.

LI Yunyan, ZHAO Wanmin, ZHU Meng, et al. Thoughts on the dilemma, ideas and basic framework of old city renewal in China in the new era[J]. Urban Development Research, 2020, 27(1): 57-66.

GUAN Li,WANG Liudan. Research on low-carbon renewal strategy of existing settlements[J].Urban and Rural Construction,2023(06):68-71.

PAN Haihai,TANG X,WU Jinyu,et al. Urban Planning Journal,2008(06):57-64.

C40 CITIES. New Beijing Project first in China to be accepted into C40’s Climate Positive Development Program [EB/OL]. (2016-06-08) [2022-10-10]. https://www.c40.org/news/new-beijing-project-first-in-china-tobe-accepted-into-c40-s-climate-positive-developmentprogramme/.

YANG Lei, LI Guicai, LIN Yaoyu, et al. Progress and Prospect on Relationship Research between

Urban Form and Carbon Emission ［J］. Urban Development Research,2011,18(2) : 12 -17,81.

Glaeser E L，Kahn M. The greenness of cities: Carbon dioxide emissions and urban development ［J］.Journal of Urban Economics，2008，38 (1) : 650 － 655 .

Ewing R，Rong F. The Impact of Urban Form on U.S.Residential Energy Use ［J］.Housing Policy Debate, 2008,19 (1):1 － 30 .

Newman P W G，Kenworthy J R. The land use － transport connection an overview ［J］.Land use policy,1996,13 (1): 1 － 22 .

Stone B，Rodgers M O. Urban Form and Thermal Efficiency: How the Design of Cities Influences the Urban Heat Island Effect ［J］.Journal of American Planning Association，2001，67 (2) : 186 － 198 .

Randolph J. Comment on Reid Ewing and Fan Rong’s “The impact of urban form on U. S. residential energy use” ［J］. Housing Policy Debate,2008,19 (1) : 45 － 52 .

ZHAO Hongyu, GUO Xiangmin, CHU Yun." Low-carbon urban planning from the perspective of "carbon footprint"[J].Planner,2010,26 (5) : 9 - 15.

LI Yi, ZHAO Kaixian, GAO Mengyao, et al. Approaches to Optimize the Circle of Life in Large Residential Communities Under the Concept of “Homo-Urbanicus”[J]. Landscape architecture,2021,28(04):27-33.

LI Kaibo. Analysis of urban planning strategy under the concept of low-carbon city[J].New Urbanization,2023(04):61-64.

Case Study

Does the Gated Form of Residential Development Matter for Community Cohesion?

Reflections on the Response to COVID-19 Outbreak in Wuhan, China

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Abstract

During the lockdown in Wuhan, urban life has effectively been confined to each gated residential community. It was an unprecedented operation that relied on mutual help from neighbors and the true community spirit. The community cohesion achieved in this impromptu self-organization demonstrates that it is potentially not the gated form itself but the absence of momentum, time, commitment, and space for engagement and participation in community affairs that ultimately leads to social alienations. The investigation has demonstrated that more than 80 percent of the respondents felt that the lockdown did not weaken their community cohesion, and the percentage of respondents with positive viewpoints on enhanced community cohesion are more than 2-3 times the ones with negative opinions. In accordance with the assumption from the interviews, the result of the investigation demonstrates that a higher level of community cohesion has been perceived in contrast to before the lockdown. Based on the reflections on whether gated or ungated matter for Community Cohesion, basic conclusions have been made that community cohesion does not relate strongly with the physical forms of housing, the level of engagement of their residents in community affairs, which depends on momentum, time, commitment, and space for participation, is of greater significance. Post COVID-19, further efforts have been suggested to make on an integrated approach through the means of governance reform and spatial interventions, promoting community cohesion.

Keywords

Gated Communities, Community Cohesion,COVID-19,Neighbourhood Development, integrated community

1. Introduction

In this ongoing battle against the COIVD-19 pandemic, social distancing measures, like “shelter-in-place”, have been proven to matter the most in “flattening the curve”(Zhang et al. 2020). In Wuhan, the epicenter of this outbreak in China, the implementation of the lockdown measures owed a great deal to the gated forms of residential communities. Globally, the practice of gating communities has generated significant debates over its social, economic, and political implications(Wu 2005;Tony&Bil 2006; Song 2010;Goix 2005;Thuillier 2005;McKenzie 2005;Grant 2004;Grant 2005). Often being accused of social segregation, this gated form of urban housing has been considered as an obstacle in improving urban

governance as it diminishes social capitals(Wu 2005; Atkinson & Blandy 2005). Before the COVID-19 outbreak, gated communities have been discouraged in China through national policy guidelines, feasibility studies and pilot programs have been carried out in attempts to transform them into open neighborhoods, which emphasis on physical forms. However, this lockdown experience in Wuhan has somehow changed our perspectives on this particular issue, especially the relationship between gated compounds and community cohesion, which is a key element in social determinants of health(SDH)(Batemen et al.2017). It begs the question, does the gated or ungated form impact the development of community cohesion? Post COVID-19, how could urban planning help to nurture more cohesive communities? These questions will be discussed with reflections from the experience during the lockdown in Wuhan.

2. The Emergency Response in Communities during the Lockdown

The majority (more than 85% of the land designated for residential use) of residential developments in Wuhan are enclosed with gates, fences, walls, and other barriers to limit public access(WLSP 2016). These gated compounds are mostly commercial residential estates managed by professional property management companies, and are jointly governed by “residents’ committees” representing the government, and elected “homeowners’ associations”.

To contain the spread of COVID-19, the municipal government ordered to cordon off all 7148 communities individually which started in early February 2020, though some of the restrictions have been partially lifted. The perimeters of these cordon zones are either the existing boundary of gated compounds or temporary barriers enclosing an originally ungated neighbourhood. Emergency response teams, which comprised of volunteers, members of “homeowners’ associations”, staff from “residents’ committees” and property management, have been established to safeguard their respective communities. As no one leaves their cordon zones, the teams are responsible for organizing daily necessities, monitoring residents’ health conditions, purchasing medicines, and dealing with any other requests. They take special care of the elderly and people with disabilities by delivering free food door to door. Residents have also volunteered to help and some donated food and money to the team to be distributed to those in need. Other than these structured interactions between the response teams and residents, spontaneous resident-to-resident help also took place during this period which contributed towards interpersonal bonding and an elevated sense of solidarity. The diagram below demonstrates the typical organization of lockdown response in communities in Wuhan (Fig. 1).

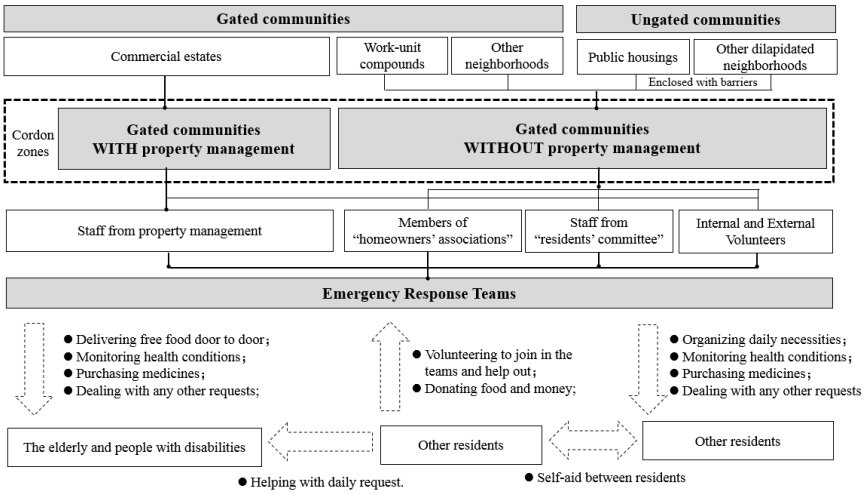

Figure 1 The Response Organization of Communities in Wuhan During the lockdown. Source: Authors .

3. Enhanced Community Cohesion Compared to Pre-COVID-19

Studies in China have found that most of the residents living in gated commercial estates, only make nodding-acquaintances, and social interactions are limited to small groups that are bounded by common interests or working relations, which limits the possibility of achieving a higher level of community cohesion(Wu 2005). Nonetheless, during this unprecedented lockdown, we observed signs of improvement in community cohesion as the unexpected result of organizing this emergency response.

To verify our hypothesis, semi-structured interviews have been conducted with our neighbors. Based on the definition of community cohesion(Forrest&Kearns 2001), two questions were put forward asking the interviewees to compare their experience before and after the lockdown:

1) Do you think you are living in a more close-knit community?

2) Do you feel more strongly attached to your community?

The outcome of this small scale study revealed that residents had engaged in more social interactions with their neighbors, and were more attached to the communities. As these interviews mostly happened in casual settings during unplanned encounters with interviewees, they should not be regarded as conclusive evidence.

To seek more convincing evidences, a questionnaire has also been conducted by the students of Hubei University of Technology, towards the inhabitants in the neighborhood of Minyi Street in Wuhan. There were 269 respondents, who consisted of 76.21% stakeholders and 15.24% tenants. Although about half of the respondents felt no differences concerning the cohesion of the neighborhood before and after the lockdown, more than one third of the respondents felt more attached to the communities and have engaged in more social interactions with their neighbors. In another words, more than 80 percent of the respondents felt that the lockdown did not weaken their community cohesion. And the percentage of respondents with positive viewpoints on enhanced community cohesion are more than 2-3 times the ones with negative opinions. In accordance with the assumption from the interviews, the result of the investigation demonstrates that a higher level of community cohesion has been perceived in contrast to before the lockdown.

Table 1 The Results of the Questionnaire. Source: Authors .

Question	Answers	Percentage
1. Do you think you are living in a more close-knit community?	much more close-knit	11.11%
	less more close-knit	26.67%
	pretty much the same	52.59%
	less close-knit	14.07%
2. Do you feel more strongly attached to your community?	Much stronger attachment	12.59%
	Stronger attachment	19.61%
	pretty much the same	58.52%
	less stronger attachment	9.63%

We can potentially credit this improvement to residents' engagement with community affairs in cooperation with emergency response teams. Social interactions have hence been reactivated between larger groups of residents, who were bounded with a mutual goal against the virus, as well as more time for participation and fewer distractions from other affairs during the lockdown.

Some interviewees responded that they are reminded of their time spent living in work-unit compounds[2], which was also gated but with "neighborhood watch" self-organized by residents. They particularly pointed out the recreation of a similar sense of solidarity in their current place of residence over the past weeks. Although the forms of social interactions are different and incomparable, the triggering of such memories demonstrates, to some extent, that community cohesion has been enhanced in gated communities during this lockdown.

4. Reflections: Does Gated or Ungated matter for Community Cohesion?

Our investigations and observations have shown that there is potential for community cohesion within gated residential compounds in the Chinese contexts, but to understand the mechanism, the social-spatial structure of cities has to be explored beyond the gated community itself. Unlike other countries, the prevalence of gated estates in China is mostly due to the commodification of real estates from total state provision. With a mix of different functions, the pre-commodification "work-unit compounds" of the communist era accommodated employees of the same company or public institution. The relationships formed from co-working were strengthened through co-living in quasi-self-sufficient units which spontaneously nurtured a sense of attachment to the community. On the other hand, residents living in post-commodification compounds have weak interpersonal ties other than co-location. They may have similar socio-economic status, but come from different parts of the country and work in a wide array of sectors. It is often the case that residents are reluctant to extract themselves from their sphere of work and social networks to interact with neighbors.

Yet, as an unexpected result of lockdown, social interactions within these compounds have all been activated out of the necessity to organize daily life in isolation, and the fear of the virus. Such a dire situation provoked residents to engage with community affairs and to help each other out where they can. These revelations show that given the right circumstances, community cohesion can be strengthened in commercial residential estates without changing gated forms. Therefore, it is possible that community cohesion does not relate strongly with the physical forms of housing, the level of engagement of their residents in community affairs, which depends on momentum, time, commitment, and space for participation, is of greater significance. With the progress of urbanization and globalization, momentum and time available for community participation have been swamped by other activities in this transient world of high-speed transport and information technology. Although the organization of communities during unprecedented urban emergency demonstrated that enhanced community cohesion in gated estates is possible, it doesn't justify its suitability for sustaining the level of cohesion post-COVID-19. At the same time, if the aforementioned conditions of community engagement are the key to cohesion, the proposed transition towards open neighborhood in China which focuses solely on physical forms is also invalidated. It is perhaps time to explore new approaches to community planning towards the goal of social cohesion.

5. Future Efforts to be Made

Recently, numerous post-COVID-19 scenarios have been imagined and are subject to intense discussions worldwide. One thing for sure, humanity will have to be prepared for unprecedented risks and challenges.

Such global uncertainty will result in an aggravated level of fear and anxiety amongst the public. There is a psychological phenomenon that the sense of fear could redefine the boundary of one's activities, so according to this argument, the boundaries of all physical realms may be reinforced post-COVID-19, including residential neighborhoods. As the product of fear, gated communities, which proved unable to ensure security but can enhance the secured feeling, will probably be more enclosed than ever before due to habitual thinking and cannot be easily ungated cause they are market-driven.

On the other hand, high urbanism, which could make the traditional ties of communities facing a new crisis of social cohesion, would require the making of "community" more desperately to improve urban governance, as bigger cities become the more risks they will get. The key to deal with risks, especially for metropolises, would be to establish an adaptive governance system, based on each community as the basic unit which can also collaborate as an integral(Folke et al.2005, Wu 2013). The system could improve the efficiency and save the cost of governance during emergency and non-emergency periods, but would require community cohesion as the cornerstone.

Under such circumstances, a renewed approach in planning cohesive communities could be established by the means of urban governance reform and spatial interventions, which focuses on inspiring residents to participate in the making of "community" rather than regulating physical forms of urban space(David&Keith 2010; French et al 2014). More efforts should be made in developing both tangible and intangible strategies at national and local levels to enhance the momentum, time, commitment, and space for public participation. For example, it is suggested to offer social infrastructures and urban amenities within walking distances and a complete network of streets and open spaces, which will not only save the time for daily commutes but more importantly provide spaces for encounters and social interactions. Co-governance between residents and authorities should also be encouraged, between whom urban planners should play the bridging roles and invite residents to engage in community affairs together.

Integrated communities, as coined by Wu Liangyong(2000), which aim to function as integral micro-cities, could be considered as a trend and become the future model of urban housing, particularly in metropolises. As a self-contained quasi-city unit, integrated communities could cultivate community cohesion by enhancing the momentum, time, commitment and space for public participation. Like the concept of Perry's neighborhood unit, it is suggested to offer various urban services within walking distances and a complete network of streets and open spaces, which could not only save the time for daily commutes but also make the space for random encounters and social interactions. To help with the shift of from hierarchy to cross-level management, it is also a commitment towards co-governance by local residents and the authorities, between whom urban planners should play the roles of bridges. Only when urban planners invite local residents to engage with community affairs together as self-organizations, can the top-down physical plan of integrated communities be implemented and the momentum of public participation be activated bottom-up.

The transition of gated communities in the Chinese context, from open neighborhoods to integrated communities, indicates that the focus of urban planning discipline, is turning to governance beyond physical forms The logic of this shift could be applied to other countries with different models of communities adjusting to local contexts.

6. Conclusion

Based on the reflections on whether gated or ungated matter for Community Cohesion, basic conclusions have been made that community cohesion does not relate strongly with the physical forms of housing, the level of engagement of their residents in community affairs, which depends on momentum, time, commitment, and space for participation, is of greater significance. Post COVID-19, further efforts have been suggested to make on an integrated approach through the means of governance reform and spatial interventions, promoting community cohesion. To benefit from integrated and sustainable urban and regional planning, Integrated communities, as coined by Wu Liangyong(2000) in China, which aim to function as integral micro-cities, has be proposed as a trend and become the future model of urban housing, particularly in metropolises. As a self-contained quasi-city unit, integrated communities could cultivate community cohesion by enhancing the momentum, time, commitment and space for public participation. Like the concept of Perry‘s neighborhood unit, it is suggested to offer various urban services within walking distances and a complete network of streets and open spaces, which could not only save the time for daily commutes but also make the space for random encounters and social interactions. To help with the shift of from hierarchy to cross-level management, it is also a commitment towards co-governance by local residents and the authorities, between whom urban planners should play the roles of bridges. Only when urban planners invite local residents to engage with community affairs together as self-organizations, can the top-down physical plan of integrated communities be implemented and the momentum of public participation be activated bottom-up.

More research and practice should be devoted to understanding the mechanisms behind the formation of community cohesion in residential neighborhoods globally, taking into consideration the social and cultural context of different localities, as well as the potential of planning as a tool to assist in improving cohesion and mitigate the impact of uncertainties.

7. References

Atkinson, R.Blandy,S. (2005)‘International Perspectives on the New Enclavism and the Rise of Gated Communities’ (Special issue), *Housing Studies*, 20(2), 177-186.

Batemen,L. Fouad,M. Hawk, B. Osborne,T. Bae,S. Eady,S. Thompson,J. Branteley,W. Crawford, L.Heider, L.Schoenberger, Y.(2017)’Examining Neighborhood Social Cohesion in the Context of Community-based Participatory Research: Descriptive Findings from an Academic-Community Partnership’, Ethnicity&Disease, 27(1), 329-336.

Chiang,C.M.(2005) ’Policy Review: Government Intervention in Housing:The Case of Macao’, Housing Studies, 20(1), 149-155.

David, C. Keith, K. (2010)’Community-based Housing Organizations and the Local Governance Debate’. Housing Studies, 20(2), 533-559.

Folke,C. Hahn,T. Olsson,P. Norberg,J. (2005)’ Adaptive Governance of Social-Ecological Systems’, Annual Review of Environment and Resources, 30(1), 441-473.

Forrest,R. Kearns,A.(2001) Social Cohesion, ’Social Capital and the Neighborhood’,Urban Studies, 38(12), 2125-2143.

French,S.Wood,L. Foster,S.A., Giles-Corti,B.etc.(2014)'Sense of Community and Its Association With the Neighborhood Built Environment'.*Environment and Behavior*,46(6), 677–697.

Glasze,G.(2005) 'Some Reflections on the Economic and Political Organisation of Private Neighbourhoods', Housing Studies, 20(2), 221-233.

Goix,R.L.(2005) 'Gated Communities: Sprawl and Social Segregation in Southern California', Housing Studies, 20(2), 323-343.

Grant,J. (2004) 'Types of gated communities',*Environment and Planning B: Planning and Design*, 31, 913-930

Grant,J. (2005) 'Planning Responses to Gated Communities in Canada',Housing Studies, 20(2), 273-285.

Kleit,R.G.Rohe,W.M. (2005) 'Using Public Housing to Achieve Self-Sufficiency: Can We Predict Success?', Housing Studies, 20(1), 81-105.

McKenzie,E. (2005)'Constructing The Pomerium in Las Vegas: A Case Study of Emerging Trends in American Gated Communities', Housing Studies, 20(2), 187-203.

Song,W.X.(2010)'A Review on Researchers of the Gated Community'. Urban Planning Forum, 189(2), 42-51.

Thuillier,G. (2005) 'Gated Communities in the Metropolitan Area ofBuenos Aires, Argentina: A challenge for Town Planning', Housing Studies, 20(2), 255-271.

Tony, M. Bill, S. (2006) 'Gated Communities as Club Goods: Segregation or Social Cohesion? ',Housing Studies, 20(2), 345-359.

WLSP (Wuhan Land use and Urban Spatial Planning Research Centre). Research on the Residential Areas in Wuhan(Unpublished Research), Wuhan Natural Resource & Planning Bureau, Wuhan. 2016.

Wu.L.Y. (2013). Human Settlements towards the Future. Beijing: Press of Tsinghua University.

Wu,F.L. (2005) 'Rediscovering the 'Gate' Under Market Transition: From Work-unit Compounds to Commodity Housing Enclaves', Housing Studies, 20(2), 235–254.

Xu,L.Y. Zhang,H.M. Deng,Y.Q. etc. (2020) 'Cost-effectiveness Analysis of Antiepidemic Policies and Global Situation Assessment of COVID-19',[online]. Available at: https://arxiv.org/abs/2004.07765(Accessed: 15 November 2021).

Endnotes

1. Han Zou is the corresponding author. Email:50682556@qq.com.

2. Imported from the former Soviet Union in the socialist era, work-unit compounds were planned residential districts or so-called "micro-region" with clear boundaries, which were often largely associated with industrial development (Wu, 2005).

Synopsis

Through investigations after the lock-down of Wuhan, this paper suggests that it is potentially not the gated form itself but the absence of momentum, time, commitment, and space for engagement and participation in community affairs that ultimately leads to social alienations. Post COVID-19, further efforts have been suggested to make on an integrated approach through the means of governance reform and spatial interventions, promoting community cohesion.

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Cooperative program for public uses

- a sustainable social-economic model for allocating land for

Ronit DAVIDOVICI, Reichman University, Lihi EIN GEDI - DAVIDOVICI,
D.M.R. Planning, Architecture, people; Israel.

Abstract .

Public buildings are significant for the quality of the public space and reflect the social values of the city. This takes on a new effect in light of the increase in the consumption of services by the community today. As planners, we are required to evaluate urban structural changes defined by those multi – disciplinarian strategic changes.

.The article will present a case study relating to the largest public complex in the city of Herzliya - a satellite city adjacent to the Tel Aviv metropolis - the largest in Israel). The complex developed over the years without any overall planning but as a one-off response to needs and was used as a hostel for several kindergartens, schools, a swimming pool, a training center, etc. Each function was assigned a plot of land that was defined by a fence and included a building and a wide parkin, including services as sport court, auditorium etc.

*In recent years, Herzliya added population and the need for public services grew. The municipality asked our planning company (D.M.R., Planning and Architecture) to plan the complex based on comprehensive perspective, pre-viewing the future emphasizing on sustainability, climate change and current economics***.**

The article will present a critical analysis of the characteristics of the place, emphasizing its un efficient development so that over the years it has become an urban wasteland.

*We'll present the planning concept that was developed under the leadership of the mayor and with the participation of the city managers and the local community leadership. All this as part of a process of planning which we led. The planning led to planning policy document which was approved by the planning committees***.**

*These days the implementation of the plan is being promoted and an innovative spatial management model will even be tested***.**

Keywords

Densification of public space; Cooperative new urban economy; Mix land uses; multigenerational planning and programing; Long life cycle synchronized planning; Planning promotes WELLBEING for all

1. Reality in change - A socio – economy -planning revolution

1.1. Doubling the population – Israeli society is getting both older and younger.

The northwestern quarter of the city center of Herzliya is facing a large and accelerated growth. In the next 20 years, it is intended to double the population from about 25,000 residents to close to 45,000 residents - as part of urban renewal and new construction in the complex.

This volume of population will crowd the district and raise multiple needs for social services with an emphasis on educational institutions, from preschool to high schools. At the same time - sports facilities will require a welfare society, etc.

All of these require an innovative multidisciplinary approach: to development in the public space in general and land allocations for public services in particular. Accompanying these needs is the need to develop open and accessible areas for the aging population on the one hand (the proportion of people aged 65+ in Israel is 11%) and at the same time - the size of the household is not decreasing (today it is close to 4 persons) because the proportion of children is stable and does not change significantly. with a long lifespan expectancy, therefore the proportion of adults in Israeli society is expanding (currently 11% of all Israeli society is 65+)

And at the same time - the rate of children in Israeli society is not decreasing. And the average size of an Israeli household currently stands at close to 4 persons per household.

Social, physical and economic challenges, which are the basis of planning programs and an approach that emphasizes programmatic challenges and produces a complex planning reality - are the basis of the presented project.

1.2. Chronic lack of public spaces in areas of demand in the metropolis

The project deals with the largest public space in a suburban city near Tel Aviv, Israel. The area has developed over the year The project deals with a large public space in a suburban city near Tel Aviv. The area has developed over the years in an extravagant way that includes a variety of educational functions; Each function is fenced and manages itself with a yard, toilets, parking, etc. Each, for example, operates in the area of a school, a therapeutic swimming pool, a walking center, and more - each has a parking lot and service areas, a fence around the lot that prevents the possibility of passing and walking between them.

In light of the lack of public spaces in the growing city, we were asked to examine the possibility of increasing the use of the space and incorporating up-to-date qualities that are suitable for climate changes and the needs of society and the new economy. The years in an extravagant way that includes a variety of educational functions; Each function is fenced and manages itself with a yard, toilets, parking, etc. Each, for example, operates in the area of a school, a therapeutic swimming pool, a walking center, and more - each has a parking lot and service areas, a fence around the lot that prevents the possibility of passing and walking between them.

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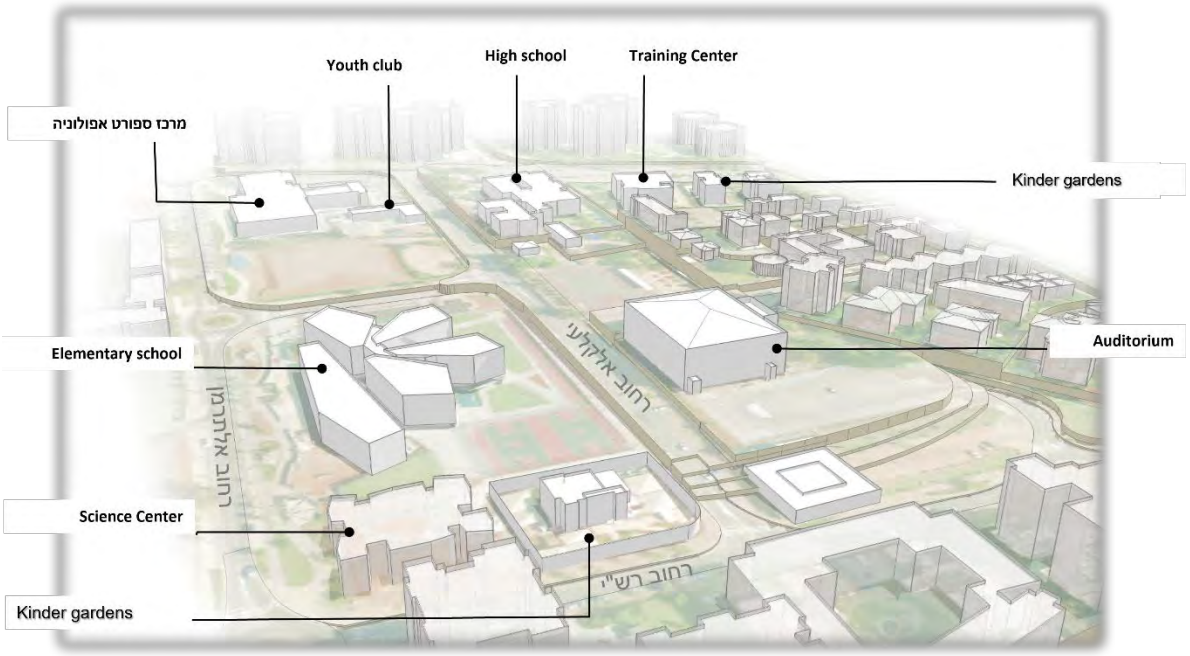
Current situation



Resource: Totem – imaging; D.M.R. planning & development

2.The urban context – A beautiful bourgeois neighbourhood in a metropolitan suburb

The Alterman 100 Dunams public space is located in an area near the northern entrance to the city, near the university. The urban district where the complex is located is intended for significant urban renewal as well as construction plans for new neighbourhoods. The district is characterized by a medium-high social economic status similar to the whole city.

The renewal and the new construction will lead the district to double its population, to the size of a residential area of about 4, and to the urban space required for a significant scope of public spaces.

The Alterman complex, located in the northwest quarter of Herzliya city centre, is facing a large and accelerated growth. In the next 20 years, it is intended to double the population from about 25,000 residents to close to 45,000 residents - as part of urban renewal and new construction in the complex.

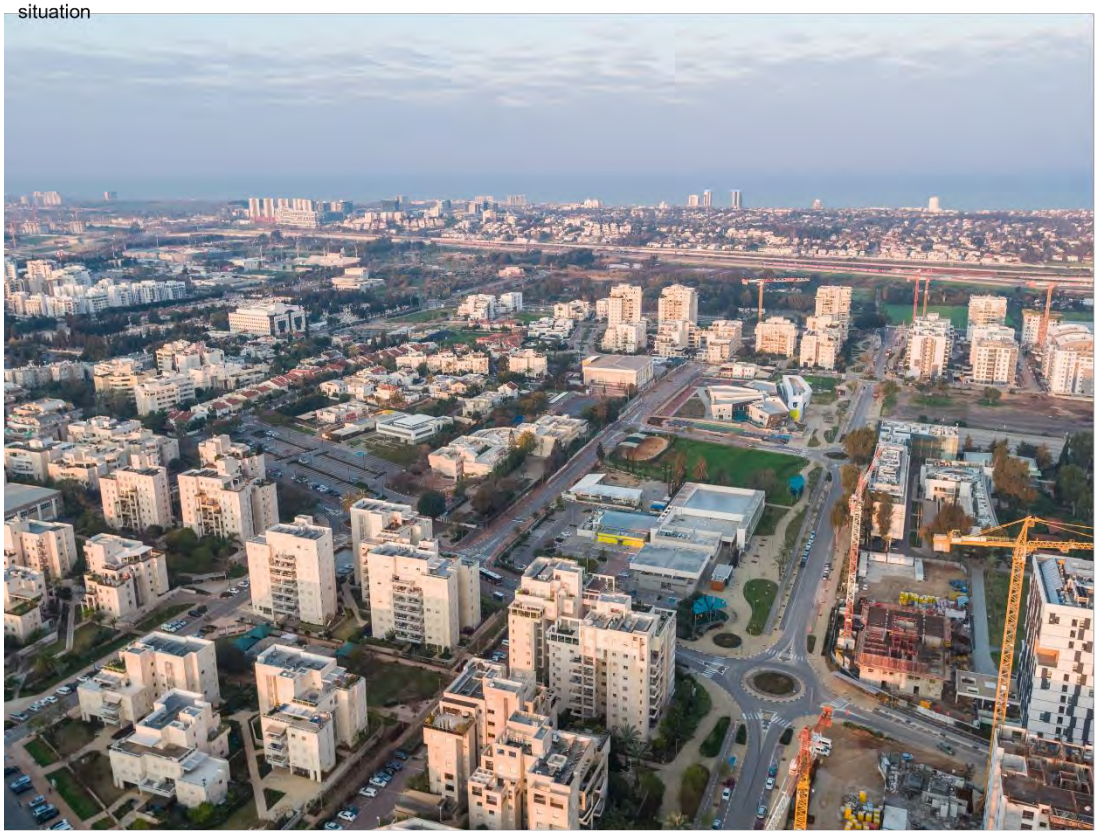
This volume of population will crowd the district and raise multiple needs for social services with an emphasis on educational institutions, from preschool to high schools. At the same time - sports facilities will require a welfare society, etc.

All of these require an innovative multidisciplinary approach: to development in the public space in general and land allocations for public services in particular. Accompanying these needs is the need to develop open and accessible areas for the aging population on the one hand (the proportion of people

aged 65+ in Israel is 11%) and at the same time - the size of the household - which is not decreasing (today it is close to 4 persons) - as the proportion of children is stable and does not change significantly.

That special combination creates a complex planning reality which stand at the basis of the presented project.

Urban Context | Alterman complex – Existing situation



Resource: Totem – imaging; D.M.R. planning & development

3. The 'cooperative public campus' model

3.1 The major idea – a new land allocation model – planning R@D

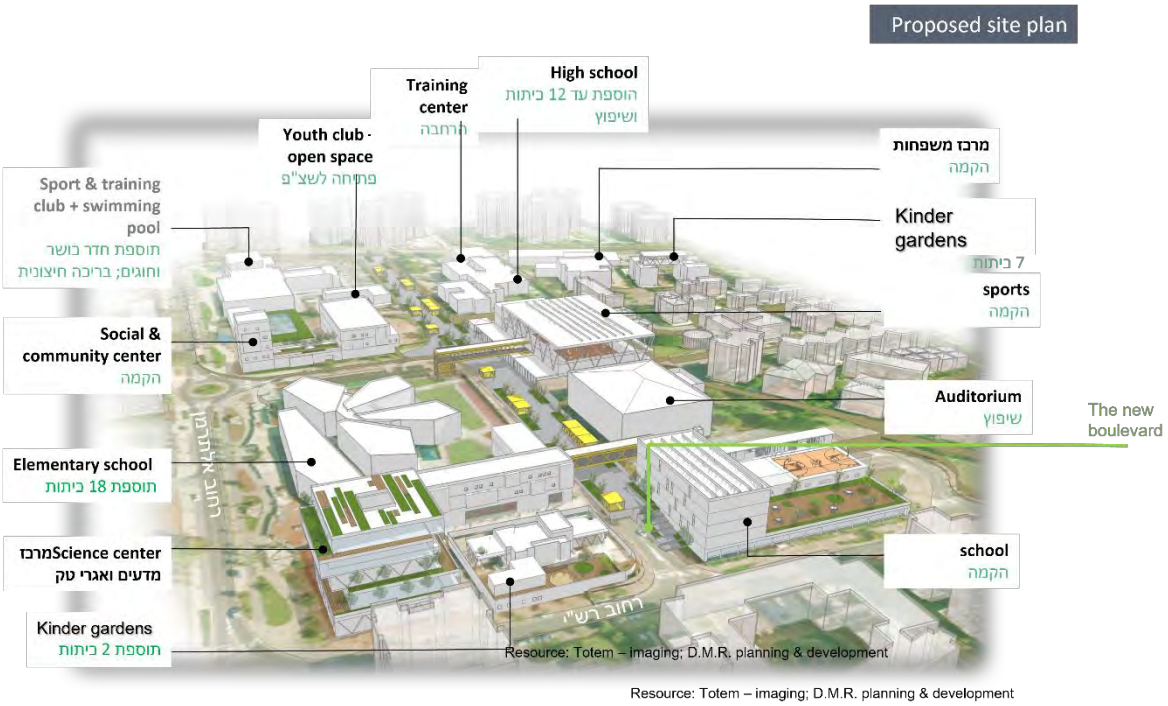
The project's approach is expressed in a vision that emphasizes the promotion of well-being for all based on walking and convenient and friendly accessibility, optimal use of land and economic - cooperative management of public assets.

In light of the value concept, we developed a program with the planning team that emphasizes several principles:

- Cooperative use of space
- Optimal use of land
- Preparing the public space for extreme climate changes

• 'Wikipedia' style planning - flexibility and participation; transparent and interactive management of change and update options as part of the planning

These principles made it possible to plan while thinking 'outside the box', to lead entrepreneurial planning, and above all to lead change. It seems that the assimilation of the STATE OF MIND, and the concept that it is important to think new and what was not appropriate should come back and be, is the leading challenge in this kind of avant-garde planning. These principles made it possible to plan while thinking 'outside the box', to lead entrepreneurial planning, and above all to lead change. It seems that the assimilation of the STATE OF MIND, and the concept that it is important to think new and what was not appropriate should come back and be, is the leading challenge in this kind of avant-garde planning.



Resource: Totem – imaging; D.M.R. planning & development

3.2 Methodology – the 'Game Changer'

The planning process of the project's public area led to the development of a model whose main focus is an overall view that promotes synergy between public buildings and emphasizes modesty, land conservation, human scale and collaborations. The project was expressed in several key points: A planning policy document - which includes all the background and concept underlying the program and plan.

The plan emphasizes a cooperative program that will allow joint use of 'support' buildings and similar services required for a wide variety of educational buildings. So not every school will have a library, sports hall, auditorium, etc. These 'service' buildings will be built at the highest level and will be used by all the educational buildings, as well as the community.

Each public building has a 'Core' and some 'Support Services'. Here lies the potential.

In order to accomplish those planning values and principles, all public buildings were analyzed carefully and divided into 'core' components and 'support' components. The core needed specific land allocation and the 'sport' components were the ones to be shared by a variety of users: schools, community etc.

• Development of quality service structures for joint use by educational institutions, culture and the community - This is the core of the plan - the joint use of cultural, leisure, sports, library, etc. buildings - creates quality and compactness in the complex, an opportunity for informal and community meetings and a space that encourages staying, walking and community life outdoors. The intention is to move the complex from a boring and empty space, to a public-educational-sports complex, with a bustling promenade.

Such an urban structure creates a connecting link between the neighborhoods, and a basis for economic-entrepreneurial management of the campus

• Interaction with the nearby university (across the Alterman road)- Reichman University is located across Alterman Street and borders the complex. To this day, the university faces a closed and fenced facade, a backyard.

The program recommends developing a dialogue with the university in order to 'take down fences' and examine the possibility of ties and connections for the benefit of the students, lecturers and the community.

- Accessibility on human scale - the plan canceled a road that passed through the center of tensions and was almost useless and turned it into the central walking avenue of the public campus. An open green space surrounded by public buildings and neighborhood commerce. which presents affinities and connections to the surrounding urban space and reference to the context in the social and economic spheres.
- Common underground parking area - based on a standard which emphasizes walkability and public transportation-
- The plan recommended developing a municipal management model that would manage the entire enclosure - during the planning, development and construction phase. So that all the public buildings will join forces around a common project.

At the same time, phases were defined for the realization of the project, planning complexes and conceptual and volumetric construction guidelines.

This methodology and planning process led to a saving of about 2/3 of the land allocation rates for the educational buildings. and added 2 schools, kindergartens and day care centers, a swimming pool, a multi-age science center, a center for public participation, a sports arena and sports halls. And above all - a longitudinal walking boulevard that connects the parts of the complex and between it and the environment. All of these were made possible in light of the co-operation

The plan which included building patterns, planning and management recommendations, was presented to the local and regional comities and was approved as a planning policy document, basis to statutory plan.

4. It is possible to build dense and good public spaces – wellbeing for future generations.

The plan we prepared created a public complex based on an innovative program model, emphasizing the possibilities of "taking down fences", modesty and partnership. All the space is connected and enjoy sharing underground parking and supporting high quality services. The 'Alterman campus' reduces the traffic infrastructure for private vehicles and expands the built and open public spaces while creating new opportunities for social, environmental and economy qualities.

. Services such as: auditorium, sports, swimming pool, library, etc. are not required for each school and community center separately. When there are possibilities of proximity, an opportunity opens for synergy and hence for cooperation. This type of process requires transparent and participatory planning with a variety of representatives of the local community, and with the ones who are meant to use the complex; using the model which promotes a new urban economy and brings up-to-date qualities in the public space.

The willingness and entrepreneurship that make it possible to produce a cooperative program led the plan and the program for the Alterman public campus, to be developed as a 'model' that encourages optimal and economical land use, walkability, community meeting, multi-generational, etc. - as a basis for the next phase of urban economy.

We hope this 'cooperative public campus' model can serve as an added planning tool for us, planners, to deal with sustainability and mainly with the extreme climate changes which already begun to appear - and are expected to challenge future generations as well.

Future public cooperative campus

מרכז ספורט שיתופי למוסדות החינוך ולתושבים – ליבת המתחם

Resource: Totem – imaging; D.M.R. planning & development

References

Boeschenstein, L. Warren. A. (1999) *Historic American Towns along the Atlantic Coast*. Baltimore: The Johns Hopkins Press.

Bohl C. (2002). *Place Making: Developing Town Centers, Main Streets, and Urban Villages*. Urban Land Institute

Carmona, M.(2010). Contemporary public space: Critique and classification. Journal of Urban Design, 15(2), 157-173.

Cysek. M. M. (2021) *Walkability – the New Urbanism principle for urban*. Journal of Urbanism: International Research on Placemaking and Urban Sustainability Volume 14, 2021 - Issue 4 regeneration

Dovey K., Pafka E. (2020) "*What is walkability? The urban DMA" 1*

Duany A. Speck J. Lydon M. (2009) The Smart Growth Manual: New Urbanism in American Communities. McGraw Hill

Gratz J.R.B. Norman M. *Cities Back From The Edge: New Life for Downtown*. New York: John Wiley and Sons, 1998

Gehl N. Svarre B. (2013). *How to study public life*. Island Press.

Jacobs J. (1985) *Cities and the Wealth of Nations: Principles of Economic Life.* Random House.

Jacobs J. (1992) *The Death and Life of Great American Cities*. Vintage Books

Katz P. (1993) *The New Urbanism: Toward an Architecture of Community*. McGraw Hill

Hall, P. (1990) *Cities of Tomorrow*. Oxford: Basil Blackwell, 1990

Littenberg, B. Peterson D. (2020*) Space and Anti-Space: The Fabric of Place, City and Architecture*

Montgomery C. (2014) *Happy City*. Farrar, Straus and Giroux

Newman O. (1974) *Defensible Space: Crime Prevention through Urban Design*

Overstreet K. (2021). *Exploring New Urbanism Principles in the 21st Century*

J. Sadik-Khan J. Solomonow S. (2017) *Streetfight: Handbook for an Urban Revolution*. Penguin Books

Santos et A. M. C. al. (2020) "*Walkability – the New Urbanism principle for urban regeneration*, SN Applied Sciences, 2020

Santos A. M. C et al. (2020) *"Planning and Design Support Tools for Walkability … - ResearchGate"*

Talen, E. (2012). *City rules: How regulations affect urban form.* Island Press.

Research Paper

Co-Evolutive Processes for Inward Urban Development

A Guideline for Planning Practice

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Prof. Dr. Ulrike STURM, Lucerne University of Applied Sciences and Arts, Switzerland

Abstract

Due to scarce land resources, population growth and strict legislation, Switzerland urgently needs to densify and develop existing settlement areas inwards. But this is easier said than done. The usual approaches applied in practice are not efficient and effective enough. And they fail the longer the more due to the resistance of opposing stakeholder groups. Therefore, the authors, based on the exploitation of 18 case studies, additional expert and stakeholder interviews and their own practical know-how on planning project management and stakeholder processes, developed a new approach: The co-evolutive process for complex planning situations like inward urban development. In this process problem analysis, solution finding and implementation measures are developed in a continuous and structured dialogue between (external) planning experts and all relevant (local) stakeholders. This article presents the most important excerpts from the corresponding guideline which was published in German in March 2023. This is because the methodology could also be helpful for other urban planning challenges with a certain technical and societal complexity.

Keywords

Densification, Methodology, Process Design, Stakeholder, Participation, Switzerland

1. Introduction

Urban growth traditionally led to expansion in the surrounding landscape. And such greenfield development is what the modern urban planning was originally conceived for. However, with rapid urbanisation all around the world, planning is more and more confronted with the limited availability of further land to expand on. In addition, the increasing competition between land uses for energy and food production as well as for biodiversity highlights the urgency of using land economically for settlements, even for countries that have more land reserves than Switzerland. Therefore, a different mode of planning is needed: “Innenentwicklung” as it is called in the German-speaking planning world, which could best be translated as “Inward Urban Development” or “Settlement Densification”.

This development within the existing urban fabric is not completely new for planning: Since decades, we have known brownfield development of derelict industrial, railway and military areas. Even though brownfields are technically more complicated due to contaminations, infrastructures, protected buildings etc., they still have the advantage that they belong to only one (or a few) owners and have no directly affected residents and employees. So, basically, brownfields and vacant lots can be re-developed in almost the same planning approach as greenfields, based on professional experts’ proposals. But what if

such brownfield developments are not sufficient to provide the necessary capacity within the given urban limits?!? Then the densification of inhabited and still-in-use urbanised neighbourhoods is inevitable. At least in democratic countries where citizens have a say, the planning process for such densification reaches a level of complexity that fundamentally changes the way planning can be done and the role of professional planning experts.

Switzerland can serve as an exemplary test case for this: First, Switzerland has a growing economy and population. The statistical forecasts predict a nationwide population growth of +10-31% until 2050 (BfS 2020), even more in urban areas. Second, in Switzerland – unlike most other countries – zoning decisions are taken at the municipal level: in Switzerland´s direct democracy, zoning decisions are taken by the municipal assembly (or parliament) in most of the 26 states (cantons). And third, in a 2013 referendum, an amendment to the Swiss federal planning law to stop urban sprawl and do promote inward settlement development was approved by nearby 2/3 of the voters. In force for almost 10 years, this legal basis strictly limits urban development to already existing building zones – with almost no exeption. And since centrally located brownfields have already been almost completely re-developed in the last three decades in Switzerland, densification of urban areas is inevitable here.

Swiss planning practitioners facing this challenge have a widespread perception that every settlement densification project is unique, especially concerning the planning process. And therefore, the respective process design should be elaborately tailored to the specific project and its context. The authors, on the other hand, have a different perspective on the matter both from an applied scientific perspective and as reflective practitioners. Not only do they consider this approach as inefficient to achieve the challenge of the average +25% densification necessary within the building zones. They have also found that what has been called “tailor-made” in most cases has been just a “copy-paste-and-adapt” of projects known to the actual planner. And that these “tailor-made” processes consistently show similar flaws in process design and implementation. The authors have experienced in their own projects that independent from the individual case there seem to be repeating process patterns. This encouraged them to conduct an in-depth analysis of successful and failed densification processes, to identify decisive process patterns and to use them to create a guideline for process design in settlement densification projects.

This paper first describes the research methodology. Then, mainly focuses on the three key elements of the guideline for densification processes. It concludes with some reflections on broader use.

The scholarly literature on which inward urban development can be based, is rather sparse (KNIELING 2018, STURM 2018, PAHL-WEBER 2022). And on future-proof spatial planning processes, it is almost inexistent (TERRYN 2016). This is due to the fact, that doing spatial planning is strongly influenced by the respective understanding of the state and the basic property rights as well as planning procedures given in the respective country. E.g. Switzerland can be described as a bottom-up federal state (like the U.S.), with an uninterrupted bourgeois-liberal understanding (since 1848), extensive property rights and direct democratic planning procedures (which slightly differ from canton to canton). This situation makes academic exchange on planning implementation questions across national and language borders difficult, as the commonalities often disappear behind the specifics of the individual case. Or because actual or supposed similarities have to be addressed differently, depending on the specific state system.

2. Methodology

For this guide, 18 different examples of inward urban development projects were analysed in terms of their process design. These cases cover different planning statuses, starting points and process efforts. Also, the processes were designed by different project leaders. The sample consists of negotiation processes carried out by the HSLU Lucerne University of Applied Sciences and Arts within the framework of the model project Sustainable Spatial Development "Network for the Cooperative Implementation of

Interior Development" from 2014 to 2018. The sample was enriched with other larger and smaller projects contributed by the OST Eastern Switzerland University of Applied Sciences to obtain a broader picture and to be able to make more comprehensive comparisons.

The analysis of already completed project phases was carried out retrospectively to. As different as the projects were, the project phases examined are always the phase of analysis, solution finding and strategy development, before the legal planning procedure with the legally required public participation takes place.

First, a desktop analysis of official, semi-official and working documents on 18 successful and failed processes was conducted. Then, the project designers of 14 processes were interviewed about the reasons for the chosen process design, the stakeholders involved and methods of implementation. In addition, some municipalities were asked how they experienced and assess the process carried out in order to include a wider perspective. With this information, the individual case studies were described in project profiles.

By analysing these case studies and reflecting on them against the background of planning, project management and participation theory, it was possible to distinguish commonalities and differences in the process design. And identify the three core elements as described in the next chapter:

- Guiding principles (3.1),

- project organisation (3.2) and

- process structuring (3.3).

3. Guideline Co-evolutive Processes

This guideline contains some quite well-known and established rules for the design and management of planning process. The very essential new element – necessary to manage the complexity of densifying built environments – is the co-evolutive (or collaborative) planning process. This is based on a structured and equal dialogue between qualified planning experts and the relevant stakeholders. And it starts already with problem analysis and continues through solution finding to implementation measures.

3.1. Guiding Principles for Process Design and Management

The aim of co-evolutive inward urban development processes is to create a development concept for certain parcels, areas or neighbourhoods that is both technically feasible and acceptable to local society and serves as the basis for the formal planning implementation, thus representing the first step in planning. This approach may seem more expensive than a purely expert-driven conceptual phase at the first sight. But it is much more politically and financially advantageous than saving an expert planning process that is about to fail (or even has failed) in the final phase because of unforeseen resistance from important stakeholders.

Such a co-evolutive process follows certain guiding principles, which are briefly described below:

1. Site-Specific Analysis
   Every inward urban development is highly dependent on its location. A careful analysis of building and open space structures is necessary, but not sufficient. It has to be complemented by an analysis of the stakeholders that are potentially affected by the development. And it has to be completed by an analysis of the political-legal framework, governance structures and political culture. This provides a wholistic picture of the space of intervention and its margins at an early stage and helps to develop an adequate process design.

2. Multi-Perspective as Core Element
   Core elements of co-evolutive processes are the composition and roles of the stakeholders involved. The perspectives of landowners, developers, inhabitants, employees, neighbours etc. can differ significantly. In addition to the actors who steer the planning process (public administration, landowners, planners), an early and well-structured involvement of the most relevant (influential / affected) stakeholders in the planning process is recommended. This is because the more relevant perspectives are included in the process, the more feasible and acceptable the jointly developed solution will be.

Figure 2: Stakeholder Matrix (interest in / influence on the project). Source: Zurfluh, Sturm, Schneider 2023

3. Core Organisation and Roles
   A straightforward core organisation consists of the commissioning body (f.e. municipality / land owner, developer), the steering group, the project management and the project team. It is important that these actors actively perform their specific roles.

4. Co-evolutive Procedural Logic
   Different stakeholders bring different knowledge and perspectives into the process. A well composed group of relevant stakeholders (e.g. municipality, landowners, neighbours, citizens, environmental organisations etc.) can be understood as model representation of the project's reality. Not just involving planning professionals in the solution finding, but reflecting and discussing their proposals in stakeholder workshops several times, contributes significantly to finding the most feasible development concept. It also creates a mutual understanding between the different stakeholders that increases acceptance and allows compromises to be made.

5. Translation
   Such exchanges need a neutral moderation, translation services for a better understanding among stakeholders and specialists as well as proper documentation of workshops and results.

6. Different Scenarios
   In co-evolutive planning processes, the planning experts' task is to show the spectrum of what is technically feasible with 3-5 different scenarios. The discussion and recommendation of what is the best scenario to realize, on the other hand, is the group task of the relevant stakeholders involved.

7. Process Design in Prefabricated Sizes
   The specific process design is developed from the prefabricated sample process S, M, L or even XL, depending on the complexity of the analysed situation.

3.2. Project Structure, Stakeholders and Roles

The project structure of a co-evolutive project consists of the commissioning body (Auftraggeberschaft), the steering group (Steuerungsgruppe), the project management (Projektleitung), the project team (Projektteam).

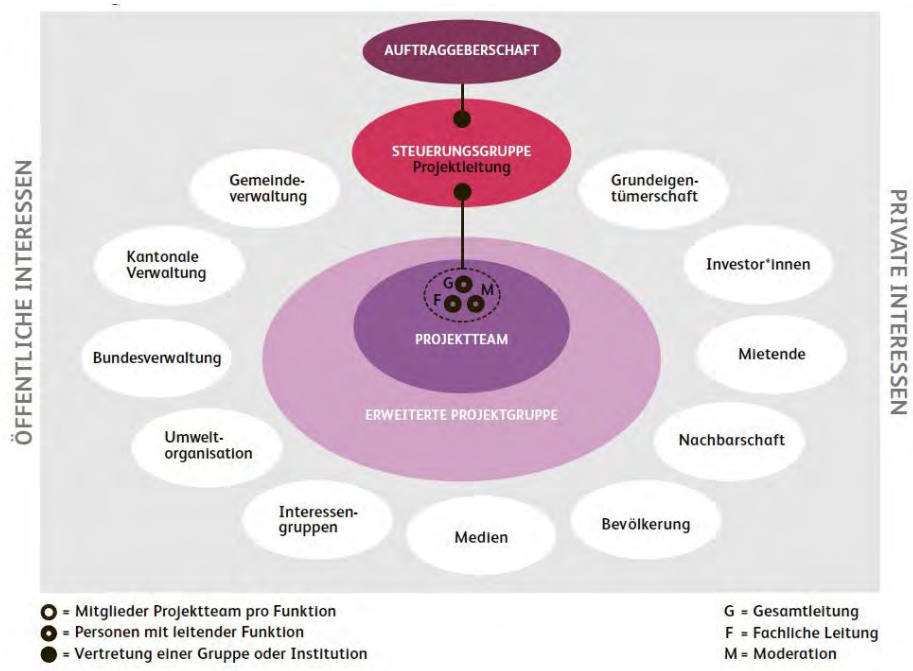

Figure 2: General project structure with possible actors constellation. Source: Zurfluh/Sturm/Schneider 2023

Two particular features of a co-evolutive process need to be mentioned here:

- First, there is an extended project group (erweiterte Projektgruppe) of stakeholders who have identified as relevant and who are invited to get directly involved in the project. They are recruited from the different stakeholder groups that exist around an urban densification project (e.g. landowners, investors, tenants, neighbours, population, media, interest groups, environmental organisations, federal / cantonal / municipal administration). The extended project group periodically mirrors the project teams' work on analyses, solution scenarios and implementation proposals.
- Second, as a rule of thumb the project management (Projektleitung) consists of at least two persons. The two roles of technical management (F = fachliche Leitung), bringing forward content and process, and of neutral moderation (M = Moderation), enabling a productive exchange between extended project group (erweiterte Projektgruppe) and broader public with the core project organisation, are completely different. Whether overall project management (G = Gesamtprojektleitung) is done by one of these two, or whether this role is performed by a separate person, depends on the size and complexity of the project.

For each actor group the guideline describes their role, composition, involvement and tasks. The following description summarizes this briefly:

The **commissioning body** (or client) carries the process and sets the framework. Throughout the process, it is responsible for showing leadership to connect the different phases of the process and to drive the process forward even in critical phases. The commissioning body informs and invites to the different activities. Basically, the process is financed by it as well.

The **steering group**, in which the commissioning body and the project management as well as other participants are represented, represents the link between the client and the project team working on the project. In terms of operational and content-related preparation and follow-up of the events, the steering group evaluates the results of analyses and workshops, assesses the scenarios, and makes both preliminary decisions on content and decisions on the procedural steps.

The **project management** is responsible for the conception, cooperation and operational steering of the planning process. In this role, the project leader is the person in the steering group who actively acts as a link between the commissioning body and the project team. The tasks of the project leader include both observing the environment and organizing the exchange with the extended project group. Therefore, the project leader needs both spatial planning and facilitation knowledge and skills in both spatial planning and facilitation. In processes of larger than S, there are therefore often two persons in the role of the technical project management on the one hand and the neutral moderation of the events on the other.

The **project team** carries out the technical planning (including the drafting of the scenarios) and the neutral moderation. It receives its work assignments from the project management. The steering group decides on the content and procedure of the work assignments. The members of the project team must be interested in and open to other points of view.

The members of the **extended project group**, who were specifically selected in the stakeholder analysis, actively contribute to the formulation of needs, bring in local-specific knowledge and help shape the development concept through the formats of involvement chosen in the participatory process.

3.3. Process Structuring in Prefabricated Samples S, M, L, XL

The prefabricated sample processes are the core of the guideline. They focus on the strategy defining phase of inward urban development. The distinctive feature of these processes lies in the co-evolutive way of working with an extended project group, which is determined in the first phase. Usually, at least some of the stakeholders in the extended project group are already connected by social relations before the beginning. They and others identified in the stakeholder analysis have specific knowledge plus interests / stakes and, accordingly, their own perspective on the problems and issues of urban development. These different bodies of knowledge and points of view need to be communicated and translated in the process. On the one hand, this involves translating the technical dimension into the practical dimension of everyday life; on the other hand, it involves bringing together, but also bringing closer, different perspectives, for example those of the different property owners involved.

For the co-evolutive process, it is crucial that the different analyses and proposals developed by the planning experts are realistic and plausible. And that the desired target state is compatible and achievable from the actual state with the available resources (no cloud castles). The co-evolutive approach is fundamentally goal-oriented but open-ended. Since the planning is done in the interaction of diverse stakeholders and depending on previous decisions, its result is not predictable. In order to make different possibilities more tangible for the stakeholders involved, three to five densification scenarios are conceived that build on existing knowledge, are technically plausible and feasible. The different scenarios are presented to the extended project group (e.g. landowners, residents, population, economy), in the context of a workshop or a similar setting, and their views are heard. This can result in one or two favoured scenarios, or a new scenario may be developed as a combination of various elements of the scenarios presented. But if so, the new scenario must also be technically plausible and feasible and must be aligned with the political strategy or inward urban development strategy of the municipality.

Since the process is site- or situation-specific, the project structure, process and implementation vary in complexity. It can be less complex (S for Small), more complex (M for Medium) or very complex (L for Large). The size XL is reserved for development projects with an extremely high degree of complexity and represents a special case in this context, where a customised procedure is recommendable.

The process for creating an inward urban development strategy consists of five phases. After the clarification of the assignment and the start of the project (1), an analysis (2) and the development of a master plan (3) follow. Once this is defined, an implementation plan (4) is drawn up, which also outlines the project follow-up (5). The starting phase (1) is important in that proper project setup is the foundation for any successful project. The core of the co-evolutive model processes are phases 2-4 (analysis, master plan, implementation plan). These phases form a unit, as their result is a development strategy, which includes a master plan and the necessary implementation steps for further development. Since the concrete implementation usually takes place as a separate project, quite often with other experts commissioned, it is necessary to have a project follow-up phase (5) as well. Especially if the project team changes, it is crucial to ensure the implementation in the sense of the stakeholders involved. Therefore, it is essential not only to carry out a simple handover of the development strategy itself (document), but a full transfer of background knowledge between the "development strategy" team and the "follow-up project" team (oral history).

To illustrate this structure, process and implementation for the case of a slightly complex project (M size) are presented below:

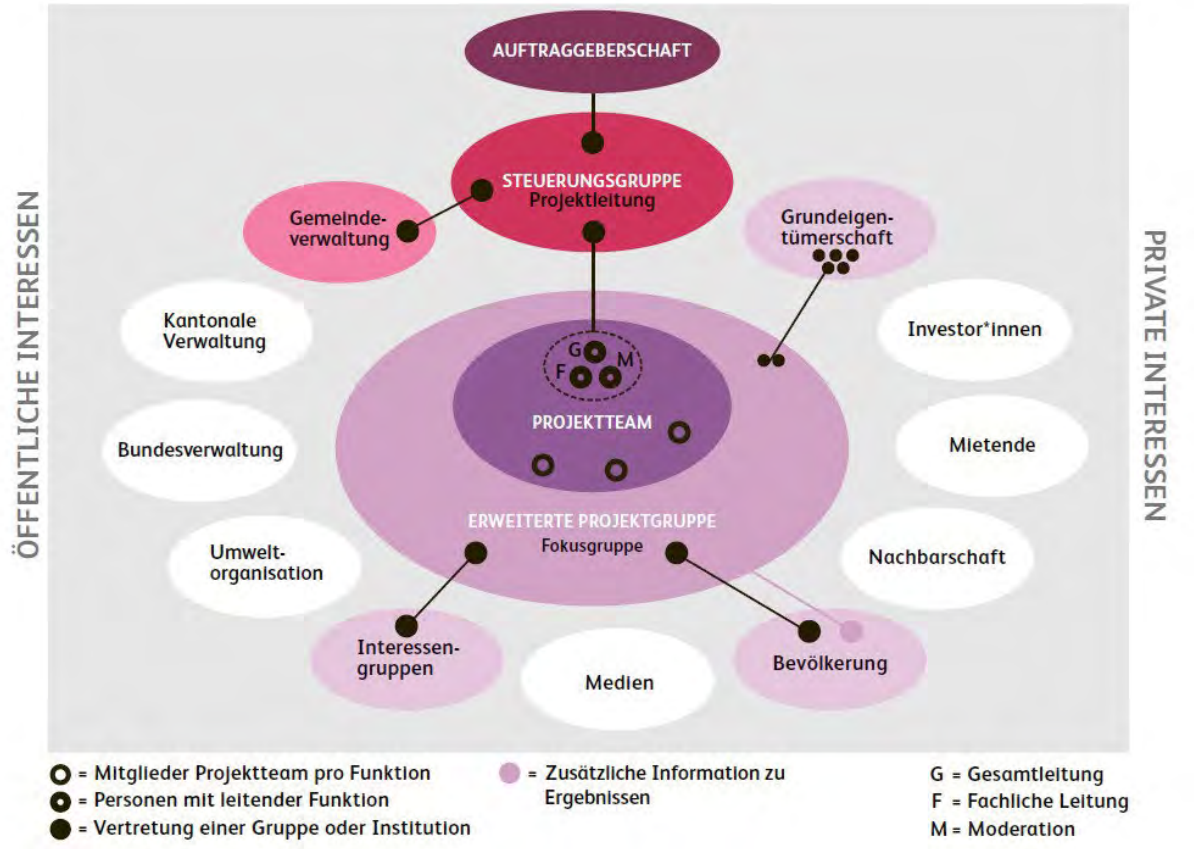

Figure 3: Generic project structure M. Source: Zurfluh/Sturm/Schneider 2023

The structure of a M size project is characterized by a larger group of institutions/groups having relevant stakes in the process. The steering group consists of at least delegates of the commissioning body (municipal executive or private), the project management and possibly others (e.g. municipality administration). The project team consists of the project management (e.g. leader/technical

management + moderator) and the necessary experts or working groups (e.g. planning, urban design, mobility, real estate, participation etc.) The extended project group consists of some representatives of landowners and other relevant stakeholder groups (e.g. population and local interest groups). Its size should ideally not be larger than 12 persons to allow direct and in-depth discussions. Broader population and media are clearly not part of it, but they are periodically informed about intermediate results via the steering group.

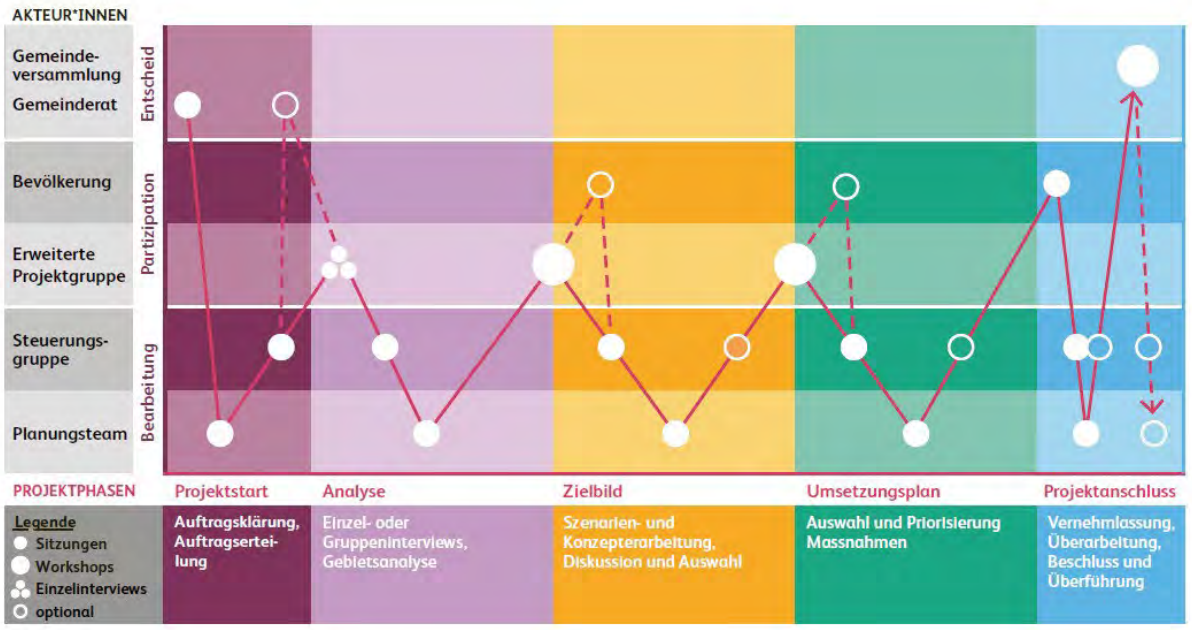

Figure 4: Generic project process M. Source: Zurfluh/Sturm/Schneider 2023

Figure 4 shows the generic process with its 5 phases. Characteristic for the co-evolutive approach is the zigzagging “fever curve” between the project team’s proposals and their evaluation in the extended project group.

The starting phase (1) often has two parts. Before the operational start in most cases a clarification of the project between commissioning body (or client) and project team/management is necessary. It must not only clarify framework conditions, the main task and the expected follow-up process. It also includes a rough perimeter definition, an approximate stakeholder analysis, the process design and role allocation. In the process design the essential elements for the analysis (2), master plan (3) and implementation plan (4) phases are agreed. The role allocation defines, who represents the commissioning body, who are the project management & team (technical & moderation), who else is in the steering group and the rough composition of the extended project group. And it ends with the installation of the steering group. In the second part, the project team starts and carries out an in-depth stakeholder analysis, which also has an impact on the precise perimeter delineation. In a simple case this can be exactly the perimeter that is to be densified, although potential side effects (e.g. street capacity, relocation of uses) must always be considered. On this basis, the steering group defines the exact perimeter and determines the persons to be invited to the extended project group. And if population should get involved, the steering group also defines the communication and participation concept. Then, the project management specifies the process design and establishes a time schedule. And the municipality as part of the commissioning body informs the broader public about the starting project in general and invites the persons nominated for the extended project group to participate actively.

In the analysis phase (2) surveys are required at various levels, which are commissioned by the steering group to the planning team (or other suitable experts). One part is, to benefit from the local knowledge

and perspectives of the different stakeholders. Their knowledge of the planning perimeter, its history and potential visions for the future can be well contributed through workshops or focus groups. However, talking about one´s own needs, concerns and intentions (especially of landowners) is practically only possible in confidential individual interviews carried out by the project management itself. These interview results may be only passed on in aggregated form to the steering group and extended working group. The other part is the classical analysis of the built environment, its development and the relevant planning framework conditions to observe. The steering group reviews the results of the analyses and, on this basis, formulates the design mandate for the project team for 3-5 draft masterplan scenarios.

The masterplan phase (3) also consists of two parts. It starts with the (technical) project team drafting 3-5 technically feasible scenarios for the future development of the site. In parallel, the (moderating) project team drafts the script for the extended project group workshop. The steering group reviews these and excludes scenarios that clearly contradict political or financial feasibility, or refines the workshop script. The project team makes the necessary adjustments to scenarios and script. Then the first workshop of the extended project group takes place: The aggregated analysis results as well as 3-4 scenarios from it are presented to and discussed with the stakeholders. Steering group, (technical) project management and team members are present, give short (!) inputs, answer questions but otherwise mainly listen. The neutral moderator, on the other hand, addresses and discusses the opportunities and challenges of the different scenarios with the different stakeholders. The feedbacks, as well as favourites and no-goes are directly documented during the event. For a broader involvement of the population, the steering group can hold an initial information event on the analysis results and approximate scenario preferences directly afterwards. This first part of the phase will be concluded by the steering group meeting, which will define the best scenario (ideally a favorite core scenario, adapted to the feedback). For the second part of this phase, the project team is commissioned to detail out this best scenario into a draft masterplan, draft the crucial implementation measures and the script for a second workshop. Once these elements are drafted, the steering group reviews them. The project team then prepares the second workshop, where the developed draft masterplan and the implementation concept are discussed by the extended project group (according to the same setting as in the first workshop). The moderation team documents the feedback and addresses the level of consensus on the draft masterplan in general, its individual specifications and the implementation ideas. For the broader population, the steering group may prepare an information and discussion event on the main features of the masterplan and its implementation at the end of this phase.

The implementation plan phase (4) starts with a steering group meeting to analyze the feedback from the stakeholder workshop and the public discussion. Based on this, it commissions the project team to consolidate and finalize the masterplan and to work out the implementation plan. Once these work results are available, the steering group may review these, before it organizes an information and participation event/process on the nearly complete development strategy (masterplan + implementation plan).

In the project follow-up phase (5), the steering group first evaluates the feedbacks from public participation and commissions the project team with last adjustments. Then, the finalized development strategy is submitted for formal decision to the commissioning body (e.g. municipality executive). For development strategy implementation follow new commissions; if completely new planning teams are involved, it is crucial that not only the plans but the background knowledge are handed over.

4. Conclusion

The co-evolutive process for inward-urban development projects outlined in the guideline is still new and not very widespread. The sample processes S-M-L(-XL) for projects of different complexity and size outline how process design and participation for site and area developments (or in a similar way also for

inward development strategies of municipalities) can be improved. The aim is to help more good-quality settlement densification projects to achieve a breakthrough.

It should not be concealed that the co-evolutive approach appears at first glance to be more time-consuming than a conventional approach with minimal participation. According to the experience of the authors, the purely technical planning work in co-evolutive processes accounts only for a good half to two thirds of the total effort. However, the conventional approach to densification projects very often and systematically underestimates the complexity of the situation. On the one hand, this leads to allegedly "unforeseeable" additional expenses, delays and process adjustments that require significantly more money and time than originally planned. On the other hand, entire inward urban development projects fail more and more often in the Swiss political process because individual interest groups can unsettle the voters. This results in a loss of face for the politicians, initiators and experts involved, as well as a "scorched earth" where settlement densification can only be discussed again after about a decade. The co-evolutive approach is therefore not favourable at first glance, but much more efficient and effective at second glance.

We hope that with this article we could give an insight into the currant challenges of Swiss inward urban development and present a guideline on how to address them effectively and efficiently. We assume, however, that with the co-evolutive methodology we have developed even more: an elementary new approach to solve really complex urban planning tasks, by a dialogue at eye level between (external) planning experts and (local) stakeholders or “experts of their own everyday life”!

The authors are grateful for any feedback and comment regarding possible further development of their concept.

5. References

BfS Bundesamt für Statisik (2020) *Szenarien zur Bevölkerungsentwicklung der Schweiz und der Kantone 2020-2050.* Available at: https://www.bfs.admin.ch/bfs/de/home/statistiken/bevoelkerung/zukuenftige-entwicklung/kantonale-szenarien.assetdetail.14963221.html (Accessed 1 July 2023)

Knieling, J. (2018) *Kooperative Planung* in Akademie für Raumforschung und Landesplanung ARL (Eds.) *Handwörterbuch der Stadt- und Raumentwicklung*. Hannover, Akademie für Raumforschung und Landesplanung ARL, p. 1229–1236.

Pahl-Weber, E., Jeutner, M., Flade, K., Gabsch, G. (2022) *Leitfaden Ko-Kreation: Urbane Transformationen mit Urban Design Thinking*. Universitätsverlag der TU Berlin.

Sturm, U., Duss, A., Bodammer, A., Aeschlimann, L. (2018) *Kooperative Verfahren zur Siedlungsentwicklung nach innen. Auf dem Weg zu einer neuen Planungskultur*. in Sturm, U., Lienhard, M. (Eds.) *Kooperation Bau und Raum, Neue interdisziplinäre Wege in Forschung und Praxis*. Zürich, vdf Hochschulverlag, p. 23–42.

Terryn, E., Boelens, L., Pisman, A. (2016) *Beyond the divide: evaluation in co-evolutionary spatial planning* in European Planning Studies 24 (6), p. 1079–1097. Available at: https://doi.org/10.1080/09654313.2016.1154019 (Acessed 1 July 2023)

Zurfluh, J., Sturm, U., Schneider, A., Näther, C., Jordi, T., Bodammer, A. (2023) *Leitfaden ko-evolutive Innenentwicklungs-Prozesse.* Luzern & Rapperswil, Hochschule Luzern & Ostschweizer Fachhochschule.

TRACK 3:
INVEST wisely

Invest in Strengthening Urban Resilience

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Exploring the resilience evolution law of Shenzhen's ecological network

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Construction of ecological space control path from the perspective of ecosystem service function: a case study of Dujiangyan City

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The “greenification” of the central business district of Jakarta: one small step for Jakarta’s commercial property, one giant leap for Indonesia’s sustainable investment

Research Paper

Exploring the resilience evolution law of Shenzhen's ecological network

Zhijie MA, Chongqing University, China

Abstract

In order to explore the resilience evolution law of urban ecological network, in the cross field of urban planning, landscape ecology and complexity science, this paper adopts the principles and methods of landscape ecology and complex network analysis, selects Shenzhen as the research area, constructs multiple ecological networks based on 8 years' land cover data, and identifies ecological network clusters at the optimal scale through the percolation theory. This paper reveals the evolution characteristics of urban ecological network from monocentric network structure to polycentric network structure under the background of rapid urbanization, and the trend of stable ecological network cluster pattern but declining ability to control urban expansion and to separate urban centres, which provides an idea for evaluating the impact of urban master planning and ecological planning policies on urban ecological network's resilience.

Keywords

Resilience, Ecological Network, Evolution, Shenzhen

1. Introduction

Worldwide urban ecological space is facing the risk of encroachment by urban expansion in the process of urbanization, which will lead to a series of ecological and environmental problems that increase the vulnerability of cities. Improving the resilience of ecological space is an important measure for countries and cities to achieve sustainable development. Western world has long explored ecological spatial structure models to limit urban expansion and to protect ecological space, such as Pan-European Ecological Network, London Green Belt and Maryland Green Infrastructure. In China, ecological space control policies of Beijing Green Belt, Shanghai Green Belt and Shenzhen Ecological Redline have achieved certain effects in protecting urban ecological resources and building urban ecological security pattern in early stages, but the phenomenon of erosion of structural green space and breaking the ecological redline still exists. The resilience of urban ecological space fails under the risk of continuous urbanization. Measuring the evolution characteristics of resilience of urban ecological space of the past and mastering the dynamic law of urban ecological security pattern are of great significance for developing strategies for improving resilience of urban ecological space under the background of rigid urban development needs.

Research on the relationship between urban space and ecological space can be divided into three categories. The erosion impact of urban expansion on ecological space, the constraints of ecological space on urban space, and the coupling effect of urban space expansion and ecological space protection (Ouyang et al, 2021). When studying the effect of ecological space on urban construction land, urban expansion has been simulated based on ecological constraint mechanism to delineate urban development boundaries (Sun et al. 2021).

Under the influence of urbanization expansion and clustering of human activities, different research fields have different research emphases on ecological spatial resilience. Geography pays attention to the change characteristics of resilience indicators constructed by economic, social, geographical and ecological factors that affect regional ecological environment, so as to identify the differences in resilience levels in different regions and propose strategies to improve resilience from various aspects (Tao et al, 2022; Zeng et al, 2022; Wang et al, 2021; Xia et al. 2022). Ecosystem ecology focuses on the ability of ecosystems to maintain and restore their own provisioning, regulating, supporting and cultural services in order to sustain regional natural life systems (Liu et al, 2023). Landscape ecology focuses on the ability of ecological landscape patches to maintain and restore original landscape size, composition, quality, form and pattern, so as to construct regional ecological security pattern (Shi et al, 2023; Niu et al, 2019). Conservation biology focuses on the ability of landscape ecological network to maintain and restore connectivity, so as to ensure species migration and protect biodiversity (Andrea et al, 2019; Isaac et al, 2018). The research method of landscape ecological network has been extended to the field of urban planning to represent urban ecological spatial structure. The measurement of resilience indicators such as connectivity and redundancy can provide a basis for realizing habitat restoration, protecting and maintaining regional ecological security pattern (Xu et al, 2022; Song et al, 2021). In general, the measurement of the resilience of ecological space pays more attention to the ability of ecological space to maintain its own landscape pattern, ecological process and ecosystem services after being disturbed, while there is a lack of research on the feedback effect of ecological space on urban construction land, such as the ability to restrict the expansion of urban construction land and isolate urban centres.

Taking Shenzhen as an example, this paper constructs ecological networks to represent the urban ecological spatial structure based on the structural connectivity among landscape ecological patches, identifies ecological network clusters at the optimal scale through the percolation theory, and analyses the changes of ecological networks' ability to control urban expansion and to separate urban centres over the years, so as to explore the resilience evolution law of ecological space in response to urban expansion under the background of rapid urbanization. This paper provides reference for the optimization of urban ecological security pattern and the practice of resilient cities.

2. Literature review

2.1. Mechanism of ecological network construction

Ecological network provides a new direction and method for the identification and analysis of ecological spatial structure. In terms of highly summarizing landscape pattern information, the traditional landscape pattern index can describe the overall characteristics of landscape form, while the ecological network based on graph theory emphasizes the relationship between landscape patches and has more advantages in describing the characteristics of hierarchical structure of ecological space (Liu et al, 2017).

There are two main mechanisms of ecological network construction. Namely structural connectivity and functional connectivity (Susanne et al, 2010) (Table 1). Structural connectivity refers to the connection of landscape patches in spatial structure, focusing on the continuity of landscape patches. Euclidean distance between patches is often used to describe the physical relationship between them. Functional connectivity refers to the connection between landscape patches in terms of function and ecological processes. It focuses on the exchange of matter and energy between landscape patches, and takes into account environmental influences during species diffusion, such as urban roads, terrain, vegetation cover, construction land and other influencing factors. Scholars often simulate the migration path of species based on cost-distance methods, such as minimum cost distance, minimum cumulative resistance model, circuit theory, etc., and use the furthest migration distance of species to represent the dispersal ability of

species. The two ecological network construction mechanisms can summarize the degree of landscape patch connection and proximity to a certain extent. This paper emphasizes the physical connection of landscape patches in spatial structure, so the ecological network construction method based on structural connectivity is more suitable for this paper.

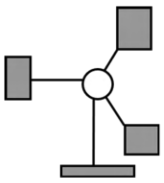
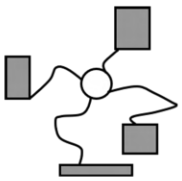
Construction mechanism	Structural connectivity	Functional connectivity
Graphical representation		
Construction method	Proximity Euclidean distance	Cost distance (Minimum cost path, minimum cumulative resistance model, circuit theory)
Connection connotation	Landscape patch connection	Potential ecological corridor, potential species migration path, species diffusion ability, etc
Research focus	The continuity of landscape	The ecological process of landscape

Table 1. Structural connectivity and functional connectivity diagram, construction method, connotation and research focus. Source: Author.

2.2. The connotation and measurement of resilience, ecological resilience and ecological network resilience

Resilience can be divided into three research perspectives. Engineering resilience refers to the ability of the whole system to restore to the equilibrium state or stable state before the disturbance (Holling, 1973). Ecological resilience means that the system can have multiple equilibrium states. The resilience of the system may not urge the system to recover to the original equilibrium state, but also guide the system to adjust itself and jump to the new equilibrium state (Holling, 1996). From the perspective of social ecological resilience, a region is a complex adaptive system without a stable equilibrium state, which adapts to long-term external environment changes by constantly adjusting its own structure and continues to grow (Walker et al, 2004). The overall cognition of resilience has changed from owning a single equilibrium steady state and multiple equilibrium steady state to owning no equilibrium steady state but constantly adapting and adjusting.

In recent years, the rapid development of complex network science provides a new perspective for measuring the resilience of ecological space. Complex network theory can highly abstract the real ecological space into a topological structure, extract the topological relationship of ecological material, energy and information flow among ecological spaces, use indicators to measure the ability of ecological networks to keep running even after node and edge failures, and reveal the structural stability of ecological networks and the dynamic propagation characteristics under attack. At present, indicators such as connectivity, redundancy and network efficiency are commonly used to measure the resilience of urban ecological networks, focusing on the ability of network connectivity and operation when the network is attacked. In the context of rapid urbanization, the resilience of ecological networks should also focus on its ability to control urban expansion or to isolate urban construction clusters. Large contiguous green space and green belt play an important role in limiting urban expansion. The continuous expansion of urban construction land causes the fragmentation of ecological patches, and the barrier ability of ecological space to urban expansion is reduced. In highly urbanized areas, large green corridors are often

built between ecological clusters to limit urban expansion and isolate urban construction clusters, but such large green corridors often become just blueprint planning, which is eroded in the real urban construction. This paper constructs ecological network based on structural connectivity, identifies ecological network clusters based on percolation theory, and analyses the change of urban ecological spatial barrier ability by analysing the evolution of ecological network clusters.

3.Methodology

3.1. Study area and data collection

Shenzhen is located in the south of Guangdong Province, south of the Tropic of Cancer. Shenzhen has a subtropical monsoon climate, with an average annual rainfall of 1933.3mm. Shenzhen has a total area of 1996.9 square kilometres, wide from east to west, narrow in the middle. Landform types include hills, terraces and plains. The terrain is high in the east and low in the west, and the highest elevation is more than 900 meters. Hilly areas account for 39.6% of the total area, terraces, plains and plateaux account for about 20% of the total area. There are also some low mountains. Shenzhen has jurisdiction over nine administrative regions including Luohu, Futian, Nanshan, Yantian, Baoan, Longgang, Longhua, Guangming, Pingshan and Dapeng (Figure 1), among which Luohu, Futian, Nanshan and Yantian are the former Shenzhen Special Economic Zone.

Since the establishment of Shenzhen Special Economic Zone, it has experienced rapid urbanization process. Shenzhen's GDP has grown from 270 million yuan in 1980 to 276.70 billion yuan in 2020, ranking third in China. The resident population has increased from 332,900 in 1980 to 17,633,800 in 2020, with a population density of 8,828.1 people per km², second only to Macau (19,700 people per km²) in China. Urban construction land increased from 3 km² in 1980 to 1006 km² in 2020, accounting for 56.1% of the city's total area, far exceeding the international warning line of 30%. While Shenzhen has achieved rapid social and economic development, the continuous and rapid expansion of urban construction land has led to a decrease in the total amount of ecological land, and therefore the urban ecological resources are under great pressure, which is in contradiction with the people's ever-growing need for a beautiful ecological environment. At the same time, Shenzhen promulgated a series of ecological spatial planning policies, the main purpose is to protect the ecological environment and isolate the urban cluster, and further limiting the expansion of the city. However, Shenzhen's structural green space has been eroded over the years, failing to play its role of isolating urban clusters. With rigid urban development needs, Shenzhen's sustainable development is still facing severe challenges.

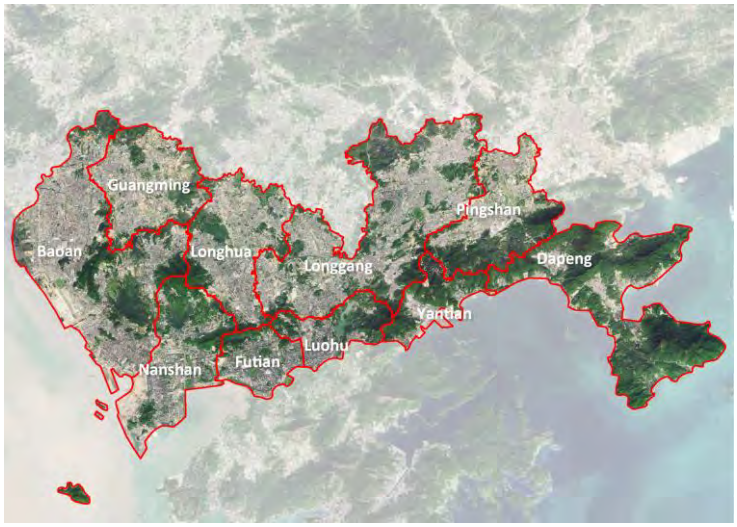


Figure 1. Administrative divisions of Shenzhen. Source: Author.

Data of this study includes the 30m resolution land use cover data of Shenzhen City in 1985, 1990, 1995, 2000, 2005, 2010, 2015 and 2020. The dataset is provided by Data Center for Resources and Environmental Sciences, Chinese Academy of Sciences(RESDC) (http://www.resdc.cn). Land cover data are manually corrected according to the visual interpretation of Landsat satellite images.

3.2. Ecological network construction

In the data preprocessing stage, the main task is to build the urban ecological network (Figure 2). In this study, based on land cover data, woodland, shrub, grassland and water were extracted as landscape ecological patches, and landscape ecological patches with an area larger than 0.1km² were screened as nodes of the ecological network, and adjacent landscape linkages were constructed based on Tyson polygon as edges of the ecological network. The weight of edges was the Euclidean distance between landscape ecological patches.

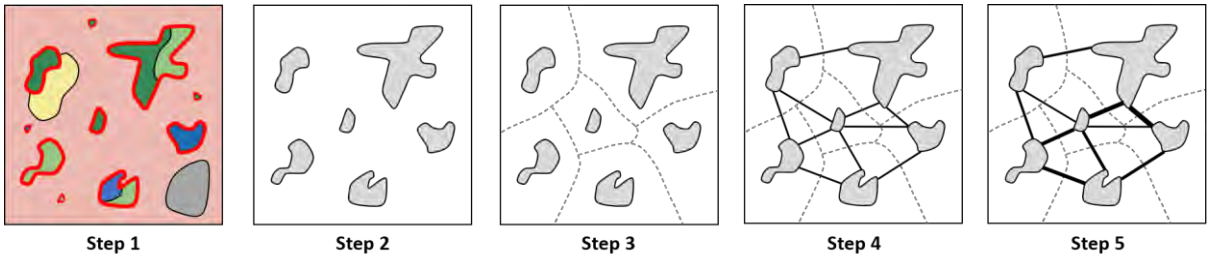


Figure 2. Construction of ecological network based on structural connectivity. Step 1: Woodland, shrub, grassland and water were extracted as landscape ecological patches; Step 2: The landscape ecological patches with an area greater than 0.1km² were screened; Step 3: Generating ecological patch field based on Tyson polygon; Step 4: Construct a network of adjacent landscape connections; Step 5: The Euclidian distance between patches is assigned as an edge weight. Source: Author.

3.3. Identification of ecological clusters at optimal scales

The identification of urban ecological clusters from the perspective of network percolation can be considered as a filtering model for low-probability ecological patch connections. For the ecological network generated based on structural connectivity, the connections whose distance is greater than the selected scale threshold are eliminated, and the unconnected ecological clusters in the remaining network are identified.

As shown in Figure 3, at distance scale 1, clusters A and B are formed by the interconnections between ecological patches. At distance scale 2, if the closest Euclidean distance between ecological patches is less than distance scale 2, the connection between them will be eliminated. Therefore, Cluster A splits into Cluster C1 and Cluster D1. At a smaller distance scale 3, the links between ecological patches are again eliminated, and the clusters size becomes smaller.

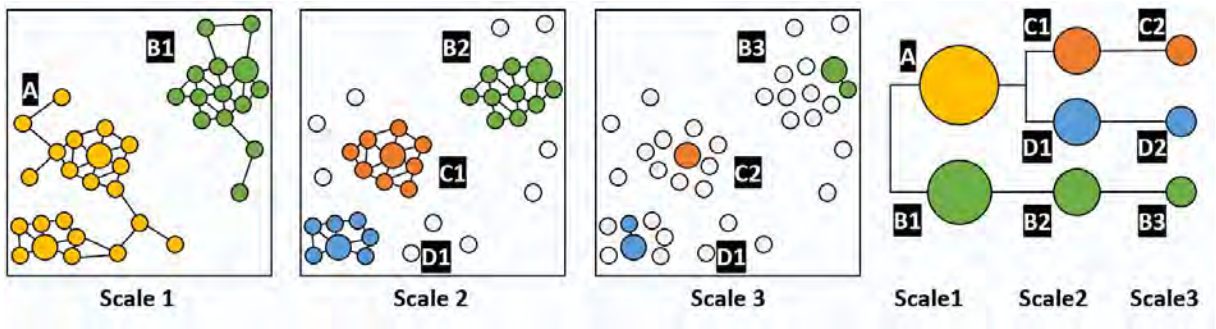


Figure 3. Ecological clusters identification based on percolation theory. Source: Author.

In order to identify the ecological clusters that can reflect the reality, the best distance scale should be selected. In this study, the edge of the ecological network was attacked from large to small according to the size of the distance, and the changes of the area of the largest ecological cluster and the area of the second largest ecological cluster were observed. The distance scale of the second largest ecological cluster reached the largest area and was about to decrease was determined as the best scale (Figure 4), which could be the basis for dividing the real ecological cluster.

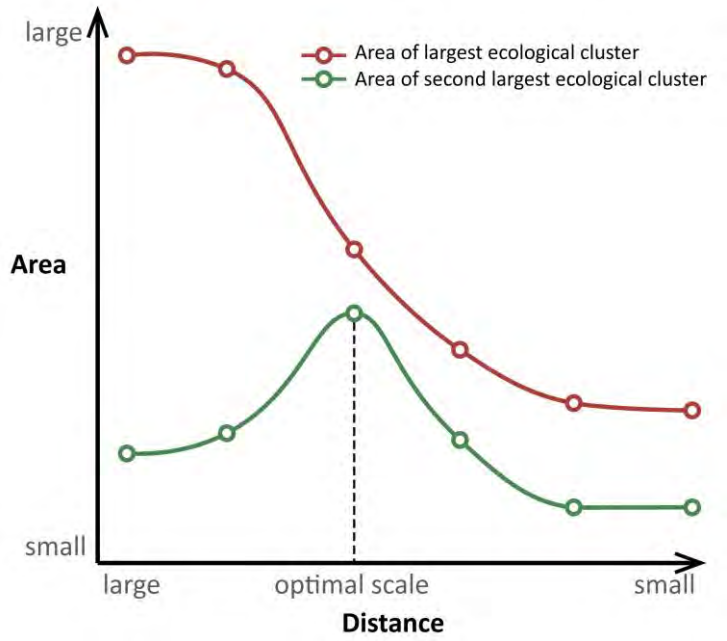


Figure 4. Optimal scale identification. Source: Author.

4. Result

4.1. Evolution of ecological network in Shenzhen

Fragmentation of ecological patches has led to the evolution of ecological network structure from monocentric network to polycentric network (Figure 5). In 1985 and 1990, the construction land of Shenzhen was concentrated in the special economic zone (Nanshan, Luohu and Futian). There was a huge ecological patch in the north, which was closely connected with other ecological patches around, and became the most centralized ecological patch in this period. At this time, the urban ecological space controlled the expansion of urban construction land from the urban periphery. In 1995, the number of ecological patches in Shenzhen changed dramatically. Due to the urban construction outside Shenzhen's special economic zone (Baoan, Longhua and Longgang), the huge ecological patch across Shenzhen was broken into multiple ecological patches dominated by mountains and reservoirs. Shenzhen's ecological network had changed from monocentric network to polycentric network since then. In 2000, ecological patches with high degree of centrality in the northwestern part of Shenzhen ecological network changed obviously, mainly through the conversion of cultivated land near mountains and reservoirs into grassland and forest land, briefly connecting several ecological patches with high degree of centrality in 1995 into one, and then urban expansion further broke the ecological patches into several. After 2005, ecological patches with high degree of centrality in Shenzhen were relatively stable, mainly because the Shenzhen Municipal People's Government promulgated the Regulations on the Management of Shenzhen Basic Ecological Control Lines in 2005. It delineated the basic ecological control lines in order to protect ecological patches of large size.

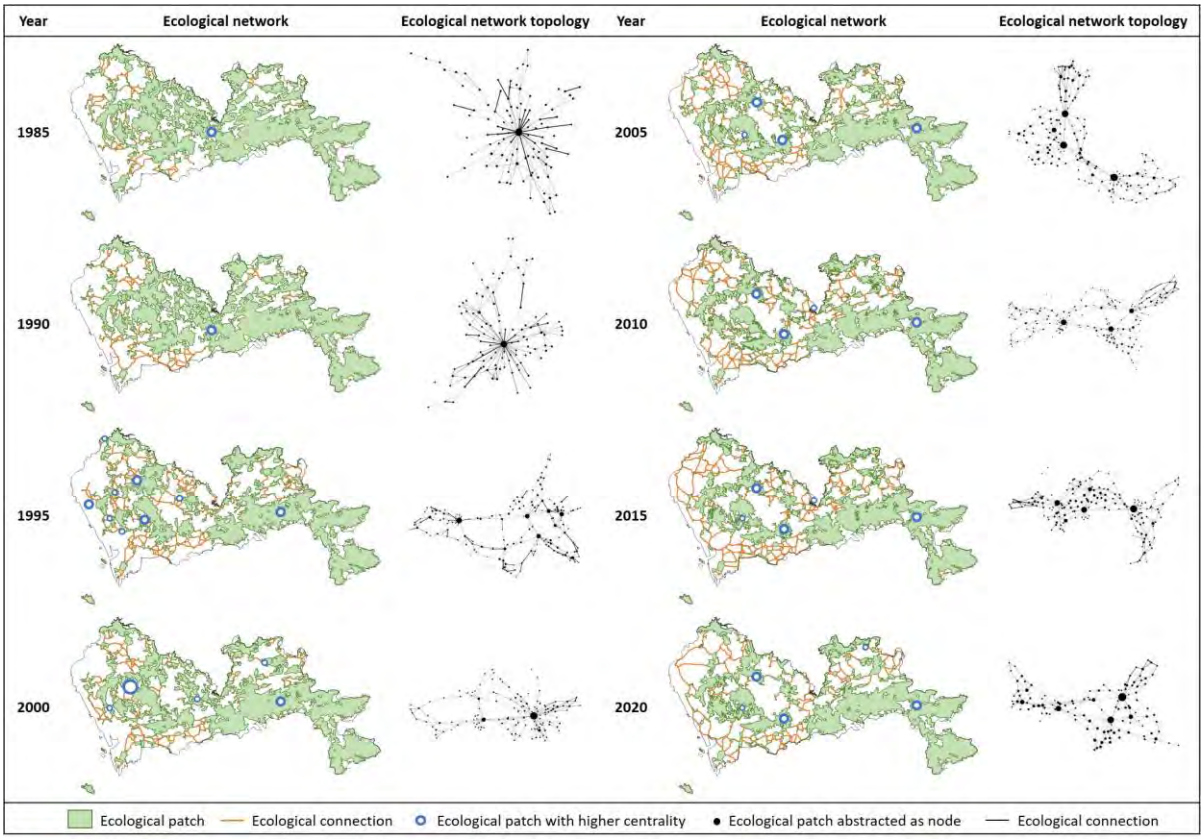


Figure 5. Ecological network and topology structure of Shenzhen City from 1985 to 2020. Source: Author.

4.2. Evolution of optimal distance scale of ecological network clusters in Shenzhen

The edges of ecological networks over the years are attacked from large to small according to the size of Euclidean distance of them. Then the scale when the area of the second largest ecological cluster reaches the largest and is about to decrease is selected as the best scale for dividing ecological clusters. Any edge whose size larger than the best distance scale is deleted, and the remaining interconnected ecological patches are ecological clusters. Ecological patches within the ecological clusters are closely connected, which serve as a large ecological entity to control urban expansion. It can be seen from Figure 6 that the variation of distance scale of ecological network over the years is in common with the size's changes of the first and second largest ecological clusters. When the size of the first largest ecological network cluster decreases sharply, the size of the second largest ecological network cluster increases sharply as well. The scale when both clusters' sizes change dramatically can better divide the real ecological clusters of the year from a more spatial perspective.

Distance scale can measure the closeness of urban ecological network clusters. The smaller the distance scale means that the ecological patch only needs a shorter distance to connect with the surrounding ecological patches and form ecological clusters. Similarly, the larger the distance scale, the greater the distance between ecological patches is required to achieve the connection among one another, and the smaller the tightness within the cluster. According to Figure 7, the optimal distance scale of ecological network in Shenzhen has shown a fluctuating growth since 1985. The optimal distance scale of the ecological network in 1985 and 1990 was 241m, and the ecological network was relatively stable and the ecological patches were relatively close in these five years. In 1995, the optimal distance scale of ecological network increased sharply, and the drastic development of urban construction land greatly increased the distance scale required for the formation of clusters among ecological patches. In 2000, the optimal distance scale of ecological network showed a decline, because the restoration of farmland and

green space reduced the distance required for the formation of ecological clusters. After intense development, the optimal distance scale in 2000 was 247m, which was almost the same as 241m in 1985 and 1990. This indicates that after the erosion of ecological network patches from 1985 to 2000, the patches in ecological network clusters were still able to maintain tightness among them, resist urban erosion, and effectively isolate urban construction clusters. Since 2000, with continuous urban expansion, optimal distance scale of ecological network has been increasing, and the tightness of the inner patches of ecological clusters has decreased. Therefore, the ability to resist urban expansion has become weaker. From 2005 to 2010, the development of urban construction was rapid, and optimal scale of ecological network changed dramatically. In general, the evolution of the optimal distance scale of the ecological network in Shenzhen showed certain resilience characteristics from 1985 to 2000, while continuous development and construction of the city after 2000 exceeded the resilience threshold of the ecological network, resulting in weaker ability of the ecological network to resist the erosion of urban construction land.

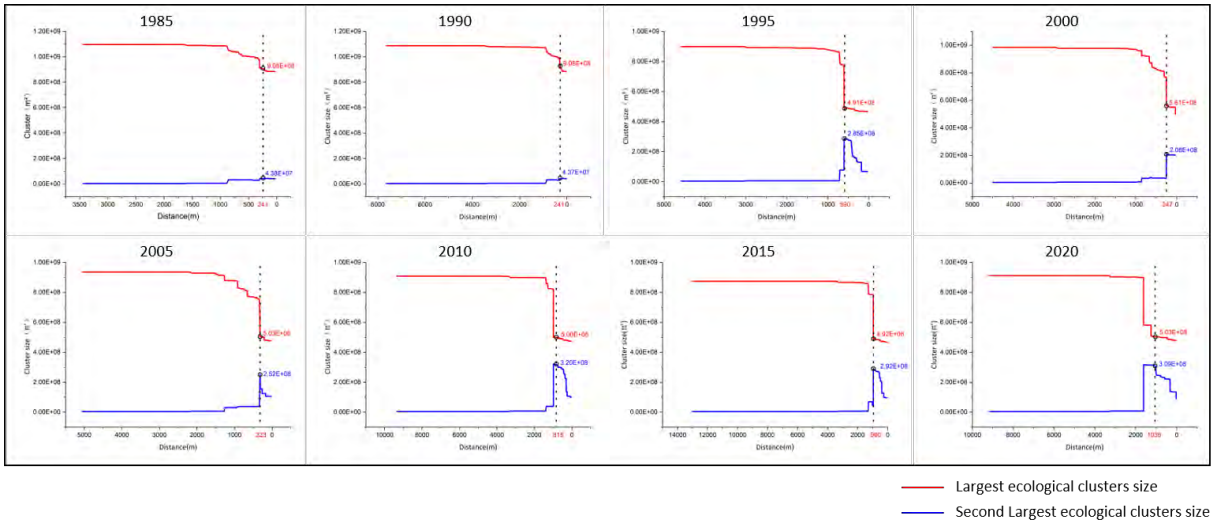


Figure 6. The area of the largest ecological cluster and the second largest ecological cluster changed with the distance scale. Source: Author.

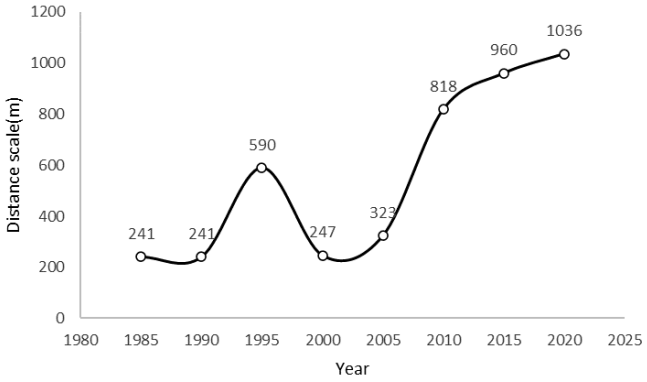


Figure 7. Optimal distance scale change of Shenzhen's ecological networks from 1985 to 2020. Source: Author.

4.3. Evolution of ecological network clusters pattern in Shenzhen

Ecological network cluster is a cluster of interconnected ecological patches at the optimal distance scale. Ecological cluster may be a collection of multiple ecological patches or a single patch. From Figure 8, we can see the evolution of ecological network clusters pattern in Shenzhen. The overall pattern of network

clusters is relatively stable and two different kind of distribution patterns are presented. In 1985 and 1990, the ecological network clusters in Shenzhen showed the distribution characteristics of huge-size ecological clusters across the east and west and small-size ecological clusters around. The barrier ability of ecological networks to restrict urban construction land reached the strongest in this period. From 1995 to 2020, the distribution pattern of ecological network clusters is characterized by eastern, western and northeastern ecological clusters. The eastern ecological clusters are the most stable, and the ability of

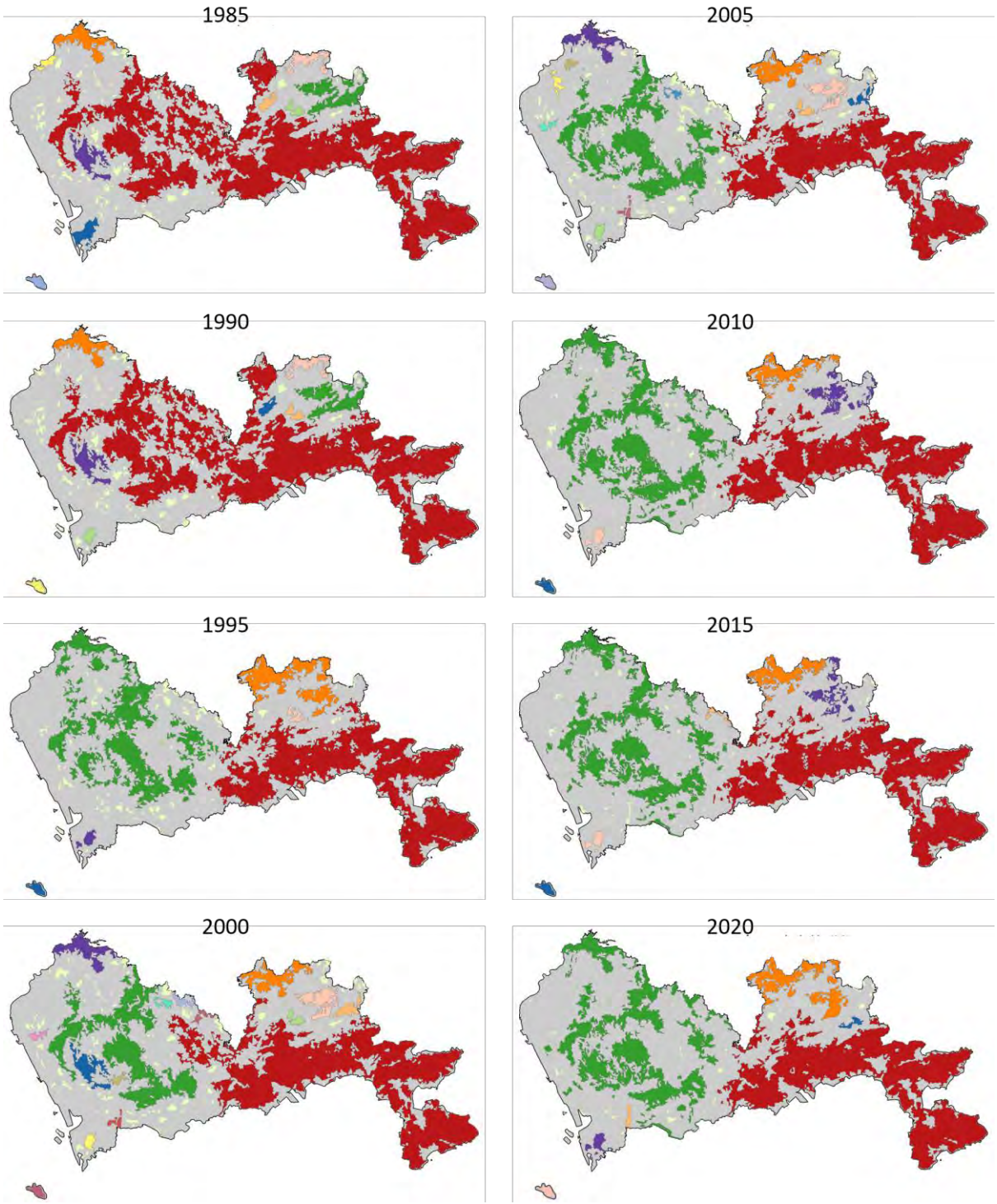


Figure 8. Evolution of ecological network clusters pattern in Shenzhen. If the colors of the ecological patches are the same, they are in the same ecological cluster. Differnt colors represent different ecological clusters. Source: Author.

ecological patches to restrict urban development and construction is the strongest. Changes of ecological patch community exist among the western ecological clusters and the northeastern ecological clusters during the evolution. That is, they break away from the the original ecological cluster and join another ecological cluster, indicating that the original ecological cluster has been eroded by urban construction. Compared with the eastern ecological clusters, the western ecological clusters are more fragmented, but the ecological patches are closely connected and still form an ecological cluster, which resists the erosion of urban construction land and isolates the construction clusters, reflecting the resilience of the ecological clusters.

5. Discussion

The polycentric urban structure of Shenzhen is constantly evolving under the comprehensive effect of many factors such as natural environment, policy planning and economic development. From the perspective of natural factors, Shenzhen's land surface is complex, with low hills, gentle terraces and terrace hills. Wutong Mountain, Qiniang Mountain, Yangtai Mountain and Danan Mountain are extended within the territory, and there are many rivers, lakes and reservoirs. The unique topography forms a natural barrier to urban construction land, which determines the dispersed development of Shenzhen along the east-west belt space. From the perspective of urban planning factors, urban grouping development is to avoid the monocentric development that leads to urban traffic congestion, environmental pollution, housing congestion and overpopulation, but the effect of urban grouping development does not isolate urban groups as expected.

5.1. Impact of urban spatial planning on resilience of ecological network

The rapid development of Shenzhen determines the continuous adjustment and change of its spatial structure in previous planning to ensure the demand for industrial development and urban construction land of urban clusters. The urban development has shifted from the extension expansion mode to the intensive development, and the urban spatial structure has shifted from the emphasis on polycentric development in the past to the balanced development of the network. This paper tries to strengthen the stability of urban system by connecting ecological clusters with network structure.

However, at the implementation level of urban spatial planning, there is a problem that planning lags behind urban construction and development. For example, from 1990 to 1995, preemptive development and construction outside Shenzhen special economic zone led to excessive erosion of ecological patches in the outer areas of the city. The city quickly entered the polycentric era, and the barrier capacity of ecological land changed drastically. After the overall urban planning, even if the ecological network cluster structure is planned, the unstoppable urbanization process makes the boundaries between the ecological clusters disappear and become contiguous urban construction land.

5.2. Impact of ecological planning policies on resilience of ecological network

According to the relevant planning of Shenzhen's ecological network, Shenzhen's ecological network has changed from being the opposite of the urban construction land in the past, emphasizing the role of urban groups isolation and ecological protection based on biological connectivity, to the integration of ecological network and urban construction, emphasizing its accessibility based on the connectivity of social ecological recreational resources. In 2005, Shenzhen promulgated the Regulations on the Management of Basic Ecological Control Lines in Shenzhen to curb the severe situation of urban ecological destruction by delineating the boundaries of urban construction. However, in the early stage, Shenzhen's ecological network did not play its function of curbing urban development or isolating urban clusters as scheduled. Problem of occupying ecological red lines still exist. The total amount of construction land in Shenzhen will continue to increase in the future, and therefore, the scope of

ecological red lines will also be reduced. All kinds of ecological planning, such as greenway planning, green space system planning and park city construction planning, can effectively improve the quality of urban green space, but the restoration of urban green space and its ability to control urban expansion are still insufficient.

6. Conclusion

This paper explains the characteristics of ecological network resilience by clarifying the specific definition and measurement methods of urban ecological network and ecological network resilience. First of all, in the field of urban planning, urban ecological network can be understood as a network based on structural connectivity, emphasizing the Euclidean distance relationship among ecological patches. Secondly, under the unstoppable risk of urban expansion, the resilience of urban ecological network should focus on the barrier ability against urban construction land. In this paper, clusters of urban ecological network are identified by the percolation theory, and the resilient barrier ability of urban ecological network is analysed by the optimal distance scale and clusters distribution pattern.

This paper takes Shenzhen as the research area to conduct an empirical study on the resilience of ecological networks. It is found that from 1985 to 2020: (1) Shenzhen's urban ecological network changes from a monocentric network to a polycentric network, and the barrier ability of ecological network against urban construction land changes from the outer green belt restricting the expansion of monocentric construction land to greenbelt network restricting the expansion of polycentric construction land. (2) The optimal distance scale of ecological network clusters in Shenzhen showed a trend of increasing volatility, the overall tightness of ecological network clusters decreased, and the barrier ability of urban construction land decreased. (3) At the optimal distance scale, the overall pattern of ecological network clusters in Shenzhen is relatively stable.

In general, in the context of rapid urban expansion, Shenzhen's ecological network still maintains a certain barrier ability against urban construction land, but this barrier ability is constantly declining. Urban planning and ecological planning have not played an effective role in improving in its ability. The future urban ecological planning should accurately identify the key areas of the city, restore and repair the green space, so as to enhance the barrier ability of the urban ecological network against the urban construction land.

7. References

Andrea D.M., Amedeo, G., Matteo, C., et al. (2019) 'Resilient ecological networks: A comparative approach', *Land Use Policy*, 89, p104207.

Holling, C.S. (1973) 'Resilience and stability of ecological systems', *Annual Review of Ecology and Systematics*, p1-23.

Holling, C.S. (1996) 'Engineering resilience versus ecological resilience', *Engineering Within Ecological Constraints*, 31(1996), p32.

Isaac, N.J.B, Brotherton, P.N.M, Bullock, J.M., et al. (2018) 'Defining and delivering resilient ecological networks: Nature conservation in England', *Journal of Applied Ecology*, 55(6), p2537-2543.

Liu, F.R., Zhang, Z.D., Wang, X.Y., Mao, Y.Y., Dong, J.B., Huang, C.H., Liu, Y.K. (2023) 'Spatio-temporal variation of ecosystem health and its response to urbanization in the Guangdong-Hong Kong-Macao Greater Bay Area', *Acta Ecologica Sinica*, 43(7), p2594-2604.

Liu, S.L., Hou, X.Y., Yin, Y.J., et al. (2017) 'Research progress on landscape ecological networks', *Acta Ecologica Sinica*, 37(12), p3947-3956.

Niu, Q., Zhou, X., Zhang, J., Yang, J.Z., Huang, X.Y. (2019) 'Evolution of ecosystem resilience in mountainous cities of Karst—Taking Guiyang urban area as an example', *Resources and Environment in the Yangtze Basin*, 28(3), p722-730.

Ouyang, X., Li, Y.H., Xu, F., Chen, J.S., Huang, M. (2021) 'Interaction between urban land expansion and ecological environment protection: Case study of Changsha-Zhuzhou-Xiangtan urban agglomeration', *Economic Geography*, 41(7), p193-201.

Shi, Q.X., Zhang, Y.P., Xu, B. (2023) 'Spatial-temporal variations of landscape stability in northern Zhejiang based on MCCA multi-scenario simulation', *Chinese Journal of Ecology*, 42(2), p445-453.

Song, S., Xu, D.W., Hu, S.S., et al. (2021) 'Ecological network optimization in urban central district based on complex network theory: A case study with the urban central district of Harbin', *International Journal of Environmental Research and Public Health*, 18(4), p1427.

Sun, W., Liu, C.G., Wang, S.N. (2021) 'Simulation research of urban development boundary based on ecological constraints: A case study of Nanjing', *Journal of Natural Resources*, 36(11), p2913-2925.

Susanne M., Urs, K., Martin, H.S., Felix, H., et al. (2010) 'Structural versus functional habitat connectivity measures to explain bird diversity in fragmented orchards', *Journal of Landscape Ecology*, 3(1), p52-64.

Tao, J.Y., Dong, P., Lu, Y.L. (2022) 'Spatial-temporal analysis and influencing factors of ecological resilience in Yangtze River Delta', *Resources and Environment in the Yangtze Basin*, 31(9), p1975-1987.

Walker, B., Holling, C.S., Carpenter, S.R., et al. (2004) 'Resilience, adaptability and transformability in social–ecological systems', *Ecology and Society*, 9(2).

Wang, S.J., Cui, Z.T., Lin, J.J., Xie, J.Y., Su, K. (2021) 'Coupling relationship between urbanization and ecological resilience in the Pearl River Delta', *Acta Geographica Sinica*, 76(4), p973-991.

Xia, C.Y., Dong, Z.Y.Z., Chen, B. (2022) 'Spatio-temporal analysis and simulation of urban ecological resilience: A case study of Hangzhou', *Acta Ecologica Sinica*, 42(1), p116-126.

Xu, L.Q., Zhang, Z.T., Tan, G.Y., et al. (2022) 'Analysis on the evolution and resilience of ecological network structure in Wuhan metropolitan area', *Sustainability*, 14(14), p8580.

Zeng, F.S., Feng, X.H., Tang, Y., Xiao, Z.P., Bi, M.Y. (2022) 'Evolution of ecological resilience space pattern at county level in Poyang Lake Basin', *Geography and Geo-Information Science*, 38(6), p29-35.

Research Paper

Construction of ecological space management and control path from the perspective of ecosystem service function

——A case study of Dujiangyan City

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Abstract

Ecosystem services have a significant impact on human well-being, and differentiated ecosystem services function characteristics are an important basis for constructing ecological space management and control paths. With Dujiangyan City as the research target area, the spatial characteristics of three kinds of ecosystem service functions in the target area, namely water conservation, soil and water conservation and biodiversity, were quantified, and ecosystem service function models were established by using quantitative assessment method and model assessment method, so as to identify ecological Spaces of different importance and construct ecological space management and control paths. (1) The assessment results of the ecosystem service function in Dujiangyan City were classified into three levels: extremely important, important and generally important, with the area ratios of 21.40%, 32.02% and 46.58%, respectively; (2) The spatial distribution of ecosystem services is very important in the northern and western regions, followed by the southern regions, and generally important in the central and eastern regions; (3) Based on the obvious spatial differences of ecosystem service functions in Dujiangyan City, the ecological space management and control path of Dujiangyan City under the three levels of system management, hierarchical zoning management and directional management is constructed. The research results provide a scientific approach for the spatial reality analysis of urban ecosystem service functions and urban ecological environment management.

Keywords

Ecosystem service, Functional evaluation, Ecological space, Control path

1. Introduction

The ecological space at home and abroad is facing the threat of urbanization. From 1981 to 2020, the scale of urban construction land in China will expand from 6720km2 to 58355.3km2. The interactive impact of urban construction expansion and ecological environment constraints leads to the gradual blurring of the boundary between ecological space and construction space, and human beings can obtain various services from the ecosystem to maintain normal life. Therefore, it is also faced with the risk of gradually reducing the quality of the ecosystem and gradually weakening the transformation of service functions. In 2020, “the 14th Five-Year Plan” clearly requires improving the quality and stability of the ecosystem, guarding the security boundary of the ecological space, and ensuring the construction of ecological civilization, indicating that ecological space planning is an important work for human survival and quality of life. On the basis of ecosystem service function assessment, the construction of urban ecological space management and control path can maintain the integrity of the ecosystem, and provide

scientific guidance for the disorderly expansion of urban areas to aggravate the mutual development contradiction between ecological space and construction space.

Research on urban ecological space is mostly based on "three-life space" and used for ecological protection (Wang et al.,2017), delineation and control of ecological space (Xiong et al.,2018) and other purposes. Studies on ecological space control are mostly conducted from a qualitative point of view, and there are still problems such as blurred control boundaries and imperfect control systems. Gradually, some scholars have quantitatively studied urban ecological spatial zoning control measures from the perspective of ecosystem service assessment (Jing et al.,2023). In 1864, Marsh (Marsh,1864) proposed for the first time in his book Man and Nature that ecosystem has service functions, but it was not until the concept of ecosystem (Tansley,1864) was put forward in the 1940s that attention was paid to it, and in-depth research on ecosystem service functions began (Xie et al.,2001). From the structure of the ecosystem to the function of the main progressive development; In 1997, Daliy et al. proposed that ecosystem service refers to the ecosystem products and ecosystem functions provided by natural ecosystems and their species to serve human life (Daily,1997), which is a universally recognized concept at present. Research on ecosystem service function has gradually shifted from single service function (Li et al.,2013) to research on ecosystem service model (Fan et al.,2022), mainly focusing on land use (Hasan et al.,2020) and ecological security (Peng et al.,2018), etc. There are also abundant studies on the combination of ecological space management and control, including urban agglomeration, province, county and other scales (Wang et al.,2020). Some scholars have discussed the ecological function zoning of Baiyangdian wetland under the integrated ecosystem service function indicators such as water supply and climate regulation, so as to protect the ecological environment (Zhu et al.,2020), or comprehensively evaluate the Marine ecosystem service function, and found that it is necessary to focus on the regulation of Marine support services and regulation services (Cheng et al.,2015). There are also quantitative assessments of supply services, regulation services and support services from the perspective of ecosystem service clusters, providing a new perspective for ecological functional zoning (Li et al.,2017). On the whole, there is no unified standard system for research methods of ecological space management and control (Xu et al.,2019), but comprehensive evaluation index is more scientific than single evaluation index to analyze ecological space management and control measures. In addition, studies on the combination of ecosystem services and ecological space mainly discuss the structure and function of ecosystems and the spatial distribution under human-land relationship from the perspectives of ecology and geography. However, studies on the combination of ecosystem services and urban control practice planning from the perspective of urban and rural planning are insufficient.

Dujiangyan City is a junction of mountainous and plain areas with complex ecological conditions and special spatial and geographical location. It is of practical significance to study the spatial characteristics of the importance of ecosystem service functions for urban ecological spatial zoning control. This paper took Dujiangyan City as an example, combined with the analysis methods of relevant scholars(Jiao et al.,2022; Wang et al.,2020), comprehensively evaluated the spatial characteristics of ecosystem service function through GIS spatial analysis and comprehensive evaluation of ecosystem service function, and defined the spatial characteristics of ecosystem service function in each region under the administrative boundary of Dujiangyan City, so as to carry out differentiated planning and control measures for the ecological space of Dujiangyan City.

2. Methodology

2.1. Study area

Dujiangyan City is located in the central part of Sichuan Province and the northwestern edge of Chengdu, China. The terrain in the region decreases from northwest to southeast, and is successively distributed

with mountains, hills and plains in the form of stairs. The geographical space presents zonal differentiation characteristics, and has the characteristics of disaster susceptibility and resource hierarchy. On the other hand, Dujiangyan is rich in ecological resources, but the built area of Dujiangyan is closely intertwined with the ecological space. The urbanization rate has increased from 42.19% in 2000 to 62.3% in 2021, indicating that it is in the stage of accelerating the development level of urbanization. Frequent construction activities and excessive consumption of ecological resources during the urbanization process lead to the weakening of ecosystem services. Ecological space is becoming more sensitive.

2.2. Index selection and model construction

According to the contents of < China Biological Diversity Protection Action Plan>, <Sichuan Biological Diversity Protection Action Plan>,< Announcement on Dynamic Monitoring Results of Water and Soil Loss in Dujiangyan City>, Dujiangyan Soil Erosion Dynamic Monitoring Results Announcement and other documents, as well as the analysis of the geological hazard distribution map of Dujiangyan City, combined with the above realistic scenarios of Dujiangyan City, Three key ecosystem service function indexes of soil and water conservation, water conservation and biodiversity were selected in the target area.

(1) Functional importance model for soil and water conservation

Due to the special mountain-plain terrain of Dujiangyan City, the evaluation of the importance of soil and water conservation functions plays a key role in the prevention and control of soil erosion and the self-regulation ability of the ecosystem to ensure the stability of the ecological space (Yang et al.,2005). In this paper, NPP quantitative index evaluation method is used to evaluate soil and water conservation function. The calculation formula is as follows (1) :

$$S_{pro} = NPP_{mean} * (1 - K) * (1 - F_{sio}) \quad (1)$$

NPP_{mean}: average annual net primary productivity of vegetation; F_{sio}: slope factor; K: soil erodibility factor.

(2) Functional importance model for biodiversity conservation

Through the analysis of the importance of biodiversity maintenance functions in Dujiangyan City, the integrity of ecosystem structure and the reasonable adjustment of urban climate can be realized (Ma et al.,2020), and the integrity of ecological space can be ensured through the balance of ecological environment. In this paper, the NPP quantitative index evaluation method was adopted to evaluate the biodiversity maintenance function. The calculation formula is as follows (2) :

$$S_{bio} = NPP_{mean} * F_{pre} * F_{tem} * (1 - F_{alt}) \quad (2)$$

F_{pre}: annual average precipitation; : F_{tem}: annual average temperature; F_{alt}: elevation factor.

(3) Functional importance model for Water conservation

The evaluation of the importance of water conservation function is of great significance for monitoring the water resource environment, urban water use and social and economic development in key regions (Fu et al.,2013), and the protection and utilization of water ecological space can be ensured through the analysis of water conservation. In this paper, the water balance equation is used to evaluate the water source conservation function. The calculation formula is as follows (3) :

$$TQ = \sum_{i}^{j} (P_i - R_i - ET_i) * A_i * 10^3$$

$$(R_i = P_i * a) \quad (3)$$

P_i: annual average precipitation (mm); R_i: Surface runoff (mm); ET_i: Evapotranspiration (mm); A_i: Class i ecosystem area (km2); a: Runoff coefficient.

(4) Functional importance model of ecosystem services

The importance of soil and water conservation function, biodiversity maintenance function and water conservation function were disjunctive, and the integrated ecosystem service function importance model was obtained. The three ecosystem service functions are equally important to the ecological environment of Dujiangyan City. In order to maintain the neutrality of the research, the research on ecosystem service functions in the study area does not involve specific weights to one side and assumes that their weights are the same. The calculation formula is as follows (4) :

$$EI = Max[S_{bio}, S_{pro}, TQ] \quad (4)$$

S_{pro}: Importance of soil and water conservation function; S_{bio}: Importance of biodiversity conservation functions; TQ: Importance of water conservation function.

2.3. Technical route

The first step is to obtain and process the data, mainly through the Data Center of Resources and Environmental Sciences of the Chinese Academy of Sciences and geospatial data Cloud, using the vegetation normalization index processing, and the obtained data is unified in the coordinate system, and the accuracy is unified to 30m. The second step is to build the ecosystem service function model of Dujiangyan City by NPP quantitative index evaluation method, water balance equation and disconnection operation method. The third step is to analyze the calculation results, including the importance of soil and water conservation function, the importance of biodiversity maintenance function, the importance of water conservation function and the importance of ecosystem service function. The fourth step is to carry out the protection planning of Dujiangyan's ecological space, which mainly includes the control and optimization of ecological space and urban construction space(Figure 1).

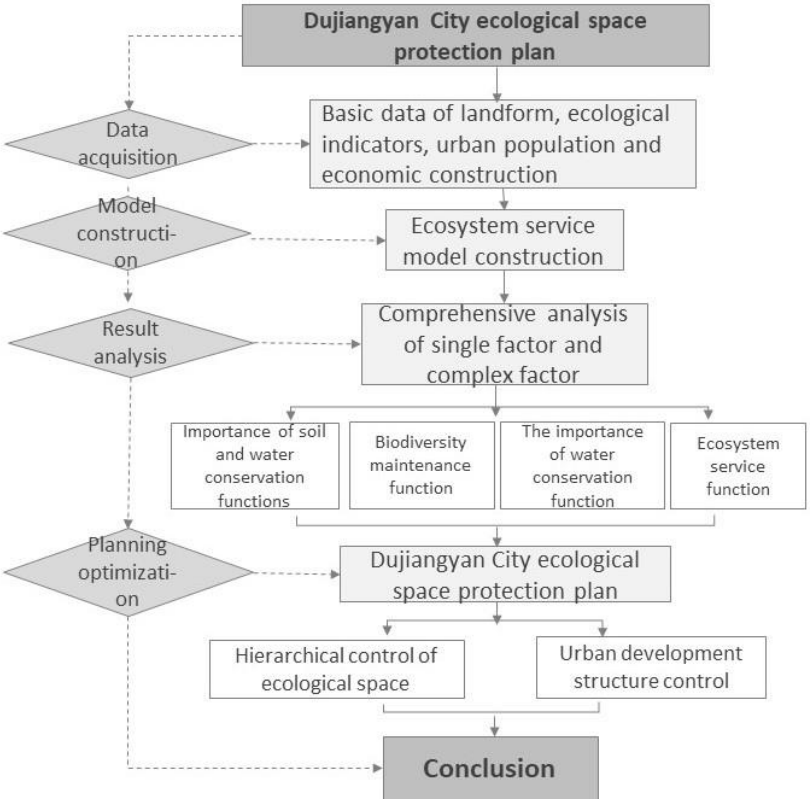

Figure 1 Technical route. Source: Author.

3. The discussion of calculation results

3.1. Single factor ecosystem service function analysis

(1) It can be seen from Table 1 that the spatial characteristics of functional importance of soil and water conservation in Dujiangyan City: In Dujiangyan, the area of the three levels of "extremely important", "important" and "generally important" increased step by step. In Dujiangyan, the area of "generally important" was 593.71km^2 (49.12%), followed by "important" and "extremely important" areas (244.51km^2, 372.18km^2 and 592.05km^2). They account for 20.23% and 30.79% of the total land area of Dujiangyan City.

The most important areas of soil and water conservation function are mainly woodland and water area, which are mainly concentrated in Qingchengshan Town and Yutang Street in the west, some are distributed in clumps in Puyang Street in the east, and a few are scattered in Longchi Town in the north; The important areas of soil and water conservation function are mainly distributed in clusters in Longchi Town in the north and Ginkgo Street and Guankou Street in the middle, and a few bands are distributed in Qingchengshan Town and Yutang street, which are mainly forest systems and have high ecological service value; Areas with generally important soil and water conservation functions are mainly distributed in the southeast of Juyuan Town, Kuiguangta Street, Tianma Town, Happiness Street and Shiyang Town, mainly in urban and rural construction land and farmland (Figure 2).

Table 1 Evaluation results of soil and water conservation function importance. Source: Author.

Grade	Main street/town	Area	Ratio
The extremely importance of the soil and water conservation capacity	Yutang Street, Qingchengshan Town, Puyang Street	243.49km^2	20.14%
The importance of the soil and water conservation capacity	Longchi Town, Ginkgo Street, Guankou street	371.54km^2	30.74%
The general importance of the soil and water conservation capacity	Juyuan Town, Kuiguangta Street, Tianma Town, Happy street, Shiyang Town	593.71km^2	49.12%

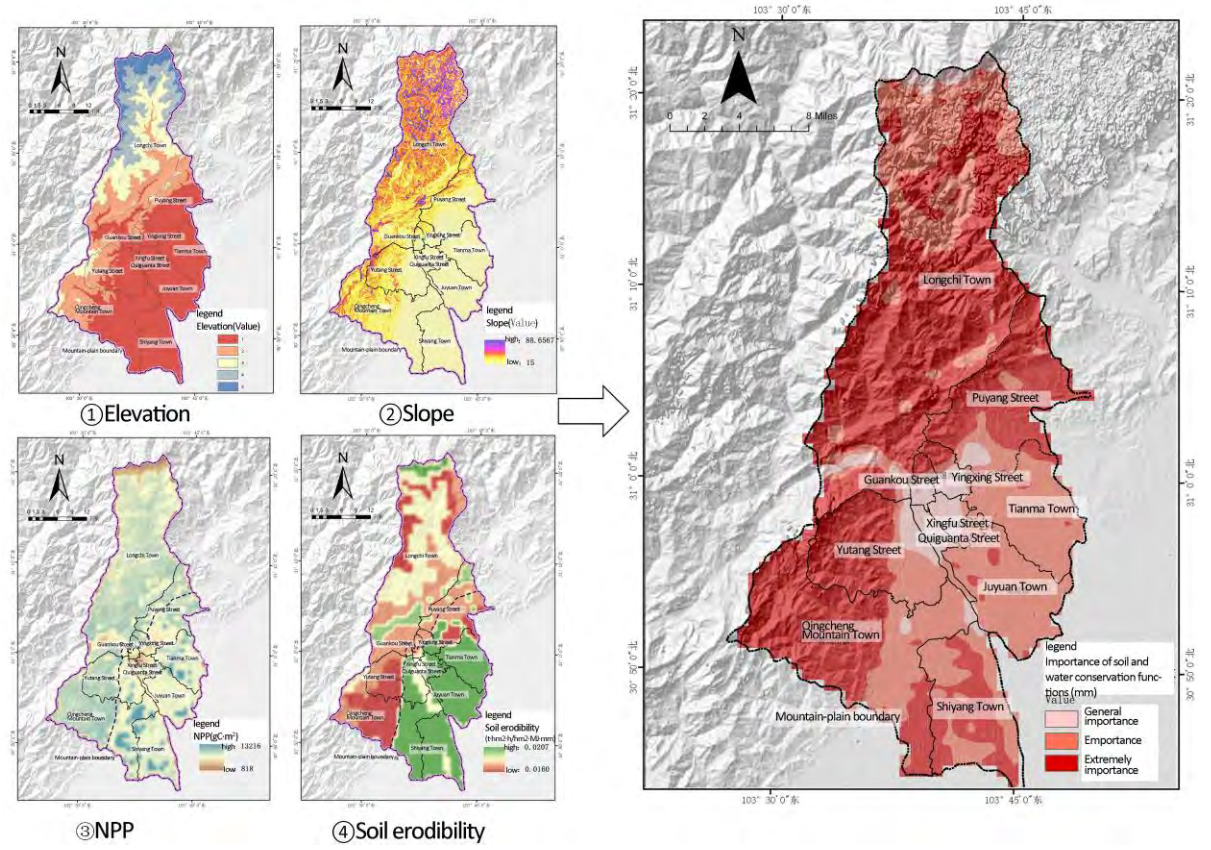

Figure 2 Spatial analysis of importance of soil and water conservation capacity in Dujiangyan City. Source: Author.

(2) As can be seen from Table 2, the spatial characteristics of the importance of biodiversity conservation functions in Dujiangyan City are as follows: the relative advantage of general importance is 598.21km^2, with an area ratio of 49.49%, followed by important and extremely important, with an area of 363.23km^2 and 247.30km^2, with an area ratio of 30.05% and 20.46%, respectively.

The areas with very important biodiversity maintenance function were mainly distributed in the form of blocky in Longchi Town and Qingchengshan Town. The areas with important biodiversity maintenance function were distributed in the form of sheet in Longchi Town in the north and concentrated in Qingchengshan Town and Shiyang Town in the south; The areas with generally important biodiversity conservation functions were concentrated in Juyuan Town, Kuiguangta Street, Xingfu Street, Tianma Town, Gingko Street, Guankou Street, Puyang Street and Yutang Street. The importance of biodiversity conservation functions in the central urban built-up area was lower than that in the northern and western mountain areas (Figure 3).

Table 2 Evaluation results of biodiversity conservation function importance. Source: Author.

Grade	Main street/town	Area	Ratio
The extremely importance of the biodiversity conservation service capacity	Longchi Town, Qingchengshan town	247.30km^2	20.46%
The importance of the biodiversity conservation service capacity	Longchi Town, Qingchengshan town, Shiyang town	363.23km^2	30.05%
The general importance of the biodiversity conservation service capacity	Juyuan Town, Kuiguangta Street, Happiness Street, Tianma Town, Ginkgo Street, Guankou Street, Puyang Street, Yutang Street	598.21km^2	49.49%

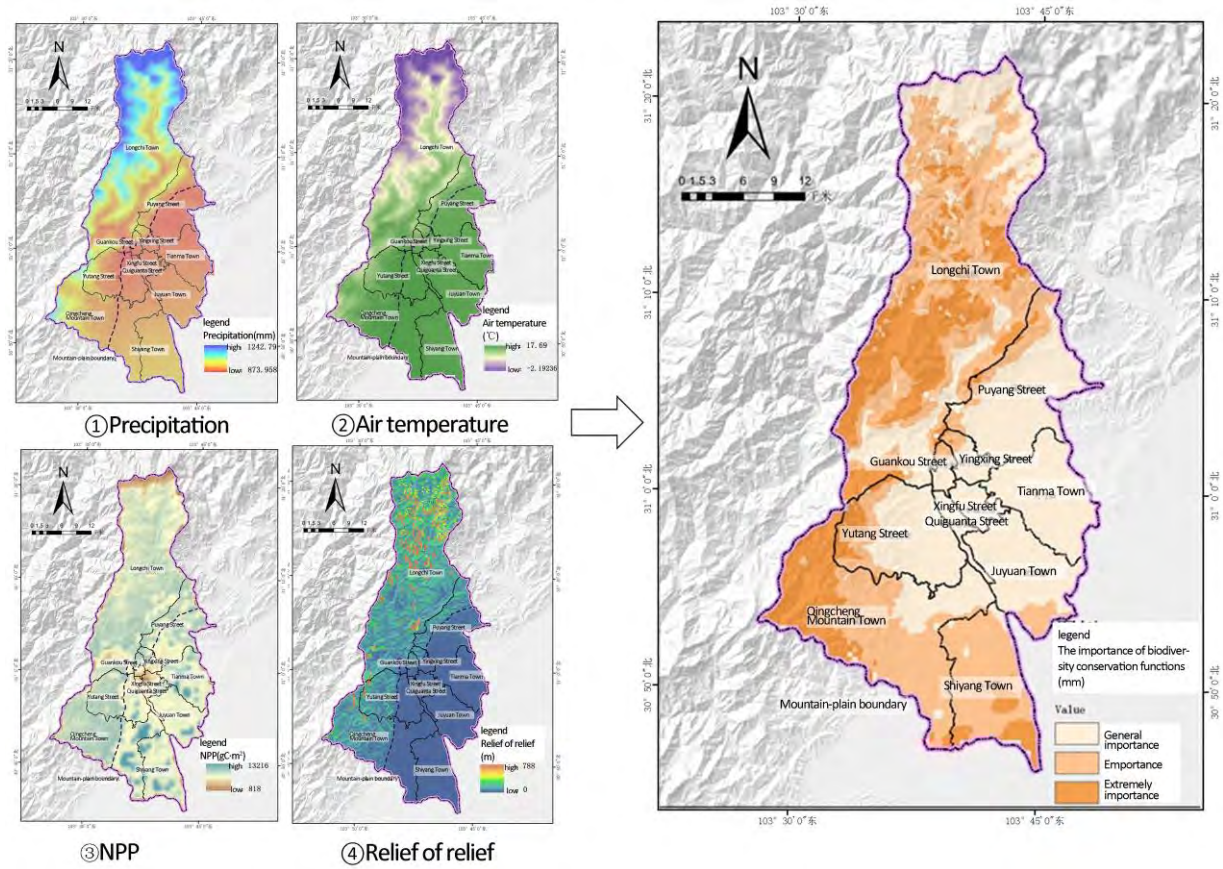

Figure 3 Spatial analysis of the importance of biodiversity conservation functions in Dujiangyan City. Source: Author.

(3) It can be seen from Table 3 that the spatial characteristics of the importance of water conservation function in Dujiangyan City are as follows: the areas of extremely important areas, important areas and generally important areas are 251.51km^2, 363.95km^2 and 593.28km^2, respectively, and the areas account for 20.81%, 30.11% and 49.08% respectively.

In Dujiangyan, seasonal natural rivers such as Puyang River and Baitiao River and perennial natural rivers such as Minjiang River are distributed in the area, and the overall water conservation function is significant. The most important areas of water conservation function are scattered in clusters and sheets

in Longchi Town in the north and Yutang Street and Qingchengshan Town in the west. The general important areas of water conservation function are concentrated in the eastern and southern Juyuan Town, Kuiguangta Street, Tianma Town, Happiness Street, Guankou Street, Shiyang Town, Gingko Street and Puyang Street (Figure 4).

Table 3 Evaluation results of the importance of water conservation function. Source: Author.

Grade	Main street/town	Area	Ratio
The extremely importance of the water conservation capacity	Longchi Town, Yutang Street, Qingchengshan Town	251.51km^2	20.81%
The importance of he water conservation capacity	Longchi Town, Yutang Street, Qingchengshan Town	363.95km^2	30.11%
The general importance of he water conservation capacity	Juyuan Town, Kuiguangta Street, Tianma Town, Happy Street, Guankou Street, Shiyang Town, Ginkgo Street, Puyang Street	593.28km^2	49.08%

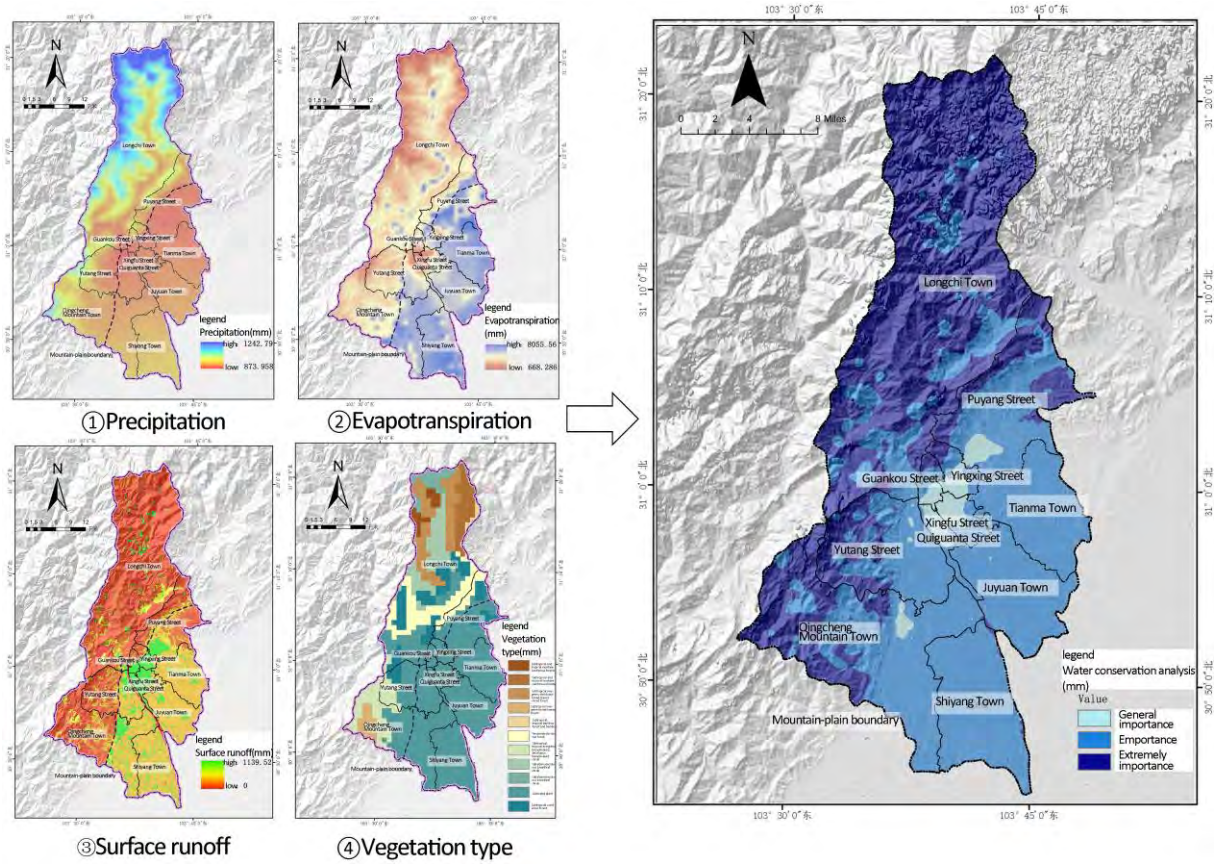

Figure 4 Spatial analysis of importance of water conservation function in Dujiangyan City. Source: Author.

3.2. Integrated analysis of ecosystem service functions

As can be seen from Table 4, the evaluation results of the importance of ecosystem service function in Dujiangyan City were divided into three grades from high to low: extremely important, important and generally important, with an area of 258.67 km^2, 387.04 km^2 and 563.03 km^2, accounting for 21.40%,

32.02% and 46.58%, respectively. On the whole, the importance of the ecological space in Dujiangyan City is mainly in the general importance level. Under the influence of urban construction expansion, the ecological space in Dujiangyan City is more and more fragile.

It can be seen from Figure 5 that the importance of ecosystem service functions in Dujiangyan City has significant spatial characteristics, showing that the importance level of ecosystem service functions in the north and west is extremely important, followed by the importance level in the south, and the importance level in the middle and east is low. Areas with very important ecosystem service function are mainly distributed in the northern and western mountainous areas in the form of concentrated contiguous areas, including Longchi Town, Yutang Street and Qingchengshan Town; The important areas of ecosystem service function are mainly distributed in the Shanyuan transitional zone of Dujiangyan City in the form of clusters and contiguous sections, including Puyang Street, Gingko Street, Guankou Street and Shiyang Town; Ecosystem service functions are generally important areas, mainly distributed in the central and eastern plains, including Happiness Street, Kuiguangta Street, Tianma Town, Juyuan Town.

Table 4 Results of comprehensive evaluation on the importance of ecosystem service functions. Source: Author.

	General importance		importance		General importance	
	Area/km2	Ratio/%	Area/km2	Ratio/%	Area/km2	Ratio/%
Water and soil conservation service capacity	243.49	20.14	371.54	30.74	593.71	49.12
Biodiversity maintenance function	247.30	20.46	363.23	30.05	598.21	49.49
Water conservation capacity	251.51	20.81	363.95	30.11	593.28	49.08
The importance of ecosystem service functions	258.67	21.40	387.04	32.02	563.03	46.58

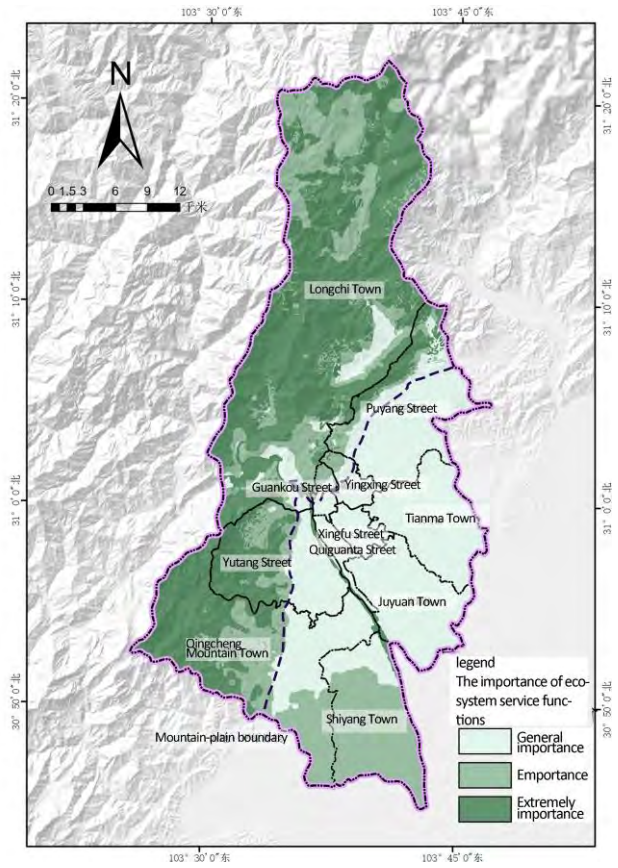

Figure 5 Spatial analysis of the importance of ecosystem service function in Dujiangyan City. Source: Author.

4. Strategy: Control path construction

According to the results of ecosystem service assessment, the overall ecosystem service function of Dujiangyan City is good, and the spatial distribution characteristics of extremely important areas, important areas and generally important areas are obvious. The evaluation results of the importance of ecosystem service function in Dujiangyan City directly show the importance of ecological space, and provide a scientific basis for the construction of urban ecological space management and control paths, including system management, hierarchical and regional management and control, and directional management and control, from macro urban development to micro and micro ecological situation analysis of small regions. The measures of ecological space control in Dujiangyan City have been gradually deepened (Figure 6).

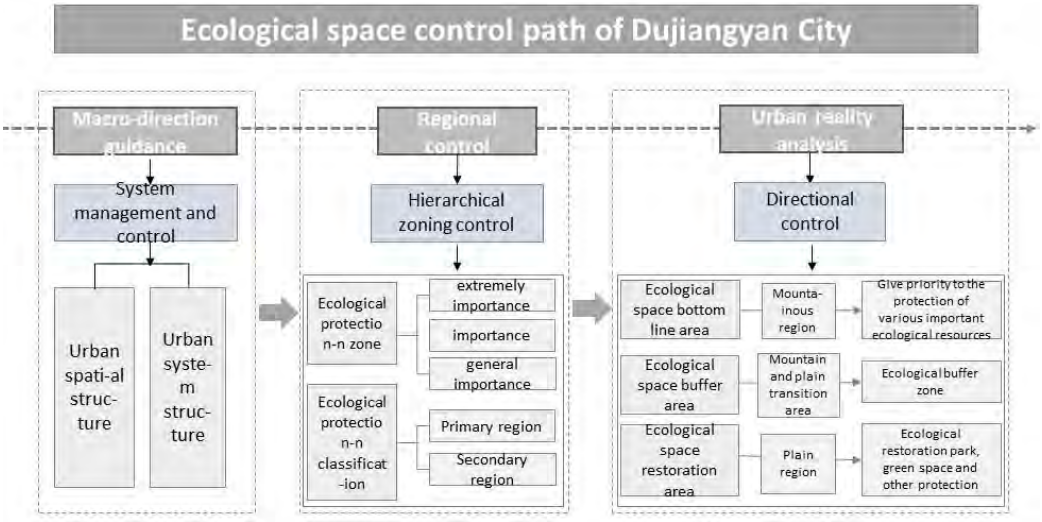

Figure 6 Schematic diagram of Dujiangyan City ecological space control path construction. Source: Author.

4.1. Systematic control of ecological space in Dujiangyan City

Through the spatial structure planning and urban system structure planning of Dujiangyan city under the background of ecological protection, the ecological space management and control of Dujiangyan City are guided from a macro perspective. The spatial structure planning of Dujiangyan City takes "four districts, four centers and three axes" as the development system to reduce the encroachment of ecological space in the process of urban construction of Dujiangyan City (Figure 7)

In the urban system structure planning of Dujiangyan city, each town develops in strict accordance with the orientation of ecological leading, agricultural leading and urban construction leading. The central urban area is the main area of urban economic development. Leading area of agricultural development: to improve the agricultural ecological environment through the protection of cultivated land and the guarantee of farmland quality; Leading areas of ecological protection: Villages within the core scope of ecological protection and those with a small population and poor infrastructure are mainly considered, and corresponding evacuation and relocation strategies are carried out according to the actual situation of each town and village (Figure 8).

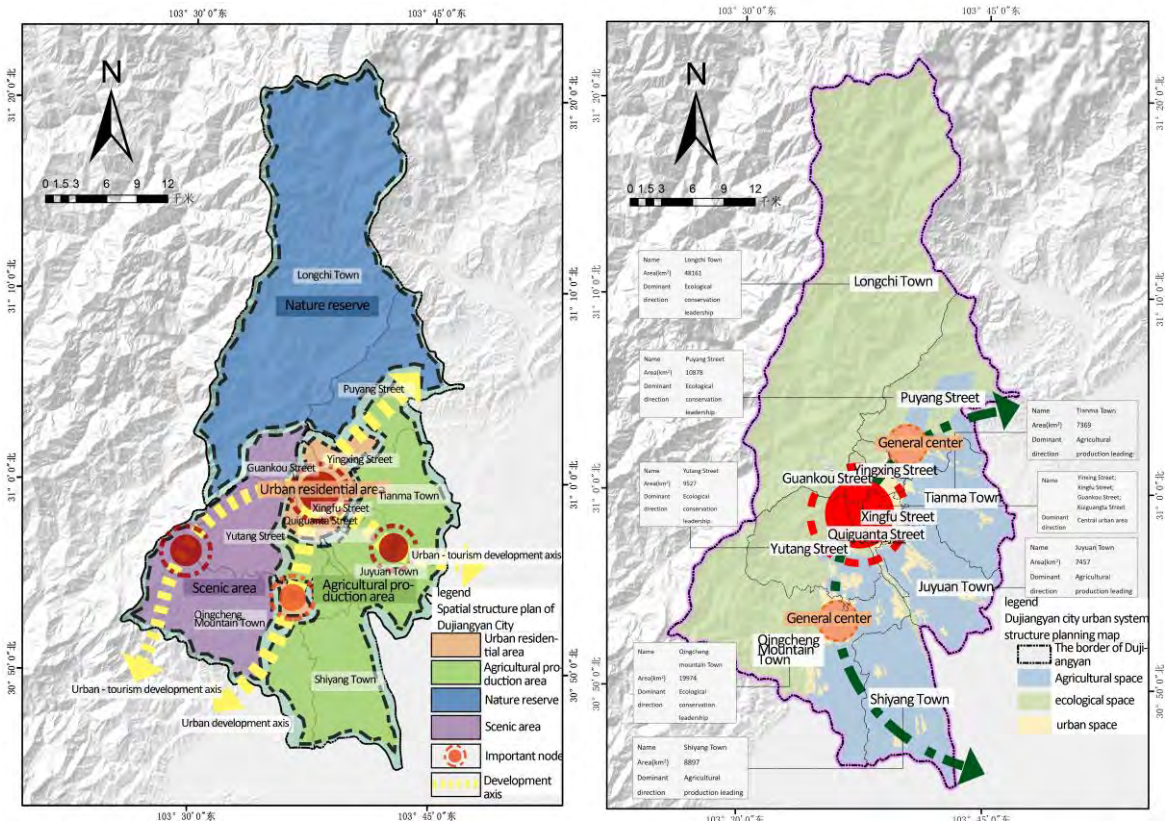

Figure 7 Spatial structure plan of Dujiangyan City. Source: Author.

Figure 8 Dujiangyan city urban system structure planning map. Source: Author.

4.2. Classification and zoning control of ecological space in Dujiangyan City

According to the assessment results of ecosystem service function, the ecological spatial importance zones of Dujiangyan City will be designated, including the extremely important areas for ecological protection, such as Longchi Town and Qingchengshan Town, etc., and the construction projects that damage the ecosystem service functions such as water conservation, biodiversity protection and soil and water conservation will be prohibited. In the important area of ecological protection mainly in Shiyang Town, large-scale and high-intensity human activities should be limited; Ecological protection is generally important areas, mainly in Ginkgo Street and Happiness Street, to prevent soil erosion and land desertification.

In addition, Dujiangyan City is divided into first and second level control areas (Table 5) : The first level control area includes all land within the ecological protection red line of Dujiangyan City, and all agricultural production and land construction and development are prohibited; The second-level control area is the ecological protection space outside the ecological protection red line of Dujiangyan City, involving forest land, water area, grassland and other ecological Spaces. It is the area that guarantees the overall ecological security pattern of Dujiangyan City and controls urban development and construction.

Table 5 Dujiangyan City level control area content. Source: Author.

Number	Type	Name	Main object of protection
1	Primary control area	National nature reserve	Rare animals such as giant pandas and forest ecosystems
		Cultural relic protection unit,	Water conservancy project: Dujiangyan

		World Heritage	
		National scenic spot	Mount Qingcheng
2	Secondary control area	Other ecological protection Spaces	Woodland, water, grassland, etc

4.3. Directional control of ecological space in Dujiangyan City

Based on the differentiated characteristics of the ecosystem service function space in Dujiangyan City, the ecological space management and control measures are put forward. The spatial differentiation of the importance of ecosystem service functions in Dujiangyan City is obviously related to the terrain. The importance of ecosystem service functions in the mountain area is the highest, followed by the transition area between mountain and plain, and the plain area, which are classified as the bottom line area of ecological space, the buffer area of ecological space, and the restoration area of ecological space, and the management and control measures are further classified.

In the mountain area of Dujiangyan City, the forest system and rivers are rich, and the ecosystem service function is significant. In the future development of Dujiangyan City, the protection measures for wild animals and plants, natural ecological base and resources are increased, and the construction of the project is clearly prohibited or the list of illegal construction projects has been made. In Puyang Street, Ginkgo Street, Guankou Street, Yutang Street and the central area of Qingchengshan Town, the transition area between mountain and plain is the place where the contradiction between urban construction and development and ecological resource protection is prominent. The ecological buffer zone is set up to reduce the damage of urban expansion to the ecosystem and ensure the integrity of ecological space. The plain area is the main construction area of the city, the population and industry are concentrated, and the transformation of ecosystem service functions is weak. On the basis of ecological restoration, ecological land such as parks and road green space in the city is strictly protected.

5. Conclusion

Starting from the three indexes of soil and water conservation function, biodiversity maintenance function and water conservation function, this study evaluated the ecosystem service function of Dujiangyan City through quantitative assessment method and model assessment method, and constructed the ecological space management and control path. The main conclusions are as follows:

(1) The importance of ecosystem service functions in Dujiangyan City is divided into three categories: Extremely important, important and generally important, with an area of 258.67 km^2, 387.04 km^2 and 563.03 km^2, respectively. The area of extremely important and important ecosystem service function areas in Dujiangyan City accounted for 78.60% of the total area of the study area. The ecosystem service function needs to be strengthened.

(2) The importance of ecosystem service functions in the northern and western regions of Dujiangyan is very important, followed by the southern region, and the central and eastern regions are generally important. Based on the special terrain analysis of Dujiangyan City, it is found that the importance of ecosystem service functions in the mountain area is the highest, followed by the mountain plain area and the plain area.

(3) The evaluation results of the importance of ecosystem services reflect the importance of the ecological space in Dujiangyan City, and provide an important reference and basis for the construction of ecological space management and control paths. At the level of system control, through the spatial structure and urban system structure planning of "four districts, four centers and three axes" of Dujiangyan City, the direction of ecological space control of Dujiangyan City is guided. At the level of

classification and zoning control, the importance of leading ecological protection and different ecological Spaces such as level 1 and level 2 of each town are subject to zoning and grading control measures. At the level of directional control, based on the different characteristics of ecological space on different terrain such as mountain area, mountain and plain transition area and plain area, combined with the realistic scene of Dujiangyan City, targeted strategies are proposed.

Due to its special geographical location and ecological conditions, Dujiangyan City is a typical area for studying urban ecological space management and control measures from the perspective of ecosystem service functions. However, due to the resolution of data acquisition, there may be errors between the area results and the field situation. However, the geographical spatial pattern calculated by the model in this paper can reflect the geographical spatial characteristics of different ecosystem service functions in Dujiangyan City, build an ecological space control path on the basis of regional ecological spatial distribution characteristics, and provide an urban spatial layout plan under the background of ecological protection, which has certain significance for the implementation of regional ecological protection space.

6. References

Cheng, C, S., Wei, Z., Hong, H, S., et al. (2015) Assessment and regulation of ocean health based on ecosystem services: Case study in the Laizhou Bay, China.*Acta Oceanologica Sinica*, 34(12):61-66.

Daily,G.C. (1997) Nature's Service:Social Dependence on Natural Ecosystems. Washingt on DC:Island Press.

Fu, B., Xu, P., Wang, Y, K., et al. (2013) Spatial pattern of water conservation function in Dujiangyan City. *Acta Ecologica Sinica*, 2013,33(03):789-797.

Hasan, S, S., Zhen, L., Miah, G, M., et al. (2020) Impact of land use change on ecosystem services: A review. *Environmental Development*, 34(prepublish).

Jing, X, D., Tian, G, L., Ban, Q, Q., et al. (2023) Analysis of the status quo and development trend of ecosystem services research in China since the 21st century. *Acta Ecologica Sinica*, 2023(17):1-11[2023-05-09].https://doi.org/10.20103/j.stxb.202207031884.

Jiao, C., Shu, S, W., Yi, T, Z. (2022) Construction of an ecological security pattern based on ecosystem sensitivity and the importance of ecological services: A case study of the Guanzhong Plain urban agglomeration, China. *Ecological Indicators*, 136.

Li, Y, C., Liu, C, X., Min, J., et al. (2013) Evaluation on the importance of ecosystem service functions in the Three Gorges Reservoir area. *Acta Ecologica Sinica*, 33(01):168-178.

Li, H, L., Peng, J., Hu, Y, N., et al. (2017) Ecological function zoning of Inner Mongolia Autonomous Region based on ecosystem service cluster. *Chinese Journal of Applied Ecology*, 28(08):2657-2666.DOI:10.13287/j.1001-9332.201708.036.

Marsh G. (2023) 《Man and Nature》.

Ma, Q., Wang, P, T., Yang, X, J., et al. (2020) Study on red line demarcation of biodiversity conservation in Qinling Mountains. *Resources and Environment in the Yangtze Basin*, 29(03):634-642.

Peng, J., Yang, Y., Liu, Y., et al. (2018) Linking ecosystem services and circuit theory to identify ecological security patterns. *Science of the Total Environment*, 644.

Qin, D, F., Xiao, Y, Y., Chen, M, Z. (2022) A Review of Ecosystem Services Research Focusing on China against the Background of Urbanization. *International Journal of Environmental Research and Public Health*, 19(14).

Tansley, A, G. (1935) The Use and Abuse of Vegetational Concepts and Terms. *Ecology*, 16(3).

Wang, F, Y., Wang, K, Y., Chen, T., et al. (2017) Research progress and prospect of urban ecological space. *Progress in Geography*, 36(02):207-218.

Wang, H, L., Gao, Y, N., Wang, Z, Y., et al. (2020) Urban ecological management zoning based on ecosystem services: A case study of Shenzhen City. *Acta Ecologica Sinica*, 40(23):8504-8515.

Xiong, S, G., Qing, C, B., Yu, L., et al. (2018) Ecological space demarcation based on ecosystem service function and ecological sensitivity: A case study of Nanning City. *Acta Ecologica Sinica*, 2018,38(22):7899-7911.

Xie, G, D., Lu, C, X., Cheng, S, K. (2001) Research progress of global ecosystem service value assessment. *Resources Science*, 2001(06):5-9.

Xu, X, L., Yang, W, D., Wu, H, T., et al. (2019) An ecosystem services zoning framework for the permafrost regions of China. *Advances in Climate Change Research*, 10(2).

Yang, A, M., Liu, X, Y., Li, Y, H., et al. (2005) The concept, classification and technical method of ecological restoration of soil and water conservation. *Soil and Water Conservation in China*, (01):15-17+55.DOI:10.14123/j.cnki.swcc.01.006.

Zhu, J, F., Zhou, Y., Wang, S, X., et al. (2020) Ecological function evaluation and zoning of Baiyangdian wetland. *Acta Ecologica Sinica*, 40(02):459-472.

Research Paper

Identify factors affecting the experience of citizens in the greenway at the bank of the Pearl River

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Abstract

Defined as a specific type of public green space, greenway is fairly welcomed by the people living in the Pearl River Delta especially in Guangzhou and it has become one of the most popular local recreational areas. The purpose of the essay is to identify the factors that can impact the feeling of citizens when they staying in the greenway. The data basically came from 706 valid questionnaires and each questionnaire consists of 16 different questions about various aspects of the greenway. The results successfully identified five factors to explain the overall feeling of visitors when they visiting the greenway. In addition, it established a simple linear programming model of which purpose is to find the best allocating scheme for governmental investment. The result of model shows that the allocation of budget should be 90000 in constructing new toilets while 9000 in installing new lights. Moreover, the result also reveals that the amount of budget needs be controlled under 72000 to ensure the effectiveness of investment. In this situation, the overall score would improve most.

Keywords

Greenway, Influencing factors, MLR, Guangzhou

1. Introduction

In the modern life, cities are fulfilling four fundamental functions, dwelling, recreation, work and transportation(Gold,1973;Coutts&Miles,2011). Nowadays, recreation has gradually become the most important function in urban areas in southeast China, especially in the Pearl River Delta and the Yangzi River Delta, as the disposable income of Chinese people were continuously increased during past decade(Peter et al., 2014). Moreover, as one of the most significant recreational places, public green space is regarded as a sort of suitable place to spend citizen's leisure time and it has been widely accepted by local dwellers.

Defined as a specific type of public green space (Charles, 1990), greenway is essentially a special linear park along a natural corridor which is set aside for recreation as well as environmental protection(Ahern,1995). In China, greenway is fairly welcomed by the people living in the Pearl River Delta especially in Guangzhou and it has become one of the most popular local recreational areas(Yu et al.,2006;Jim&Shan,2013). Therefore, Guangzhou government plans to allocate more budget for constructing greenway even though they have already invested large amount of money in greenway. Although the constructional status of greenway seems successful, it still needs to be objectively estimated and improved.

Existing research on greenway started early and has gradually shifted from discussing planning methods and evaluation techniques to analyse the implementation and management strategies as well as successful cases of greenways (Furuseth&Altman,1991; Gobster,1995). In terms of user experience, relevant social surveys have covered various aspects such as greenway service recipients, perception of greenway functions, usage patterns, and satisfaction levels (Lindsey,1999; Shafer et al.,2000; West and Shores,2011; Price et al.,2012; Dallat et al.,2013). However, the research methods and analysis used in existing studies are relatively narrow, and there is a lack of research on how various spatial factors of greenways affect overall visitor satisfaction (Gobster&Westphal,2004). Research conclusions often lack practical applicability, and the results are difficult to guide specific implementation by the government (Lindsey et al.,2001).

Basically focusing on the greenway at bank of the Pearl River, a typical greenway in Guangzhou, the purpose of the essay is to identify the factors that can impact the feeling of citizens when they staying in the greenway. Moreover, the essay also tries to find some reasonable and practical schemes to allocate governmental investments. The whole essay is mainly divided into two parts. The first one is a multiple linear regression analysis aiming at explaining the weights of various factors. The other one is a linear programming for the best distribution of government budget.

2. Data and Methodology

The data basically came from 706 valid questionnaires collected in 2013 and each questionnaire consists of 16 different questions about various aspects of the P.R. greenway (The greenway at the bank of the Pearl River) (Table 1). In addition, each aspect, including the overall impression or feeling of the greenway, is assessed by the public (score 1- 5).

Factor 1	The quantity of toilets	Factor 9	The proportion of greenery coverage
Factor 2	The quantity of bicycle renters	Factor 10	Sound environment (noisy or not)
Factor 3	The location	Factor 11	The trees and the shadows
Factor 4	The available for public transportation	Factor 12	The availability for restaurants (including cafes)
Factor 5	The connection to other places of interest	Factor 13	The quantity of lights
Factor 6	The quantity of sport facilities	Factor 14	The quality of guideline system. (such as road sign)
Factor 7	The quality of water	Factor 15	The degree of crowding
Factor 8	The quality of landscape architectures (such as, pavilions)		

Table 1. The index of factors. Source: Author.

However, these data are somewhat not sufficiently objective because the assessment of each citizen impact equally to the final result although the time they spending in the greenway is totally different. Thus, based on the time (ti) of each citizen staying in the greenway, we define a parameter (βi) to adjust the data (Table 2&3).

$$\beta_i = f(t_i) = \frac{it_i}{\sum_{i=1}^{n} t_i}$$

	Factor1	Factor2	….	Factor14	Factor15	Overall
1	a_1	b_1	….	m_1	n_1	o_1
2	a_2	b_2	….	m_2	n_2	o_2
3	a_3	b_3	….	m_3	n_3	o_3
….	….	….	….	….	….	….
706	a_{706}	b_{706}	….	m_{706}	n_{706}	o_{706}

Table2. The original data. Source: Author.

	Factor1	Factor2	….	Factor14	Factor15	Overall
1	$\beta_1 a_1$	$\beta_1 b_1$	….	$\beta_1 m_1$	$\beta_1 n_1$	$\beta_1 o_1$
2	$\beta_2 a_2$	$\beta_2 b_2$	….	$\beta_2 m_2$	$\beta_2 n_2$	$\beta_2 o_2$
3	$\beta_3 a_3$	$\beta_3 b_3$	….	$\beta_3 m_3$	$\beta_3 n_3$	$\beta_3 o_3$
….	….	….	….	….	….	….
706	$\beta_{706} a_{706}$	$\beta_{706} b_{706}$	….	$\beta_{706} m_{706}$	$\beta_{706} n_{706}$	$\beta_{706} o_{706}$

Table 3. The adjusted data. Source: Author.

The main analysis of the essay is to conjecture and prove the possible linear relationship between each factors' score and the overall score. First of all, dimensionality reduction will be conducted to get rid of multicollinearity to ensure the accurancy of multiple linear regression (MLR), which is followed by Pearson's correlation analysis that is given to select the corelated factors. Secondly, stepwise multiple linear regression will be introduced to create an equation to explain the overall score (dependent variable) by the combination of all corelated factors (independent variables). Finally, a linear programming will be used to establish a simple model for finding the best allocation according to the result of stepwise MLR analysis.

3. Stepwise MLR Analysis

Dimensionality reduction: Table 7 and 8 (Appendix) shows the result of correlation test and VLF (Variance Inflation Factor) between each factor. It clearly demonstrates that the score of factor 2, 4, 5, 6, 8, 10, 11 and 14 are significantly correlated with the score of factor 1 as their VLF are larger than 5.0 while their correlation coefficients are around 0.8 or larger than 0.8. Thus, these factors need to be removed from the independent variables list.

Factors Selection for stepwise MLR: For selecting correlated factors, a Pearson test is conducted between the overall score and each factor's score (Table 4). In table 4, it obviously shows that there are strong correlation between the score of factor 1, 7, 9, 12, 13 and the overall score as all of their P-value are smaller than 0.05. Meanwhile, the significance of correlation between the score of factor 15 and 3 and overall score is too small to achieve the threshold of statistics (their P-value >> 0.05). Therefore, the final regression independent variables list contains five factors including factor 1, 7, 9, 12, 13. All of their correlation coefficients are higher than zero which means the overall score can be positively influenced by them. In addition, in order to prepare for stepwise multiple linear regression, the five selected factors are ranked from highest to lowest according to the value of factors' correlation coefficients.

	Factor1	Factor13	Factor9	Factor7	Factor12	Factor3	Factor15
Correlation coefficients	0.632**	0.530**	0.524**	0.524**	0.523**	0.171**	0.144**
p-value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	=0.076	=0.131

Table 4. The result of Pearson's test. Source: Author.

Stepwise multiple Linear regression:

Step 1: At this stage, the factor 1 (The quantity of toilets), which has the highest value of correlation coefficients, is introduced into the regression equation and the r value, R2 and adjust R2 of the regression is 0.632, 0.400 and 0.399 respectively. In addition, the P-value of F-test is far lower than consensus significant level (0.05). Thus, the essay gets the initial equation(1) in which $\mathbf{O}$ stands for overall score while $\boldsymbol{xn}$ represents different factors and it can be concluded that factor 1 contributes 39.9% of the overall score.

$$\mathbf{O} = \mathbf{1}.\mathbf{847} + \mathbf{0}.\mathbf{494}\boldsymbol{x1} \quad (1)$$

Step 2: Same as step 1, the secondly ranked factor, the quantity of lights (factor 13) is involved in the regression. In this step, the r value, R2 and adjust R2 of the regression change into 0.659, 0.434 and 0.433 respectively while the significance of F-test is at P=0.000 level, which means factor 1 and 13 are able to explain 43.3% of variations in the overall score. In addition, the regression equation(2) shows below.

$$\mathbf{O} = \mathbf{1}.\mathbf{488} + \mathbf{0}.\mathbf{395}\boldsymbol{x1} + \mathbf{0}.\mathbf{189}\boldsymbol{x2} \quad (2)$$

Step 3: Similarly, factor 9(the proportion of greenery coverage), the third ranked one, enters into the equation. In this stage, the r value, R2 and adjust R2 are calculated as equal to 0.558, 0.450 and 0.448 for each and the result of F-test is also significant at P=0.000 level. Therefore, based on the regression equation(3), it can be stated that the factor 1, 13 and 9 together, to some extent, dominate 44.8% of the overall score.

$$\mathbf{O} = \mathbf{1}.\mathbf{373} + \mathbf{0}.\mathbf{351}\boldsymbol{x1} + \mathbf{0}.\mathbf{112}\boldsymbol{x2} + \mathbf{0}.\mathbf{141}\boldsymbol{x3} \quad (3)$$

Step 4: At this stage, the final two, factor 7 and 12 (The quality of water and the availability for restaurant) are introduced into the MLR equation. In this step, the r value, R2 and adjust R2 increases to 0.677, 0.458 and 0.455 respectively while P-value of F-test is still smaller than 0.001. Moreover, the MLR equation(4) of final stage is:

$$\mathbf{O} = \mathbf{1}.\mathbf{306} + \mathbf{0}.\mathbf{340}\boldsymbol{x1} + \mathbf{0}.\mathbf{137}\boldsymbol{x2} + \mathbf{0}.\mathbf{108}\boldsymbol{x3} + \mathbf{0}.\mathbf{109}\boldsymbol{x4} - \mathbf{0}.\mathbf{079}\boldsymbol{x5} \quad (4)$$

To conclude, the whole stepwise MLR analysis demonstrates that the combination of factor 1, 13, 9, 7 and 12 can be responsible for 45.5% of the changes of dependent variable (overall score).

	Durbin-Watson	F-value	F-value significance level	Approximate standard deviation	Adjusted R^2	R^2
Step1	2.057	516.08	0.000	1.773	0.399	0.400
Step2		296.77	0.000	1.723	0.433	0.434
Step3		210.59	0.000	1.699	0.448	0.450
Step4		161.81	0.000	1.691	0.453	0.456
		130.39	0.000	1.689	0.455	0.458

Table 5. The result of stepwise MLR regression. Source: Author.

4. Tentative linear programming

Due to the attentions of Guangzhou authority, there are considerably many investments from local government aiming at improving the greenway every year(He, 2013), but there is not a fairly good scheme to deal with the investments. Therefore, the essay put forward a briefly but to some extent effectively tentative method, linear programming to solve the distributing items.

The essay assumes that the total investment **B0** (the amount of budget) from the government will be spent on two aspects (**B1** and **B2**), so there is an inequality built to describe this:

$$\mathbf{B0} \geqslant \mathbf{B1} + \mathbf{B2}$$

From the former stepwise MLR analysis, the essay figures out an equation (5) .

$$\begin{aligned}\textbf{Overall score} = {} & \mathbf{1.306} + \mathbf{0.340}\ \textbf{The score of quantity of toilets} \\ & + \mathbf{0.137}\ \textbf{The score of quantity of lights} \\ & + \mathbf{0.108}\ \textbf{The score of proportion of greenery coverage} \\ & + \mathbf{0.109}\ \textbf{The score of water quality} \\ & - \mathbf{0.079}\ \textbf{The score of availability for restaurant} \end{aligned} \quad (5)$$

The essay select two factors that p-value of T-test are both at p=0.000 level to build our linear programming (Table 6) and these two factors are the quantity of toilets and the quantity of lights. Thus,

$$\begin{aligned}\textbf{Overall score} = {} & \mathbf{1.306} + \mathbf{0.340}\ \textbf{The score of number of toilets} \\ & + \mathbf{0.137}\ \textbf{The score of number of lights}\end{aligned}$$

	Regression coefficient	Standard deviation	t	P-value level
(Constant)	1.306	0.120	10.888	0.000
Factor 1	0.340	0.032	10.629	0.000
Factor 13	0.137	0.035	3.876	0.000
Factor 9	0.108	0.032	3.380	0.001
Factor 7	0.109	0.033	3.344	0.001
Factor 12	-0.079	0.043	-1.815	0.070

Table 6. The T-test of stepwise MLR regression. Source: Author.

In order to build another equation of linear programming, the essay defines two parameters $\boldsymbol{m}$ and $\boldsymbol{n}$ which are the efficiency of investment spending on constructing toilets and installing lights respectively. In addition, according to the 2013 Guangzhou Statistical Yearbooks, each public toilet

needs approximately 30000 while each lights may cost about 1500. Therefore, based on unit price of toilets and lights and the amount of investment (Here it is assumed as "1"), it is simple to calculator the specific increasing numbers of toilets and lights. These increasing numbers will be proportional to the growth of scores of these two factors within a certain range Furthermore, the proportions between increasing number of toilets and its growing scores is $\boldsymbol{\alpha}$, lights and its scores is $\boldsymbol{\beta}$. However, if government continuously allocate investment on them, based on Diminishing Marginal Returns (Friedrich, 1889), "the total return on investment as a proportion of the total investment (the average product or return) might decrease". Therefore, the essay needs to figure out the most suitable quantities of toilets as well as lights and set them as thresholds in order to ensure the effectiveness of investment spending. According to the quantity of visitors and the demand of them (Architectural Design Data Set, 1994), the suitably total number of toilets along the greenway should be 8 while currently is 5. Similarly, the appropriate lights' quantity is 66 but now is 52 including 2 broken one. That means the investment on toilets (**B1**) had better to smaller than 90000 (30000 for each) while lights' investment (**B2**) should be lower than 24000 (1500 for each), which can be considered as the total budget had better not to more than 114000. To conclude, all these information forms four equations.

$$m=\alpha/30000 \quad \& \; n=\beta/30000$$

$$\mathbf{Y}(\text{Overall score}) = \mathbf{0.340mB1} + \mathbf{0.137nB2} + \mathbf{1.306}$$

$$\mathbf{B1} \leqslant \mathbf{90000}$$

$$\mathbf{B2} \leqslant \mathbf{24}000$$

Through the Combination of all equations, a simple linear programming is formed below. In the programming model, $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ are calculated as equal to 0.80 and 0.075 respectively based on the data from 706 questionnaires. Moreover, the essay assumes **B0** (investment) is equal to 100000.

$$\mathbf{100000} \geqslant \mathbf{B1} + \mathbf{B2}$$

$$\mathbf{Y} = \mathbf{9.07} \times \mathbf{10}{-}\mathbf{6B1} + \mathbf{6.85} \times \mathbf{10}{-}\mathbf{6B2} + \mathbf{1.306}$$

$$\mathbf{0} \leqslant \mathbf{B1} \leqslant \mathbf{90000}$$

$$\mathbf{0} \leqslant \mathbf{B2} \leqslant \mathbf{24000}$$

Therefore, according to figure 1, under the condition that governmental investment is 100000, the best distribution is that the budget spending on toilets (**B1**) should be 90000 while budget costing on lights (**B2**) should be 10000. However, considering that **B1**and **B2**should be the multiple of cost of each unit (toilet, 30000; lights, 1500), the adjusted result is that it should build 3 toilets and 6 lights ($\mathbf{B1} = \mathbf{90000}$; $\mathbf{B2} = \mathbf{9000}$) to approach the best solutions. In this situation, the overall score would improve most (Ymax =2.184).

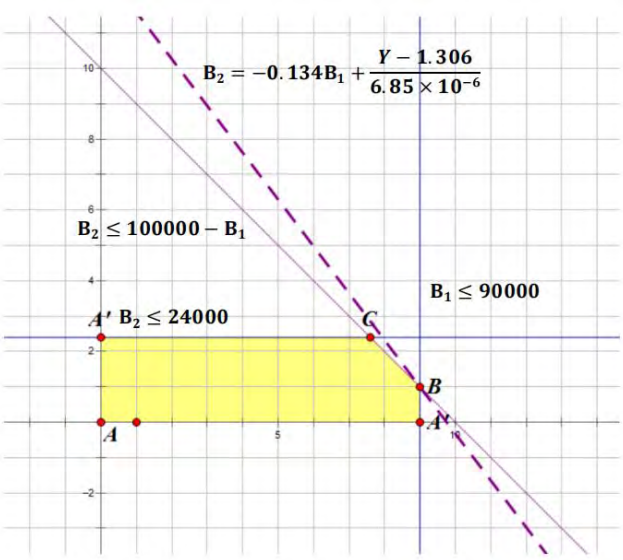

Figure1. The Linear programming (every unit standards for 10000). Source: Author.

5. Discussion and conclusion

To conclude, through stepwise multiple linear regression, the essay analyzed the data came from 706 valid questionnaires and successfully identified five factors, including the quantity of toilets, the quality of water, the proportion of greenery coverage, the availability for restaurants and the quantity of lights, to explain the overall feeling of visitors when they visiting the greenway. In addition, it established a simple linear programming model of which purpose is to find the best allocating scheme for governmental investment. The result of model shows that the allocation of budget should be 90000 in constructing new toilets while 9000 in installing new lights. Moreover, the result also reveals that the amount of budget needs be controlled under 72000 to ensure the effectiveness of investment. However, there are still some restrictions of the essay's analysis. Firstly, although the quantity of questionnaires are up to 706, the sample still cannot represent all opinions of visitors. Secondly, the relationship between increasing quantity of toilets and lights and the growth of scores may not be just a simple linear correlation. Actually, there should be a logarithmic or even more complicated relationship between them. All these might cause some deviations to the final analytical results and impact the objectivity of conclusions. Furthermore, there are some limitations of the final tentative linear programming model, as is difficult to dispose of three or more factors. To conclude, although there are large amount of research needs to be accomplished, the essay carries out a few feasible and rational methods to objectively assess as well as reasonably improve the greenway.

6. References.

Ahern, J.Greenways as a Planning Strategy.*Landscape and Urban Planning*, 1995(3): 131-155.

Charles, L. (1990) *Greenways for America.* Johns Hopkins University Press.

Coutts, C.,Miles, R. Greenways as green magnets: The relationship between the race of greenway users and race in proximal neighborhoods. *Journal of Leisure Research*, 2011,43(3): 317-333.

Dallat, M.A.T., Soerjomataram, I., Hunter, R.F., et al. Urban greenways have the potential to increase physical activity levels cost-effectively. *European Journal of Public Health*, 2013, 24(2): 190-195.

Friedrich, F.V.W. (1889) *Natural Value*. University of Saint Charles Press.

Furuseth, O.J., Altman, R.E. Who's on the greenway: Socioeconomic, demographic, and locational characteristics of greenway users. *Environmental Management*, 1991(3): 329-336.

Gobster, P.H. Perception and use of a metropolitan greenway system for recreation. *Landscape and Urban Planning*, 1995(33): 401-413.

Gobster, P.H., Westphal, L.M.The Human Dimensions of Urban Greenways: Planning for Recreation and Related Experiences.*Landscape and Urban Planning*,2004, (68): 147-165.

Gold, S.M. Urban recreation planning. *Journal of Health, Physical Education, Recreation*, 1973:44 (5) .

Guangzhou Government (2013) *The Guangzhou statistical yearbooks*. Guangzhou: China Statics.

He, Z.M. (2013) *The citizen experiencing survey of banking greenway in urban area in Hangzhou*. Zhejiang University Press.

Jim, C.Y., Shan, X. Socioeconomic effect on perception of urban green spaces in Guangzhou, China. *Landscape and Urban Planning*,2013, 31: 123-131.

Lindsey, G. Use of urban greenways: insights from Indianapolis. *Landscape and Urban Planning*, 1999, 45(2): 145-157.

Lindsey, G., Maraj, M., Kuan, S. Access, equity and urban greenways: An exploratory investigation. Professional Geographer,2001, 53(3): 332-346.

Peter, H., Josefine, F. and Detlev, I. (2014)*Beyond Urbanism: Urban(izing) Villages and the Mega-urban Landscape in the Pearl River Delta in China*. Berlin: Lit Verlag Fresnostr.

Price, A.E., Reed, J.A., Muthukrishnan, S. Trail user demographics, physical activity behaviors, and perceptions of a newly constructed greenway trail. *Journal of Community Health*, 2012(37): 949-956.

Shafer, C.S., Lee,B.K., Turner,S. A tale of three greenway trails: user perceptions related to quality of life. *Landscape and Urban Planning*, 2000, 49(3): 163-178.

West, S.T., Shores, K.A. The impacts of building a greenway on proximate residents' physical activity. *Journal of Physical Activity & Health*, 2011(88): 1092-1097.

Yang, X.H., Liu, Y.G. Public satisfactory survey of greenway in Fushan, Guangzhou, based on the method of IPA, *Journal of Southwest Agricultural University*,2011, 10(6).

Yu, K., Li, D., Li, N. The evolution of greenways in China. *Landscape and Urban Planning*, 2006, 76(1-4): 223-239.

7. Appendix

factor	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1		9.83	2.24	12.82	11.92	8.28	3.34	5.61	3.71	8.21	7.53	4.76	4.21	9.83	2.15
2	5.16		2.31	10.06	11.59	7.63	3.3	5.94	3.8	8.1	8.16	4.8	4.46	9.89	2.09
3	5.08	10		12.99	11.91	7.9	3.2	5.93	3.82	8.2	8.4	4.8	4	9.9	2.1
4	5.2	7.77	2.32		10.26	8.03	3.3	5.94	3.8	7.98	8.17	4.7	4.34	9.75	2.05
5	5.23	9.74	2.32	11.16		8.08	3.13	5.9	3.73	7.82	8.68	4.54	4.37	9.65	2.15
6	5.28	9.25	2.23	12.07	11.67		3.33	5.93	3.82	8.17	8.51	4.75	4.28	9.3	2.14
7	5.27	9.89	2.2	12.73	11.18	8.24		5.95	3.8	8.18	8.64	4.79	4.01	9.77	1.92
8	4.98	10.03	2.32	12.98	11.77	8.25	3.35		3.79	8.07	8.58	4.8	4.15	9.06	2.13
9	5.12	10	2.32	12.93	11.66	8.29	3.34	5.9		8.09	8.4	4.64	4.43	7.67	1.98
10	5.27	9.91	2.32	12.64	11.39	8.25	3.38	5.85	3.77		7.02	4.78	4.41	9.68	2.12
11	4.57	9.43	2.26	12.21	11.94	8.12	3.33	5.88	3.7	6.63		4.46	4.38	9.66	2.03
12	5.24	10.04	2.32	12.75	11.31	8.21	3.34	5.95	3.7	8.17	8.08		4.46	9.42	2.04
13	4.98	10.03	2.1	12.61	11.68	7.95	3.01	5.53	3.79	8.1	8.51	4.79		9.84	2.04
14	5.24	10.04	2.32	12.81	11.65	7.78	3.31	5.45	2.96	8.02	8.48	4.56	4.44		2.13
15	5.27	9.74	2.31	12.92	11.93	8.25	2.99	5.9	3.52	8.11	8.22	4.54	4.24	9.78	

Table 7. The VFL of 15 factors. Source: Author.

factor	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1		0.84	0.55	0.82	0.80	0.81	0.63	0.77	0.56	0.81	0.85	0.73	0.61	0.76	0.30
2	0.84		0.56	0.92	0.85	0.89	0.66	0.79	0.66	0.88	0.88	0.79	0.71	0.82	0.41
3	0.55	0.56		0.61	0.62	0.63	0.62	0.61	0.57	0.56	0.51	0.58	0.64	0.66	0.49
4	0.82	0.92	0.61		0.92	0.89	0.72	0.80	0.65	0.88	0.83	0.83	0.74	0.84	0.39
5	0.80	0.85	0.62	0.92		0.88	0.76	0.83	0.66	0.88	0.83	0.86	0.77	0.87	0.44
6	0.81	0.89	0.63	0.89	0.88		0.73	0.91	0.68	0.83	0.83	0.78	0.68	0.86	0.39
7	0.62	0.66	0.62	0.72	0.76	0.73		0.67	0.62	0.65	0.62	0.66	0.54	0.74	0.53
8	0.77	0.79	0.61	0.80	0.84	0.91	0.67		0.74	0.78	0.79	0.77	0.79	0.88	0.50
9	0.56	0.66	0.57	0.65	0.66	0.68	0.62	0.74		0.63	0.64	0.61	0.68	0.81	0.59
10	0.81	0.88	0.56	0.88	0.88	0.83	0.65	0.78	0.63		0.89	0.90	0.45	0.82	0.41
11	0.85	0.88	0.51	0.83	0.83	0.83	0.62	0.79	0.63	0.89		0.80	0.70	0.79	0.34
12	0.73	0.79	0.58	0.83	0.86	0.79	0.66	0.77	0.61	0.90	0.80		0.73	0.81	0.48
13	0.61	0.71	0.64	0.74	0.77	0.68	0.54	0.79	0.68	0.75	0.70	0.73		0.78	0.54
14	0.76	0.82	0.66	0.84	0.87	0.86	0.74	0.88	0.81	0.82	0.79	0.81	0.77		0.51
15	0.30	0.41	0.49	0.39	0.44	0.39	0.53	0.50	0.59	0.41	0.34	0.48	0.54	0.51	

Table 8. Correlation coefficients of 15 factors. Source: Author.

Research Paper

Research on regularity and influence of the spatiotemporal distribution on university shared bikes -- A case study of Tsinghua University

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Abstract

Shared bikes on university campuses is important due to the significant increase in usage conflicts in recent years. Existing studies either using subjective evaluations or black-box models, which lack objectivity and interpretability. This study uses the POI and streetscapes indicator to investigate the spatial distribution of shared bikes at university and gains a high R-squared value. The study ranks the most significant environmental factors contributing to shared bike usage conflicts, and found that the number of entrances, total road length, intersections consistently, and residential density have the greatest impact on shared bike usage conflicts. It suggests designing parking spots to relieve traffic conflicts and adjusting shared bike distribution in residential areas by replenishing bikes in dormitory areas during peak hours. These recommendations can help improve the efficiency of shared bike management on campus and alleviate usage conflicts. The methodology used in this study can also be applied in other small-scale scenarios to investigate the spatial distribution of shared bikes and their impact on the built environment. This study provides insights into the impact of shared bikes on the built environment but does not just call for increasing their numbers, which is of great relevance to policymakers, urban planners, and researchers.

Keywords

shared bike; built environment; spatial and temporal distribution patterns; campus design and planning; regulation strategy

1. Introduction

1.1 Conceptual of Dockless Bike Sharing System (DBSS)

In recent years, dockless bike sharing systems (DBSS), also known as free-floating bike sharing systems (Xu et al., 2019), have gained significant popularity in China. These systems offer users the autonomy and convenience of unlocking and paying for bikes through mobile apps, without the

need for docking stations (He and Wang, 2023). They have effectively reduced reliance on private cars for short-distance travel (Qin and Karimi, 2023). Therefore, shared bikes have been recognized as a crucial solution for reducing carbon emissions, and their popularity is rapidly increasing (Zhao et al., 2023).

1.2 Conflicts on Campus Bike Sharing

Since the introduction of bike sharing in the Chinese market, students have been the primary users of shared bikes. Surveys indicate that the first platform-based shared bike service in China was launched on the campus of Peking University in 2014 (Chen et al., 2022). Students remain the largest customer segment for shared bikes (Kellstedt et al., 2019), with users under the age of 30 constituting 30% of the total customer base （CAICT, 2018）.

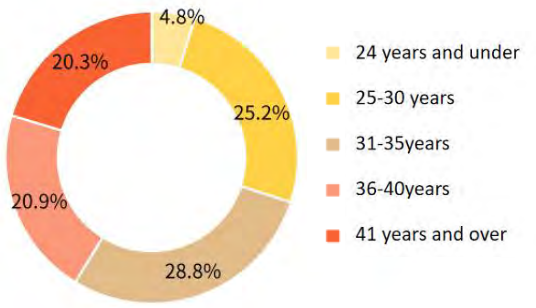

Figure 1. Age distribution of bike-sharing users in 2017. Source: iiMedia Polaris Internet Product Analysis System (bjx.iimedia.cn).

However, In universities, where land is limited, and buildings are older, the layout and deployment of shared bikes has become the most pressing issue for university management systems. Firstly, the current built environment often fails to cater to the specific needs of shared bike usage, and the changing needs of user various day by day (Chen et al., 2018), which raises concerns about whether campus areas can support the surge of shared bikes. Secondly, peak-hour bike shortages and improper parking, leading to the occupation of public areas within the campus (Chevalier et al., 2019) ,and this oversight has a negative impact on campus landscapes and increases the likelihood of accidents and traffic jams (Sun and Duan, 2021). Furthermore, as time passed, this problem become particularly severe in old campus settings where renovation opportunities and space are limited, yet shared bike usage conflicts are twice as severe as in urban areas. Therefore, the shared bikes on campuses remain inadequate but have led to severe traffic accidents, congestion, and usage conflicts.

1.3 Literature Review

To address the existing issues related to campus bike sharing, scholars both domestically and internationally have conducted preliminary discussions. However, existing research mainly relies on questionnaire data and subjective evaluation systems, lacking objectivity. Another approach involves constructing models, often referred to as "black box models," which only provide judgment on the conclusions but fail to explain the underlying principles and influencing factors. In recent years, scholars have proposed using Point of Interest (POI) and other indicators to predict the impact, but the effectiveness of such models in different scales, usage scenarios, and functional contexts still requires further examination (Chen and Ye, 2021).

The above review indicates that while bike sharing has been widely promoted, there is still a need to improve the reliability and interpretability of bike distribution patterns on university campuses (Godavarthy et al., 2022). The application of Geographically Weighted Regression (GWR) models

may offer a solution to this problem. However, the effectiveness of such an approach in the context of university campuses with their unique functionalities requires further exploration (Zhou et al., 2023). Therefore, this study focuses on Tsinghua University, a typical Chinese university with shared bike usage, and aims to use the GWR model to investigate the spatial-temporal distribution patterns of shared bikes on campus. The study intends to provide constructive recommendations for optimizing the integration of shared bikes and the built environment on university campuses (Yang et al., 2017).

Scale	*Types*	*Author*	*research method*	*research result*
University	*Subjective evaluation*	TANG,Y. et al.,2019.	Questionnaires	Suggestions for optimising shared bicycle travel on campus
		TANG, M., et al.,2021.	Questionnaires, spatial syntax, Tyson polygons	A multi-level bicycle sharing parking system
		ZHENG, T. W et al., 2019.	Heat map overlaid with shared bike riding segments	Establishes a campus cycling safety evaluation index system
	Objective model	JIANG, X. et al., 2022.	Time series regression	A model for predicting the short-term supply and demand of dockless shared bicycles on campus
		SUN, Q, et al., 2022.	Non-negative Matrix Factorization(NMF)	A prediction model with better accuracy than BP neural network and LSTM neural network
City	*Subjective and objective modelling*	LI, H. et al., 2022.	The impact of junctions and POI) etc. on cycling demand	A prediction model with higher accuracy than least squares regression models and geographically weighted regression models
		XU, B & Lu, Q. 2023,	Impact of built environment and regional economic attributes on parking demand	A model with higher explanatory power than the spatio-temporal Geographical and Temporal Weighted Regression (GTWR) was obtained
		WEN, C. et al., 2022.	Bicycle data, POI, field survey and questionnaire collection	Propose a GMOD model to finalise the purpose of the user's trip

Table 1. Literature review on shared bikes model in different scales.

1.4 Research objectives

Therefore, this study focuses on exploring the most effective ways to improve the adaptation between the built environment and shared bike usage, and university campuses are the first to be explored. The study emphasizes the importance of considering the carrying capacity and usage patterns between the built environment and shared bikes and finding effective ways to invest in shared bikes. The study focuses to figure out these objects:

1) A model construction method that can be used for investigating small-scale shared bike usage pattern;

2) An assessment method for the adaptability of the built environment to shared bikes is proposed;

3) This study highlights new factors for improving the efficiency of shared bike usage.

2. Methodology

2.1 Study Area

The study area chosen for this research is Beijing, which has the highest number of universities in China, with a total of 87 universities. Among them, the Haidian District is the most densely

populated area with universities, housing 35 universities. According to statistics from 2017, the monthly active user (MAU) count for bike-sharing in Beijing was approximately 4 million, accounting for 20.2% of the total national user base (Trustdata, 2018). As early as January 2016, bike-sharing platforms were already operational in Haidian District, covering six universities including Peking University, with over 5,000 bikes available. During peak periods, approximately 20,000 people were using the bikes daily (Gao et al., 2023). The abundance of users, mature development system, and large dataset at Tsinghua University, located in an area with the highest bike-sharing user count and earliest deployment, make it conducive to drawing reliable conclusions, which can serve as a reference for other universities.

2.2 Data Source

The original dataset used in this research is the Mobike Cup Algorithm Challenge Dataset from 2017, provided by Mobike. The report indicates that Mobike had the highest user coverage among bike-sharing companies nationwide (Trustdata, 2018). The dataset comprises 3,214,096 bike trip records in Beijing from May 10 to May 24, with seven data fields: Order ID, User ID, Vehicle ID, Vehicle Type, Ride Start Time, and Start and End Points of the trip. The start and end points are represented by 7-digit Geohash codes, each representing an area of approximately 152 m × 152 m. Python was used to decode the geospatial information.

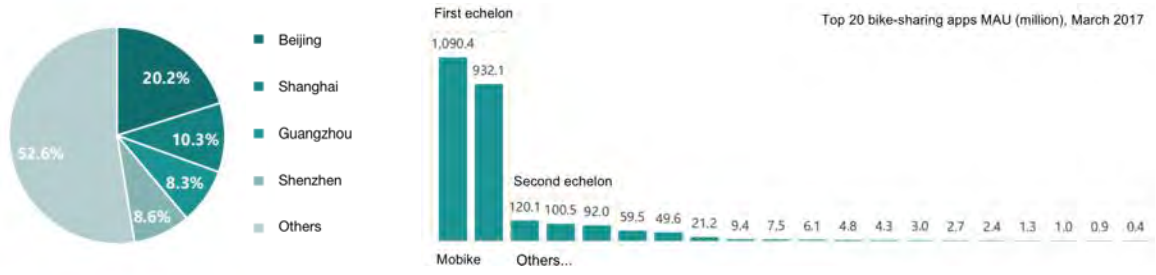

Figure 2. National share by city and bike-sharing MAU in 2017. Source: TRUSTDATA.

Order id	*User id*	*Bike id*	*biketype*	*starttime*	*geohashed_start_loc*	*geohashed_end_loc*
1893973	451147	210617	2	2017/5/14 22:16:50	wx4snhx	wx4snhj
4657992	1061133	465394	1	2017/5/14 22:16:52	wx4dr59	wx4dquz
2965085	549189	310572	1	2017/5/14 22:16:51	wx4fgur	wx4fu5n
.....	.....	.....	.....	.....	.....	.....

Table 2. Sample dataset for the 2017 Mobley Cup Algorithm Challenge. Source: Mobike.

2.3 Data Cleaning

To ensure data quality, the decoded data underwent a cleaning process to handle potential anomalies caused by weather conditions or software issues. Firstly, using Python, weather data for Haidian District from May 10 to May 24, 2017, was obtained from the European Centre for Medium-Range Weather Forecasts (ECMWF), and only the records corresponding to sunny days were retained (Jaber and Csonka, 2023). Following the research method of Zhai et al., 537,385 records

from May 11 and 12 were selected as weekday analysis data, and 461,876 records from May 13 and 14 were selected as weekend analysis data for comparison (Zhai, D. & Zhuo, J, 2021).

Next, the latitude and longitude of the bike-sharing origin-destination (OD) points were converted to X and Y coordinates in the Gauss-Krüger coordinate system using the Gauss projection (Xin et al., 2023). The Euclidean distance for each OD pair was calculated. The widely adopted box plot method in academia and industry was employed to eliminate outliers, removing orders with OD distances greater than the upper whisker of 1685.02 m for weekends and 1747.94 m for weekdays. This resulted in a selection of 433,327 records for weekends and 501,857 records for weekdays.

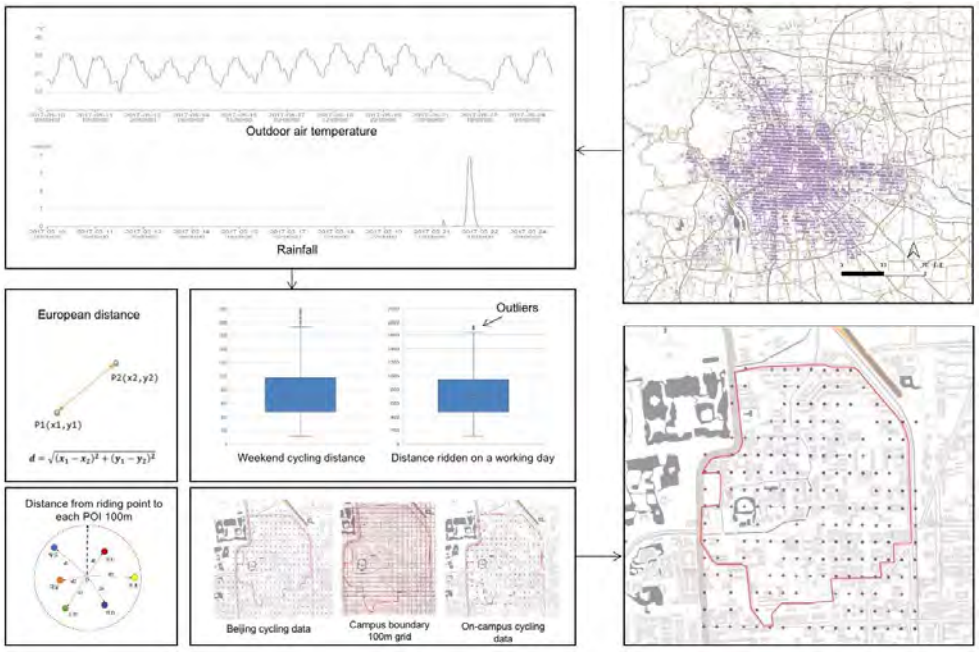

Figure 3. Dataset cleaning and cropping process.

Finally, using QGIS, the research area was delineated by clipping the coordinates of Tsinghua University. Since the Mobike dataset used GCJ02 coordinate system, it was converted to the WGS coordinate system for ease of subsequent processing. According to the findings of Wen et al. (Wen, C. et al, 2022), the maximum walking radius for riders was determined to be 100 m. Therefore, a research grid of 100 m × 100 m was established. The geographic boundary of Tsinghua University's campus was obtained from the Gaode Maps API to perform a secondary filtering of the data within the study area. Consequently, the final dataset consisted of 3,262 origin records and 2,969 destination records for weekdays, as well as 2,044 origin records and 1,967 destination records for weekends.

2.4 Description of Factors Influencing Bike Usage

Existing literature suggests that built environment factors influencing bike usage and parking demand include population density, land use, service facility density, road attributes, public transportation accessibility, and location conditions (Xu, B. & Lu, Q. 2023). Given the specific characteristics of university campuses, this research primarily focuses on service facility density and road attributes as the influencing factors. The data for service facility density and road attributes

were obtained from the POI2017, Junction2014, Street2016, Road2016, and Streetscapes2016 datasets.

2.5 Research Flow

The research framework consists of two aspects: spatial distribution and temporal distribution. The spatial distribution includes the locations of bike trip origins and destinations for weekends and weekdays (Zhang et al., 2021). The temporal distribution involves selecting representative time periods by plotting the overall distribution of the data. For the analysis of influencing factors, based on a review of the literature, the dependent variables were identified as road attributes and service facility density. Additional street form indicators were included for auxiliary analysis. Pearson correlation coefficient analysis and R-squared prediction were used to identify factors with strong correlations(Liu and Lin, 2019). The selected factors, ranked according to their R-squared prediction values, were added to the multiple linear regression (MLR) model (Zhang et al., 2017). Variables with variance inflation factors (VIF) higher than 10 were excluded. The final MLR model can explain the impact and predictability of different built environment factors on bike parking and usage (Godavarthy et al., 2022).

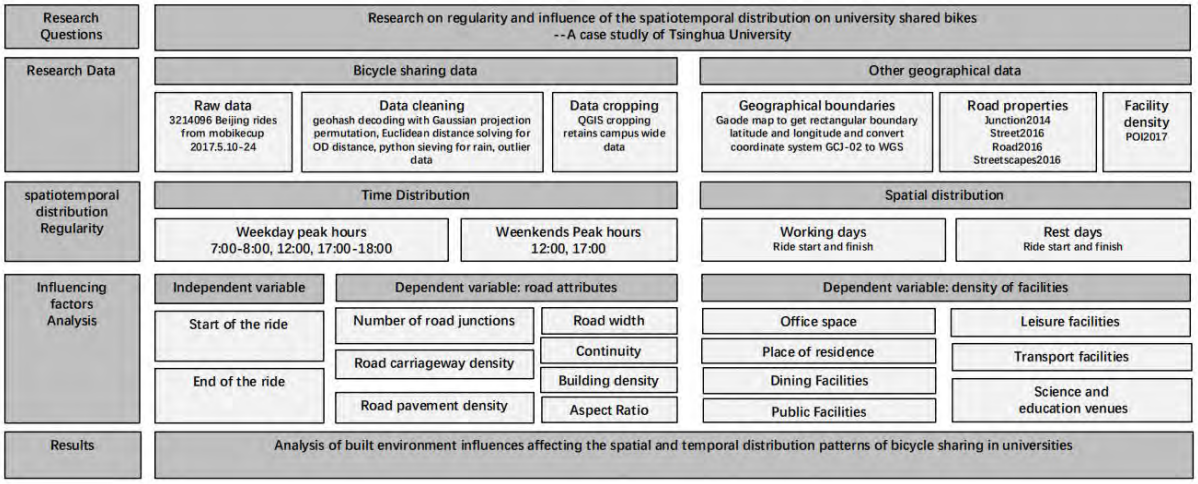

Figure 4. Research Flow.

3. Result and Discussion

3.1 Temporal Patterns of Bike Usage at University

The usage of shared bikes at Tsinghua University exhibits distinct temporal patterns between weekdays and weekends. Through analyzing the time-specific bike trip data within the campus, we found that the tidal effect of bike usage is more pronounced within the university premises. Specifically, during weekdays, in the campus, the peak usage quantity during certain time periods is 3 to 4 times higher than the normal usage periods. In contrast, the peak usage for bikes in urban is only twice as high as the normal usage periods. Additionally, there is a peak observed between 10:00 and 14:00 on weekdays in the campus. During weekends, there is also a peak observed within the campus, which is significantly different from the usage patterns in urban. Therefore, it can be

concluded that the temporal patterns of bike usage are more pronounced within the university campus, indicating a stronger regularity and greater potential for optimization between shared bikes and the built environment.

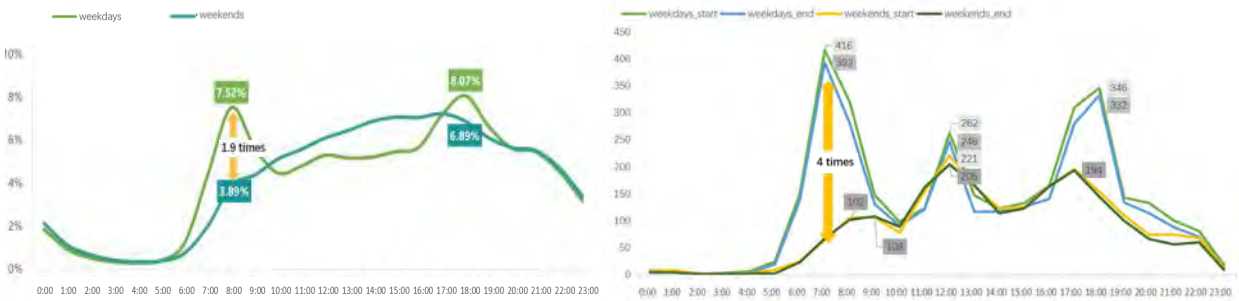

Figure 5. Timing patterns of city and campus shared bicycle use.

3.2 Spatial Patterns of Bike Usage at University

Weekday bike data was analyzed using heat maps to examine the distribution of starting and ending points. Starting points showed an even distribution in teaching buildings and residential areas, with lower densities in specific locations. In the teaching area, higher concentrations were observed near certain buildings and gates. In the residential area, clear clusters were observed in specific locations. The distribution of ending points followed a similar pattern but with changes in the locations of clustered areas. Notable clusters were found in different places within the teaching and residential areas. Overall, bike aggregation points within the campus aligned with each other on weekdays, but certain areas had a higher likelihood of bike clustering, suggesting the need for timely redistribution.

The same analysis was applied to weekend bike data. The uniformity and low-density areas remained consistent with weekdays, but significant changes occurred in the locations of clustering points. Starting points showed clustering near specific areas, while other clusters were no longer significant. In the residential area, certain locations maintained their clustering patterns, and a new clustering point emerged. The distribution of ending points also showed changes in clustering patterns. Significant clusters appeared in different areas within the teaching and residential zones. Consequently, on weekends, there was a tendency for bike redundancy in certain locations and a potential shortage of bikes in others.

Figure 6. Campus weekday and weekend bike-sharing origin and destination heat map.

3.3 Spatial-Temporal Contradictions

The most significant issue observed is the excessive bike usage during peak hours. On weekdays, peak periods occur from 7:00 to 8:00, 12:00, and 17:00 to 18:00. On weekends, peak periods are at 12:00 and 17:00. Urgent improvement is needed to address these peak phenomena.

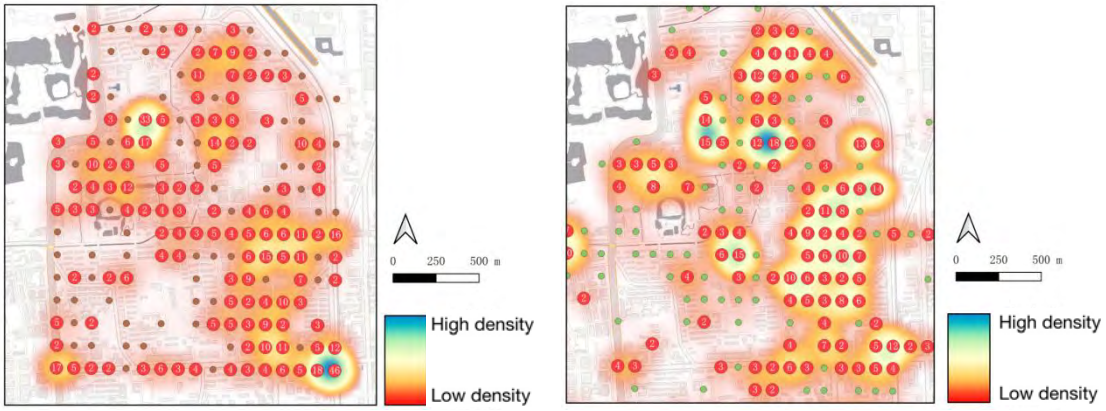

Figure 7. Campus weekdays 7:00-8:00 bike sharing start and end points.

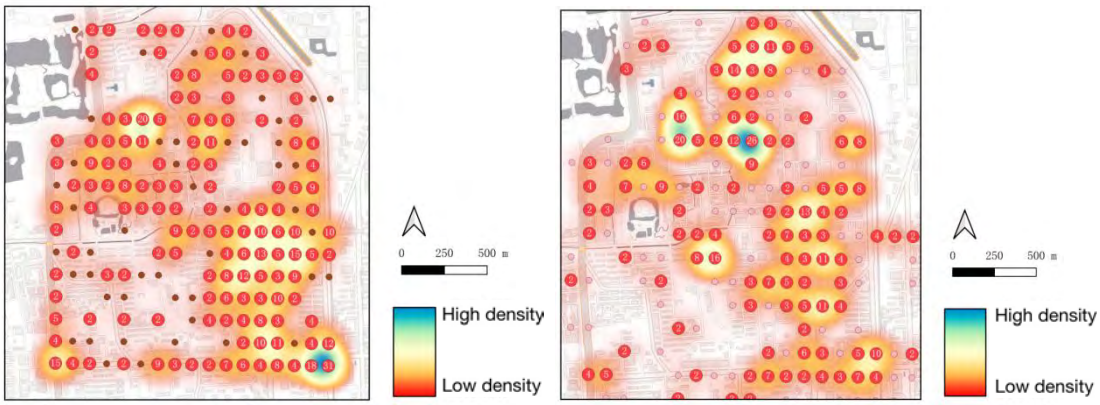

Figure 8. Campus weekdays 12:00 bike sharing start and end points.

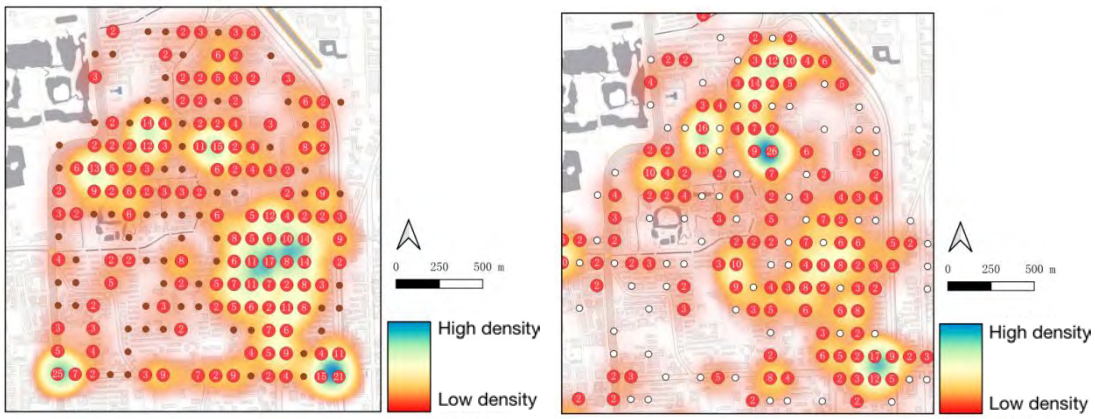

Figure 9. Campus weekdays 17:00—18:00 bike sharing start and end points.

During weekdays from 7:00 to 8:00, bike usage concentrates around Guanchou Garden and Taoli. At 12:00, Guanchou Garden remains a prominent starting point, with students traveling near the main building. Ending points are primarily Qingfen Garden, Guanchou Garden, and Zijing Cafeteria. From 17:00 to 18:00, starting points are concentrated around Guanchou Garden, Qingfen Garden, and the

central axis in front of the main building. Guanchou Garden is the main ending point during this time.

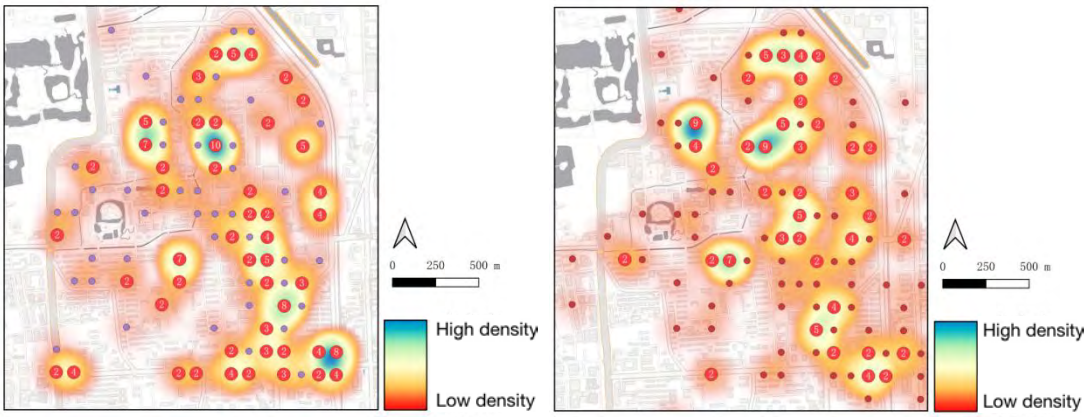

Figure 10. Campus weekends 12:00 bike sharing start and end points.

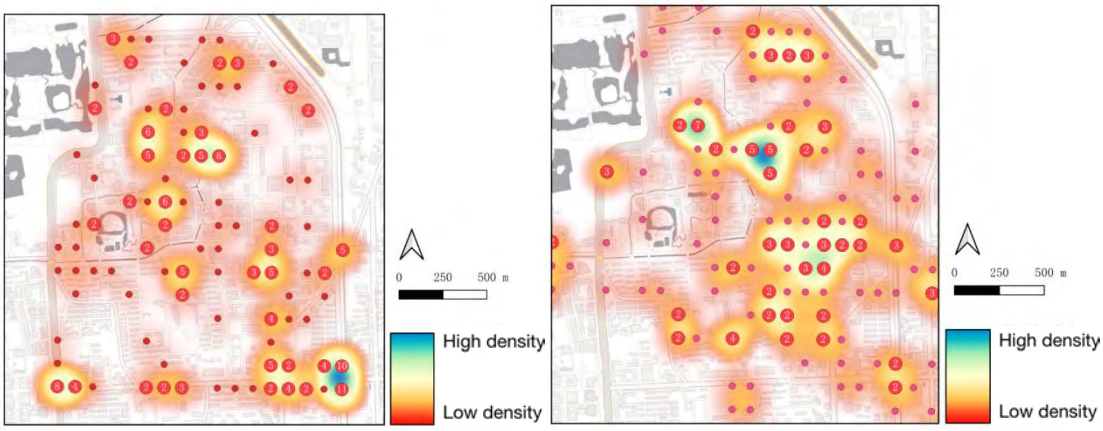

Figure 11. Campus weekends 17:00 bike sharing start and end points.

On weekends, peak hours are at 12:00 and 17:00. Starting points revolve around Qingfen Garden and Guanchou Garden, with even distribution in other areas. Ending points are primarily located in the residential area, specifically Zijing Cafeteria, Qingfen Garden, and the Library of Lee Wen Zheng. Qingfen Garden and Guanchou Garden are the main starting points during weekend peak hours, while the choice of ending points shows less regularity in terms of location.

3.4 Factors influencing the spatial and temporal distribution pattern

(1) Dependent Variable

To investigate the spatial-temporal conflicts of on-campus bike-sharing discussed earlier, the dependent variable was chosen as the number of bikes at the starting and ending points within spatial grids.

(2) Construction of Independent Variable System

In this study, a model prediction approach was adopted to assess the effects of different factors on bike-sharing usage. Therefore, commonly used Point of Interest (POI) data and road attribute data

were selected, street morphology indicators were incorporated to construct the prediction model. Due to the excessive categorization of service facilities in the original POI data, which represents the density of service facilities, this study followed the research method of Wen Chuan et al. (Wen, C. et al, 2022) and classified all POIs into five categories based on the statistical quantity of POIs, sorted from smallest to largest. Regarding road attribute analysis, existing studies (Xu, B. & Lu, Q. 2023) only considered physical parameters such as intersection density, main road density, and secondary road density. In this study, we added street morphology indicators proposed by Harvey et al., such as street width, continuity, building density, and aspect ratio, to improve the accuracy of the regression model (Harvey, C., et al, 2017).

Figure 12. Campus POI.

(3) Analysis of Influencing Factors

SPSS and Python were chosen as the tools for model construction. After selecting appropriate predictor variables from potential factors, multiple linear regression (MLR) was used to predict the bike docking situation influenced by different factors (Feng et al., 2022).

- First, each potential predictor variable was subjected to univariate regression analysis with the five time period datasets. Only predictor variables that showed significance in the univariate models (P-value < 0.05) were retained.
- To avoid affecting the results of subsequent models, the variables were tested for multicollinearity using the variance inflation factor (VIF), and variables with VIF values greater than 10 were removed from the model. After removing these variables, the remaining variables had VIF values ranging from 0 to 10, indicating the absence of multicollinearity.

- For each predictor variable remaining after Step 2, the R-squared value between the individual factor and the dependent variable was calculated using Python. The predictor variables were then added to the regression model in descending order of their R-squared values within the same layer of univariate regression.
- The final MLR model was constructed using the selected predictor variables, and variable coefficients and model accuracy were calculated. Finally, seven MLR models were built since there was no apparent correlation pattern found for the bike starting points at 12:00 and 17:00-18:00 on weekdays, as well as the bike starting points at 17:00 on weekends.

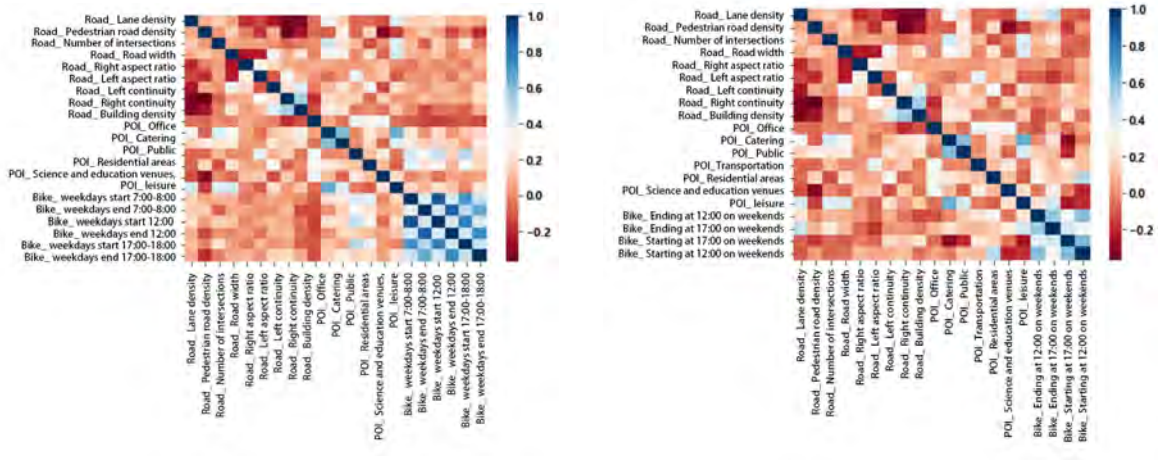

Figure 13. Correlation coefficient matrix heat map for weekday and weekend.

Bicycle density at different times			transportation facilities	road length	residence	junction	teaching building	office	R^2
weekday	start	7:00—8:00	0.369	0.218	0.216				0.086
		12:00	0.501	0.143		-0.004			0.228
		17:00-18:00	0.494			0.027			0.233
	end	7:00—8:00	0.321						0.093
weenkend	start	12:00			0.511				0.229
	end	12:00		0.212					0.034
		17:00		0.696		0.57	0.037	0.07	0.904
Average			0.421	0.317	0.364	0.198	0.037	0.07	0.258

Table 3. Campus weekend and weekday bike-sharing multiple linear regression models.

During weekdays, the peak bike starting points at 7:00-8:00 were primarily influenced by the density of transportation facilities, followed by road length and residential areas. The ending points were largely influenced by entrance and exit facilities, indicating that the starting points were mostly residential areas and the ending points were various facility entrances and exits. For the peak at 12:00, the starting points were influenced by entrance facilities and positively affected by road lanes, while negatively affected by intersections. The ending points were relatively weakly influenced by the built environment. For the peak at 17:00-18:00, the starting points were strongly influenced by entrance facilities and intersection quantity. To improve transportation during peak periods and address on-campus traffic issues, road infrastructure should be more evenly distributed in terms of road length and the distribution of entrance and exit facilities should be more balanced, reducing the frequency of intersection occurrence. In terms of facility distribution, the distribution of

residential areas should also be more balanced, as the separation between teaching areas and residential areas could lead to difficulties in bike usage and traffic congestion.

During weekends, the density of residential areas and road lanes influenced the bike starting points at 12:00, while road lane density, intersection quantity, educational facilities, and office facilities influenced bike parking at 17:00. Therefore, in terms of road infrastructure, the distribution density of entrance and exit facilities should be improved, and the distribution of road lanes and intersection quantities should be more balanced, avoiding excessive concentration. Additionally, the distribution of residential areas, educational areas, and office areas should be more balanced to reduce the number of bikes during peak periods and address other traffic hazards.

3.5 limitation

However, this study also has limitations. In terms of roads, further investigation should focus on bike riding routes rather than solely relying on simple OD distance statistics. Improving existing university roads could involve increasing the width of popular bike lanes, creating separate entrances convenient for bike parking, and reducing the number of intersections. Regarding facility distribution, during renovations, a functional reorganization of teaching areas, office areas, and residential areas could be considered. Public classrooms could be set up near residential areas to address the issue. Further research could employ methods such as offline questionnaires and manual surveys to assess available unused spaces in public classrooms for various functions, such as dining facilities, to avoid a disconnect between residential areas and teaching areas.

4. Conclusion

Shared bikes has become an essential means of transportation for many universities. However, existing literature mostly relies on subjective judgments or predictive models to understand its patterns, lacking objective recommendations for improving its relationship with the built environment. This study analyzed the spatiotemporal patterns of bike riding and parking on weekdays and weekends at Tsinghua University. To address the main contradictions related to the spatiotemporal issues of bike sharing and understand the causes of peak periods, MLR models were established using Python and SPSS.

Our model exhibits a high R-squared value, indicating the inadequacy of shared bikes for daily use and the pressure they exert on the built environment. The number of entrances, total road length, and intersections consistently have the greatest impact on shared bike usage. This highlights the severity of clustered bike parking at entrances, roadsides, and intersections, leading to conflicts and accidents in vehicle lanes and entry/exit spaces. Designing parking spots can help alleviate these conflicts. Residential density also significantly affects shared bike usage, while integrating teaching and office spaces can adjust bike distribution to some extent. Thus, shared bike quantity regulation should primarily focus on residential areas, ensuring prompt replenishment during peak usage and transporting excess bikes for repair in dormitory areas.

The contribution of this study is that, firstly, the research method applies a large-scale shared bike spatiotemporal pattern judgment model to a smaller scale study and validates its effectiveness.

Secondly, existing studies often focus on building more efficient shared bike prediction models, whereas this study emphasizes exploring improvement strategies for the built environment affected by shared bikes and provides references for planning and design. Lastly, the research findings indicate the limited carrying capacity of the built environment for shared bikes. To enhance the efficiency of shared bike usage, we should focus not only on increasing their quantity but also on considering the built environment adaption.

5. References

CHEN, E. & YE, Z. 2021. Identifying the nonlinear relationship between free-floating bike sharing usage and built environment. *Journal of Cleaner Production,* 280.

CHEN, M., WANG, D., SUN, Y., WAYGOOD, E. O. D. & YANG, W. 2018. A comparison of users' characteristics between station-based bikesharing system and free-floating bikesharing system: case study in Hangzhou, China. *Transportation,* 47**,** 689-704.

CHEN, X., MA, Z., YE, G. & LI, Z. 2022. Usage behavior and satisfaction analysis of free-floating bicycle sharing system service: Evidence from a Chinese university campus. *Research in Transportation Business & Management,* 43.

CHEVALIER, A., CHARLEMAGNE, M. & XU, L. 2019. Bicycle acceptance on campus: Influence of the built environment and shared bikes. *Transportation Research Part D: Transport and Environment,* 76**,** 211-235.

FENG, J., ZHOU, Z. & LI, W. 2022. Associating indoor air temperature with building spatial design and occupancy features: A statistical analysis on university classrooms. *Building and Environment,* 216.

GAO, J., MA, S., WANG, L., SHUAI, L. & DU, H. 2023. Does greenness bring more green travelling? Evidence from free-floating bike-sharing in Beijing. *Journal of Transport Geography,* 109.

GODAVARTHY, R., MATTSON, J. & HOUGH, J. 2022. Impact of bike share on transit ridership in a smaller city with a university-oriented bike share program. *Journal of Public Transportation,* 24.

HE, X. & WANG, Q. 2023. A location-routing model for free-floating shared bike collection considering manual gathering and truck transportation. *Socio-Economic Planning Sciences,* 88.

JABER, A. & CSONKA, B. 2023. Investigating the temporal differences among bike-sharing users through comparative analysis based on count, time series, and data mining models. *Alexandria Engineering Journal,* 77**,** 1-13.

KELLSTEDT, D., SPENGLER, J. O., BRADLEY, K. & MADDOCK, J. E. 2019. Evaluation of free-floating bike-share on a university campus using a multi-method approach. *Prev Med Rep,* 16**,** 100981.

LIU, H.-C. & LIN, J.-J. 2019. Associations of built environments with spatiotemporal patterns of public bicycle use. *Journal of Transport Geography,* 74**,** 299-312.

QIN, Y. & KARIMI, H. A. 2023. Evolvement patterns of usage in a medium-sized bike-sharing system during the COVID-19 pandemic. *Sustain Cities Soc,* 96**,** 104669.

SUN, S. & DUAN, Z. 2021. Sustaining the development of campus bike-sharing: A lesson from the unsuccessful practice in Dalian Maritime University, China. *Journal of Cleaner Production,* 295.

XIN, R., YANG, J., AI, B., DING, L., LI, T. & ZHU, R. 2023. Spatiotemporal analysis of bike mobility chain: A new perspective on mobility pattern discovery in urban bike-sharing system. *Journal of Transport Geography,* 109.

XU, Y., CHEN, D., ZHANG, X., TU, W., CHEN, Y., SHEN, Y. & RATTI, C. 2019. Unravel the landscape and pulses of cycling activities from a dockless bike-sharing system. *Computers, Environment and Urban Systems,* 75**,** 184-203.

YANG, H., LU, X., CHERRY, C., LIU, X. & LI, Y. 2017. Spatial variations in active mode trip volume at intersections: a local analysis utilizing geographically weighted regression. *Journal of Transport Geography,* 64**,** 184-194.

ZHANG, X., SHEN, Y. & ZHAO, J. 2021. The mobility pattern of dockless bike sharing: A four-month study in Singapore. *Transportation Research Part D: Transport and Environment,* 98.

ZHANG, Y., THOMAS, T., BRUSSEL, M. & VAN MAARSEVEEN, M. 2017. Exploring the impact of built environment factors on the use of public bikes at bike stations: Case study in Zhongshan, China. *Journal of Transport Geography,* 58**,** 59-70.

ZHAO, C., WANG, Y. & GE, Z. 2023. Is digital finance environmentally friendly in China? Evidence from shared-bike trips. *Transport Policy,* 138**,** 129-143.

ZHOU, X., DONG, Q., HUANG, Z., YIN, G., ZHOU, G. & LIU, Y. 2023. The spatially varying effects of built environment characteristics on the integrated usage of dockless bike-sharing and public transport. *Sustainable Cities and Society,* 89.

CAICT. 2018. Mobike. China Bicycle Sharing Industry Development Report. http://www.caict.ac.cn/xwdt/hyxw/201804/t20180426_158046.htm.

TRUSTDATA 2018. China Bicycle Sharing Industry Development Analysis Report 2018. http://www.itrustdata.com/#publish.

ZHAI, D. & Zhuo, J.2021. Research on China's Urban Bike Sharing Space Performance in the "Post-sharing Era": From Traffic Quality to Space Quality. *Modern Urban Research*, 36(10):80-89.

WEN, C.,Cheng,W.,Xiao,H. & J, X. 2022. Inference method of travel purpose considering the origin and destination points of shared bicycl. *Journal of Railway Science and Engineering*, 19(12):3590-3599. DOI:10.19713/j.cnki.43-1423/u.T20220075.

XU, B & Lu, Q. 2023, Multi-scale spatiotemporal influencing factors of bike-sharing parking demand. Journal of Zhejiang University:Engineering Science, 57(2):380-391. . http://kns.cnki.net/kcms/detail/33.1245.T.20221031.1117.002.html.

HARVEY, C., Aultman-Hall, L., Troy, A., & Hurley, S. E. (2017). Streetscape skeleton measurement and classification. *Environment and Planning B: Urban Analytics and City Science*, *44*(4), 668–692. https://doi.org/10.1177/0265813515624688.

TANG, Y.,HE, Y.,JI, N.,CHEN, X.& LIU, W. 2019. Characteristics and Behaviors of College Traveling by Bike-sharing. *Traffic & Transportation*, 0(A01):203-206211.

TANG, M., TAN, N.& ZENG, J. 2021. Shared Bicycle Parking Area Planning Based on Parking Suitability Evaluation - Tianjin University Weijin Road Campus as an Example. *Spatial Governance for High Quality Development - Proceedings of the 2020 China Urban Planning Annual Conference (06 Urban Transport Planning).*,2021: 194-204. DOI: 10.26914/c.cnkihy.2021.036805.

ZHENG, T., LIU, R., LIU, H. & ZHAO, L. 2019.Research on the identification and safety evaluation of high-frequency sections of shared bicycle riding on university campuses - A case study of Huazhong University of Science and Technology. *Proceedings of the 2019 China Urban Planning Annual Conference (05 New Technology Applications in Urban Planning),* 2019:931-943. DOI: 10.26914/c.cnkihy.2019.024652.

JIANG, X., XU, C., ZHANG, J. & LIANG, Q. 2022. Forecasting the spatial and temporal dynamics of demand for dockless bicycle sharing on campus. *Journal of Chang'an University (Natural Science Edition)*, 42(05): 105-115. DOI: 10.19721/j.cnki.1671-8879.2022.05.011

SUN, Q., ZENG, K, ZHANG, K., YANG, Y., & ZHANG, S. 2022. Spatiotemporal Travel Patterns and Demand Prediction of Shared Bikes in Beijing, *Journal of Transportation Systems Engineering and Information Technology,* 22(01): 332-338. DOI: 10.16097/j.cnki.1009-6744.2022.01.035

LI, H., CAO, Y.&TU, H. 2022. Bike-Sharing Demand Forecast Based on Multi-Scale Geographically Weighted Regression Model. *CHINA TRANSPORTATION REVIEW*, 44(05):92-101.

Research Paper

The "Greenification" of the Central Business District of Jakarta

One Small Step for Jakarta's Commercial Property, One Giant Leap for Indonesia's Sustainable Investment

Brian CHRISTIAN, SSEAYP International Indonesia Inc., Indonesia

Abstract

Reducing carbon emissions is a global mission to overcome humankind's biggest challenge of the 21st century. Several movements have been established to reduce carbon emissions as they have set the roles to reduce emissions to limit global temperature growth to less than 2 degrees Celsius in the long-term, or ideally 1.5 degrees Celsius above the pre-industrial level. Indonesia is committed to reducing carbon emissions by 29% from BAU (Business-As-Usual) practices through its own effort and is also committed to the NZE (Net Zero Emissions) target by 2060 or sooner. In the private sector, one of the initiatives that corporations could implement is to reduce carbon emissions in the real estate or commercial property sector, which is estimated to contribute around 40% of global carbon emissions. The implementation of sustainable building development in Indonesia was started by the establishment of the GBCI (Green Building Council Indonesia) in 2009. Subsequently, due to continuous growth in the importance of sustainability, Indonesia's government has issued several regulations to strategically encourage the "greenification" of Jakarta's commercial property, especially in its CBD (Central Business District). The outcomes of developing sustainable buildings are crucial in the effort to reduce carbon emissions as the demand for green-certified buildings is continuously growing as investors, occupiers, and talents are currently more aware of urban sustainability's importance. Investors prioritise building or buying assets that are recognised with green certification as 78% of investors accept that climate risk also means financial risk. Furthermore, around 80% occupiers agree to prioritise buildings that could help reduce carbon emissions and more than 60% of the talents in Asia Pacific countries believe that sustainability initiatives are a requirement for nowadays business. Sustainability, through green building development, has become the new and upcoming leverage to attract investors, occupiers, and talents. Along with the data analysis using a qualitative and quantitative approach, spatial visualization will also be used in this research to display the existing location of green buildings agglomeration. Expectantly, the exploration and comprehension of this study, which associates green building development and investment in urban sustainability, might identify a new way of planning and investing from the private sector's perspective, specifically the real estate market.

Keywords

Green Building, Sustainability, Real Estate, Investment, Urban Economy, Jakarta CBD

1. Introduction

1.1. Findings

Greenification, as part of the actions of reducing carbon emissions for climate resilience, is one response to overcome humankind's biggest challenge of the century. As a global mission, several movements have been established to help accomplish the goal in a macro framework. Those were administered even before the 21st century began as in the Kyoto Protocol: international treaty of 1992 UN FCCC, and during this 21st century as in the Paris Agreement: international treaty of the 2015 UN FCCC.

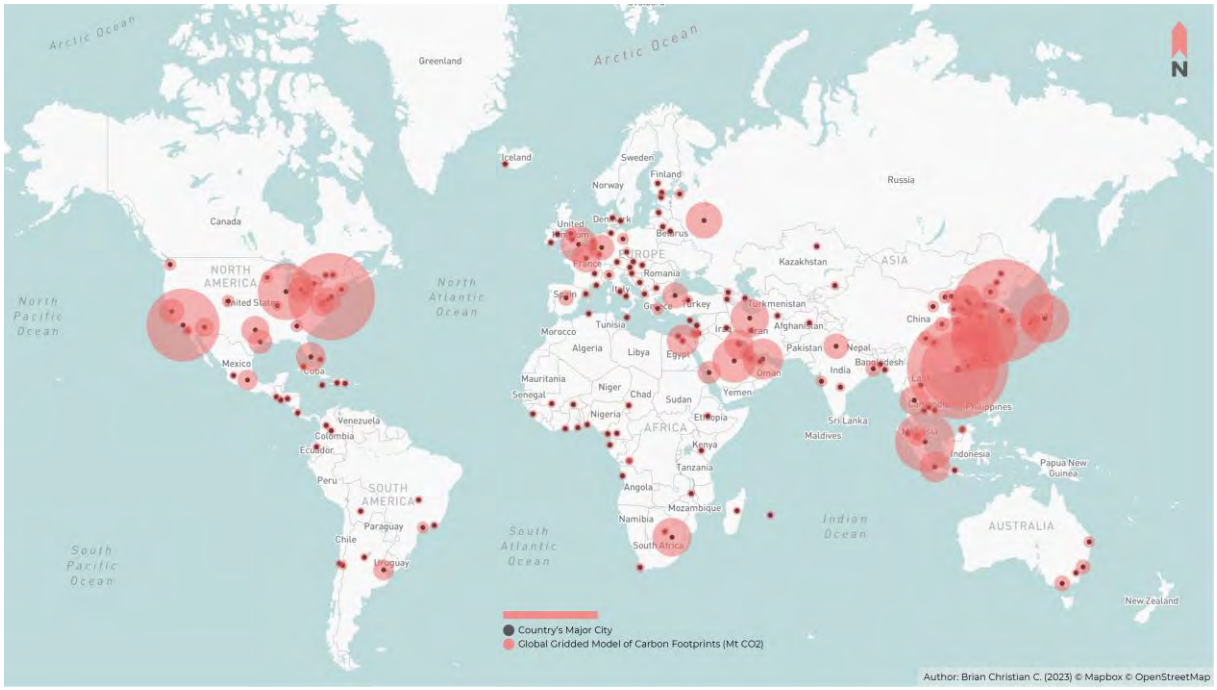

Figure 01. Map of World's Major Cities and the 2018 Estimated Top Carbon Footprints by City. Source: City Carbon Footprints. Output: Mapbox Studio & Microsoft Publisher (Author's Design) [1][2].

Cities represent intense concentrations of populations and consumption. Even allowing considerable margins of uncertainty, footprints are highly concentrated (Moran, D., et al., 2018). The map above visualizes the locations of the world's major cities, based on general demographic and economic values, along with the estimated production of carbon footprints. The model is called GGMCF (Global Gridded Model of Carbon Footprints) which provides globally consistent and spatially resolved annual carbon footprints of individual cities. Cities in the East Asia and Southeast Asia are dominating the global carbon footprints proportion due to the high rate of population growth and rapid level of urban development. In this scope, reducing carbon footprints means reducing carbon emissions to limit global temperature growth to less than 2°Celsius in the long term, or ideally 1.5°Celsius above the pre-industrial level.

While in the East Asia region, Seoul (South Korea) and Guangzhou (China) have the global highest level of carbon footprints, respectively at 276.1 Mt CO_2 and 272.0 Mt CO_2, Southeast Asia region has Singapore at 161.1 Mt CO_2 and Jakarta (Indonesia) at 83.7 Mt CO_2 as part of the top 20 cities with the highest level of carbon footprints. Considering the total carbon footprints of those 100 cities reaching around 6229 Mt CO_2, Indonesia has contributed to more than 1% of the estimated CO_2 emissions produced. The statistic is one reason for Indonesia to be committed to reducing carbon emissions by 29% from BAU practices through its own efforts and up to 41% with international assistance as stated in the NDC document (JLL, 2022, Indonesia's Journey Towards Sustainable Real Estate, p.4). Indonesia has also committed to the NZE target and is expected to reach this goal by 2060 or sooner (Ministry of Energy and Mineral Resources of the Republic of Indonesia).

1.2. Terms & Focus

In this Research Paper, "greenification" is a term used to define the transformation process of making an area or sector greener, traditionally by the addition of trees and other plants. The Author aims to expand this term on the involvement of city planning, site design, and building development process. The concept of green infrastructures and nature-based solutions has emerged as a way to secure the provisioning of ecosystem services in a human-dominated landscape (Ahem, et al., 2014).

This Research Paper is focusing on the scope of Jakarta CBD (Central Business District), the "golden triangle" of Indonesia's capital city, a roughly triangular area as the agglomerations of the city's tallest skyscrapers and busiest districts. Besides the gradually developed commercial clusters e.g., SCBD, Mega Kuningan, and HI Roundabout, the CBD is also served and connected by various public transportations of Jakarta. The CBD represents the commercial heart of the metropolitan area, containing the highest density of institutional-grade office products, major infrastructure hubs and government and cultural anchors (JLL, 2023, The Future of the Central Business District, p.2). The Jakarta CBD, due to its high rate of agglomeration and rapid level of operation, contributes more significantly to the carbon footprint level compared to the most of less commercialized and/or industrialized areas inside the city, suburban areas, and regions far from the urban perimeter.

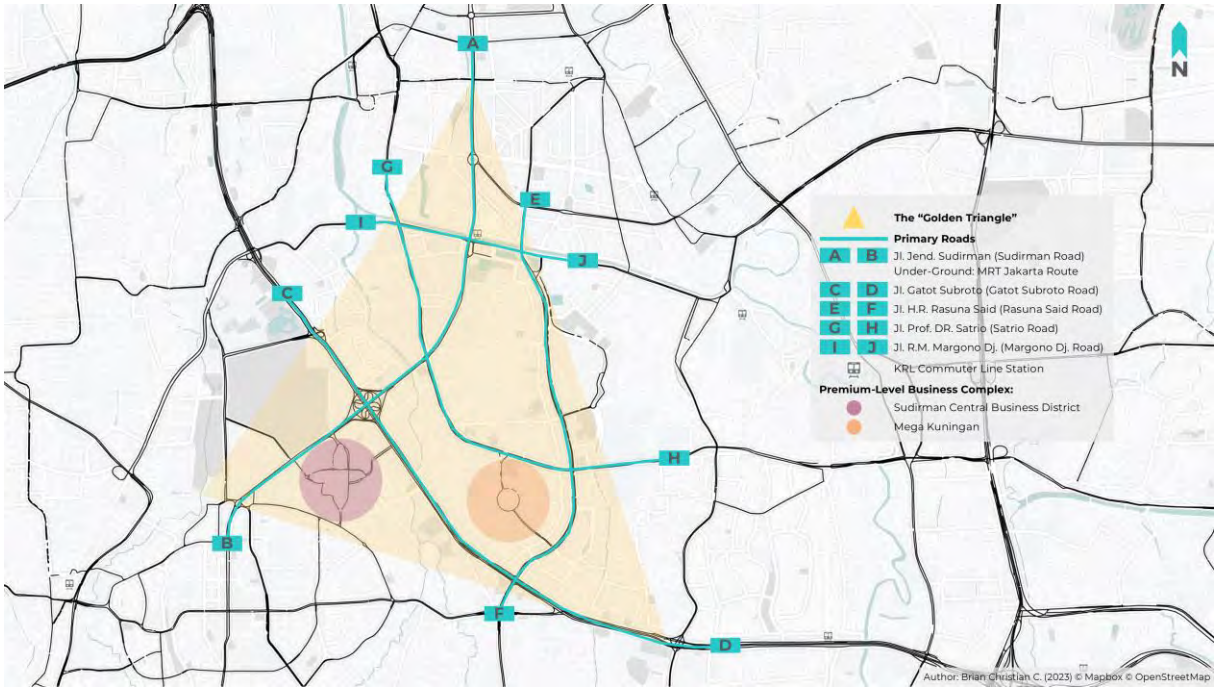

Figure 02. Map of Jakarta CBD and Primary Roads. Source: Google Maps & Google Earth (Author's Analysis). Output: Mapbox Studio & Microsoft Publisher (Author's Design).

Furthermore, the situation in the Jakarta CBD area could be associated with nowadays sustainability requirements as various commercial buildings need to accomplish more on energy efficiency and carbon emissions. This is supported by the fact that on a global level, more than 1 billion square meters of office space will need to be retrofitted by 2050 and 80% of office buildings that exist today will still be in use in 2050, meaning that they will have to be retrofitted at a rate of at least 3% to 3.5% per year if net-zero targets are to be met. Refurbishing buildings comes at a lower environmental cost than new developments. Renovations can take place with carbon impacts of less than 500 kg of CO_2 per square meter, well below the 500 kg to 1,500 kg of CO_2 per square meter seen in new development. This will be significant in helping cities in their move towards carbon neutrality (JLL, 2023, The Future of the Central Business District, p.7).

2. Theories and Objectives

2.1. Urban Theories

Market forces in the development of cities relate to how the location decision of firms and households causes the development of cities. The nature and behaviour of markets depend somewhat on their locations therefore market performance partly depends on geography (McCann, 2001). Connected with the Bid Rent Theory, the idea explains how CBD affects and is affected by the market growth, inside and outside the relatively indivisible perimeter. Alonso's General Theory of Movement establishes an important advance in Spatial Interaction Modelling (De Vries, J., et al., 2000). The theoretical foundation set by William Alonso has developed into the topics we understand now as urban economics and how, as one of the three pillars of urban sustainability, it affects the development of commercial property and the private sector's vital components. Considering the spatial organisation of activities within cities, urban economics addresses questions in terms of what determines the price of land and why those prices vary across space, the economic forces that caused the spread of employment from the central core of cities outward, identifying land-use controls, such as zoning, and interpreting how such controls affect the urban economy (O'Sullivan, 2003). However, the market-oriented development in urban economics shall not overcome the importance and urgencies of the other two pillars: environment and society. Without planning, new values may displace existing ones, but even if a net gain results there may well be considerable losses (McHarg, 1971). For a sustainable investment, or even better urban sustainability, the aspects of nature's preservation and people's consideration should be more prioritized. Autocrats like Alexander the Great and Philip II could build cities according to well-thought-out and carefully matured plans, because they could impose their will by force; but a city which is to be the outward expression of a strong desire to secure the best interests of all its inhabitants can, among a self-governing people, only arise as the outcome of much patient and well-sustained effort (Howard, 1902).

2.2. Research Objectives

In the track of Invest Wisely, by the 59th ISOCARP World Planning Congress and the 5th Urban Economy Forum, the Author aims to share the idea of how cities and communities could progress into a sustainable and regarding place due to their friendly environment, inclusive society, and prosperous economy. It explores the topics of climate change and urban sustainability through the real estate market or commercial property development, as one of the most influential private sector businesses. In Indonesia, starting from Jakarta, several policy briefs have already been published to initiate the common objective. The Governor Regulation of DKI Jakarta No. 38 of 2012 on Green Buildings regulates the implementation of green buildings in Jakarta. The regulation introduces mandatory requirements for new and existing buildings in the areas of energy and water use efficiency, indoor air quality and thermal comfort, waste management, soil treatment, and construction practices. The Jakarta International Stadium is a prime example of a green building in Jakarta, receiving a Greenship Platinum certification from the Green Building Council Indonesia (C40 Cities, 2017, Green Building Implementation). Jakarta also has the "30:30 Commitment" aiming to reduce energy and water consumption and GHG – Greenhouse Gases emissions by 30% by 2030. Jakarta's Green Building Program targets compliance for 100% of new buildings and 60% of existing buildings with the program in 2030. The implementation of sustainable buildings in Indonesia was encouraged by the establishment of the Green Building Council Indonesia 20 years before the targeted year. Subsequently, due to continuous growth in the importance of sustainability, Indonesia's government has issued several regulations to spur the implementation of green buildings (JLL, 2022, Indonesia's Journey Towards Sustainable Real Estate, p.3). Sustainability has become the new and upcoming leverage to attract investors, occupiers, and talents, which is aligned with the common objectives and global missions established through the multilateral consensus.

3. Path to Sustainability in Indonesia

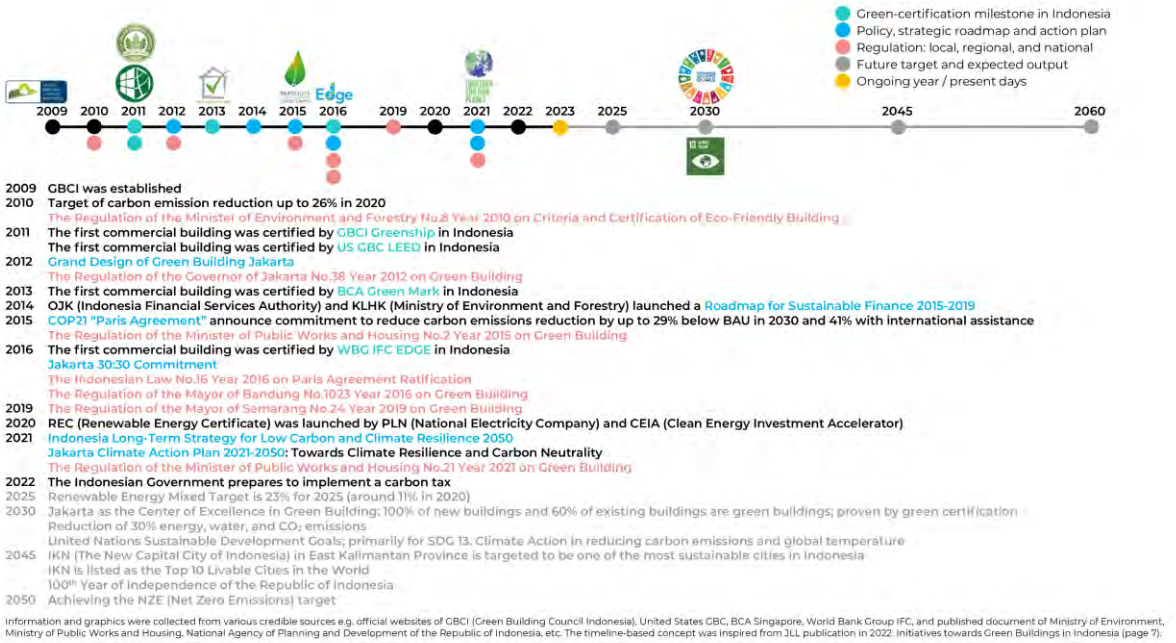

Figure 03. Year-Based Occurrence, Policy, and Regulation of the Sustainability and Net Zero Target in Indonesia. Source: JLL Indonesia. Output: Microsoft Publisher (Author's Design).

There are four well-known green certifications or rating systems used in Indonesia for the buildings to officially carry the green reputation and potentially leverage their asset value. Those green certifications are: (1) LEED, launched in 1998, by US GBC – the United States Green Building Council, (2) Green Mark, launched in 2005, by Singapore BCA – Building and Construction Authority, (3) Greenship, launched in 2009, by GBCI – Green Building Council Indonesia, and (4) EDGE, launched in 2015, by WBG IFC – World Bank Group International Finance Corporation. Despite both LEED and Green Mark having set the cornerstones of green certifications earlier, primarily in global scope, than GBCI Greenship, the path to sustainability in Indonesia is summarized to begin when the first council of green building in Indonesia was established.

Since its establishment, several regulations have been announced; more than five policies have been formulated to direct and guide the accomplishment of sustainability in Indonesia. The number of green-certified buildings increases from year to year, especially in Jakarta, tested and confirmed by those four green certification institutions. The impact of the Paris Agreement was also seen in most regulations and policies related to the Net Zero Emissions announced a year after COP 21's conclusion. In general, there are two targets of the government regulations and policies to initiate the carbon reduction efforts and drive the green buildings development. The first one is the private sector; commercial building owners and property developers which need to fulfil several requirements such as using environmentally friendly building materials, conserving water resources, improving waste management systems and recycling initiatives, also facilitating the building area with green open spaces. Those requirements are considered mandatory for certain categories and sizes of buildings: (1) commercial offices, shopping centres, and residential buildings with an area of more than 50,000 square metres, (2) hotels and hospitals with an area of more than 20,000 square metres, (3) educational facilities with an area of more than 10,000 square metres. The second one is the public sector; financial services institutions and government agencies need to provide research and reports related to sustainability progress. It consists of the data of financial, social, and environmental performance in conducting their functions and operations with sustainability values and principles (JLL, 2022, Indonesia's Journey Towards Sustainable Real Estate, p.8).

4. Data Consolidation and Analysis

4.1. Urban Tendency: Business-Centralized City

As a city with a business-centralized area, Jakarta has evolved into the economic and financial hub of the country and plays a significant role in international corporations, business establishments, and recently, sustainability accomplishments. The common goals came as an influence of globalization in which Jakarta has become part of the agenda. Global firms and markets need multiple global cities from where they can organize their operations (Taylor, et al., 2007) – as well as to be aligned with the envisioned sustainability goals and net zero emissions target.

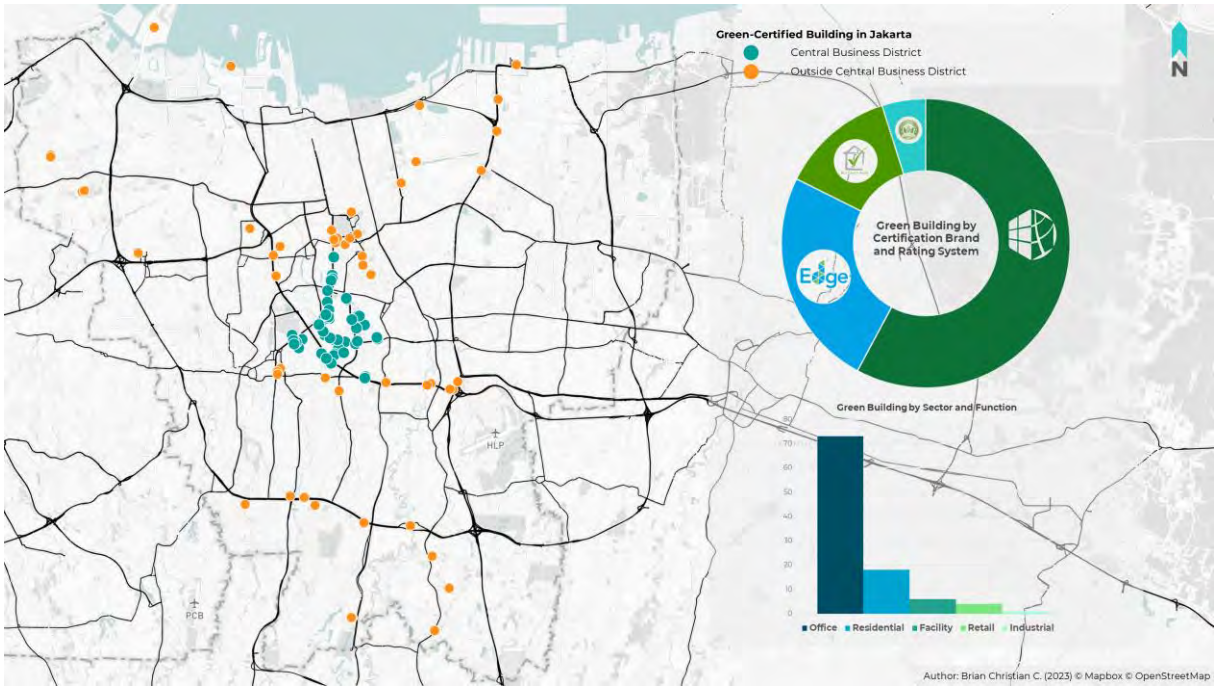

Figure 04. Green-Certified Buildings in Jakarta: Location, Certification, and Function. Source: GBC Indonesia, IFC World Bank, BCA Singapore, US GBC (Author's Analysis). Output: Mapbox Studio, Microsoft PowerPoint, and Microsoft Publisher (Author's Design).

The figure above displays information related to the location, certification, and function of green-certified buildings in Jakarta. From the first green certification year in 2011 to the first half of 2023, Jakarta has already more than 100 green-certified buildings. Despite having less than 10% of the total area in Jakarta, the Central Business District – more as an interpreted area rather than an administrative district, has around 48% of green-certified buildings concentrated. While green-certified buildings outside the Jakarta CBD are distributed without a significant pattern other than following the primary roads, the green-certified buildings in the business-centralized area could be identified as an agglomeration. More than 100 buildings are certified by four well-known green certifications used in Indonesia, respectively from the highest green-certified proportion: Greenship (57.8%), EDGE (24.5%), Green Mark (12.7%), and LEED (4.9%). The agglomeration among the green certifications proportion is presumptively influenced by brand popularity, pricing range, requirement standard, specification level, etc. As a business-centralized city, the "centralization" in Jakarta could be identified as more significant for the Office buildings (71.6%) as the green-certified buildings based on sectors and functions. The dominating figure is followed by eighteen Residential buildings: condominiums, serviced apartments, and flats (17.6%), several public Facilities (5.9%) such as Jakarta International Stadium, Istiqlal Mosque, Kemayoran Athletes Dormitory, TelkomSigma Data Center, then four Retail buildings: mall (3.9%), and one Industrial building: micro-sized factory (0.9%) located in Jakarta.

4.2. Urban Economy: Green-Certified Property

Sustainability has become mainstream and entered the private sector; one of the cores is real estate or commercial property which is already on the pathway through green building development, technology, and policy. Other than the factors of location and pricing, sustainability is considered one of the main priorities of both end-user lease agreements and long-term direct investments. In the Asia Pacific real estate market, around 70% of tenants or occupiers are willing to pay more than the market average to lease green-certified commercial offices; the landlords can expect premium-level rental rates as well from their green-certified buildings (JLL, 2021, Sustainable Real Estate: From Ambitions to Actions, p.10).

The journey was recorded from the first year of green-certified commercial building to the beginning of the property bubble era in 2012, where both massive supply and office demand were dominating the market and escalating the price. Followed by the "burst" or saturated market – forcing the price fall period, but later saved by the technological start-up boom in Indonesia which was started significantly in 2017. The trend and number of green-certified commercial buildings eventually emerged during the start of the pandemic era in 2020. It was presumed as an effort from building landlords or property owners to bring added value to their assets – which were struggling due to weakened demand and competing supply, to improve both technical performance and substantial reputation through the sustainability concept. This created more than just supply-demand dynamics in the market competition and reflected the urban economy growth in Jakarta, represented by the market situation in the CBD area.

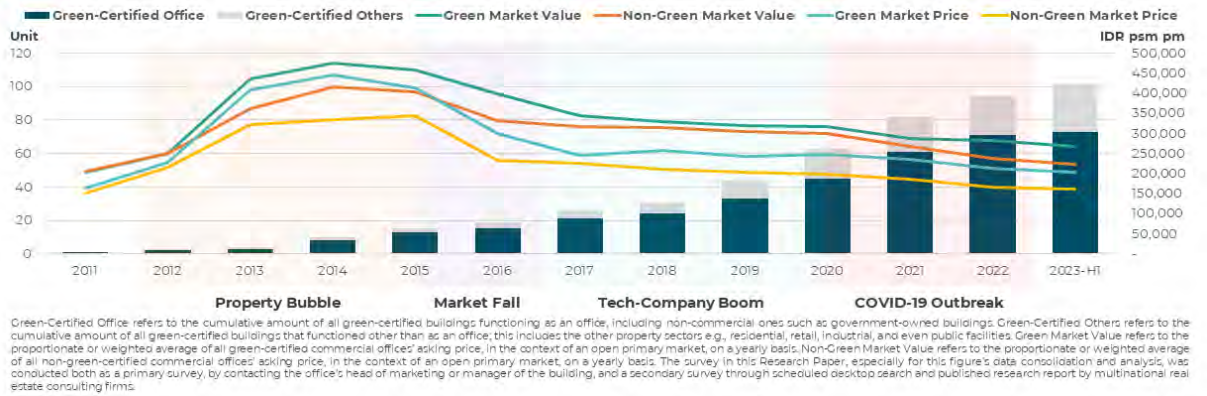

Figure 05. Comparison of Green-Certified Buildings Cumulative with Green-Certified and Non-Green Offices Market Value in the CBD Area of Jakarta. Source: GBC Indonesia, IFC World Bank, BCA Singapore, US GBC, and JLL Inc. (Author's Primary Survey and Analysis). Output: Microsoft PowerPoint (Author's Design).

Market price (offering price or transacted price) is the price tenants are willing to pay for leased office space, while market value (asking price or published rate) indicates the price set by property owners based on research advisory and valuation processes conducted by market researchers and asset valuators. Both market value and market price for green-certified and non-green offices are relatively similar, prices ranging from IDR 150,000 to IDR 165,000 per square meter per month (psm pm) before the property bubble era. Significant disparities in value and price were identified once rental rates started to rise due to strong demand and ample supply in the CBD area. Market prices for green-certified offices could even be maintained above IDR 400,000 psm pm for three years (2013 to 2015), on average 16.7% to 24.8% higher than the market prices of non-green offices. During the tech-company boom, despite the perceived oversupply of office buildings in the CBD area, creating a more competitive market, both green market value and price remained relatively better than the non-green market value and price. The resilience of green-certified offices' market value and price was further demonstrated during the COVID-19 outbreak or pandemic era, with approximately 20.3% to 22.4% higher values compared to non-green offices. On average, green-certified offices had market prices above IDR 200,000 psm pm, while non-green offices had prices below that figure in the last four years (2020 to the first half of 2023).

4.3. Urban Policy: Sustainability-Carried Technology

Leading the sustainability journey requires more than just green certifications. While they are sufficient to demonstrate green credibility, investing in technologies and cities that are at the forefront of climate change policies and actions is essential. In the private sector of commercial property, technology and data play a crucial in creating sustainable real estate developments. Investing in expertise and specialists in sustainability, as well as collaborating with other companies and sectors, can lead to better solutions. The Author agrees that all these elements have a profound impact on the definition of new policy styles and new urban governance tools (Taylor, et al., 2007).

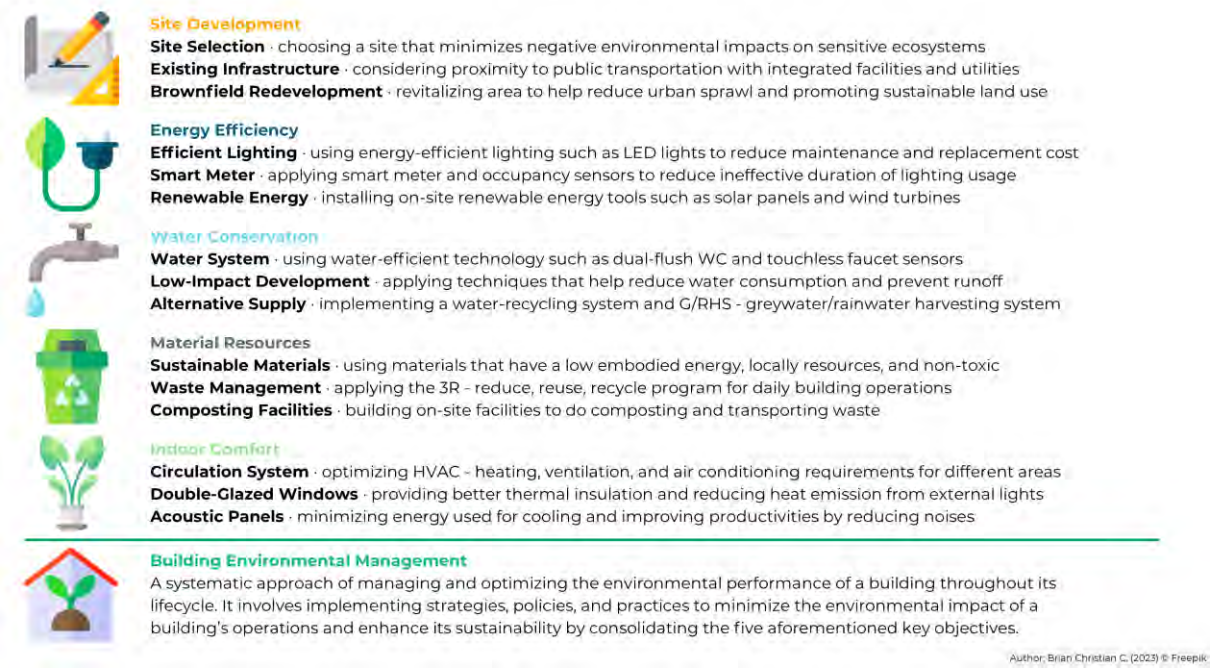

Figure 06. Five Key Objectives of Building Environmental Management. Source: GBC Indonesia and JLL Inc. (Author's Analysis). Output: Microsoft Publisher (Author's Design).

As real estate is one of the most contributing sectors of carbon emissions, stakeholders, including building owners, will need to balance the efforts from new construction to retrofitting, as new buildings alone will not get Indonesia to achieve the target (JLL, 2022, Indonesia's Journey Towards Sustainable Real Estate, p.17).

To amplify Jakarta's sustainability and green building targets, several objectives need to be formulated into strategic-level urban policies that covers the operational-level management procedures:
(1) Creating an investment climate: It is essential to attract interest from financial institutions to provide green loans and encourage investors to prioritize green buildings. By promoting a favourable environment for green investments, we can foster the growth of sustainable projects.
(2) Driving the corporate actions: It is crucial to raise awareness among corporations about the urgent need to implement net-zero targets and embrace sustainability. This not only positions them as leaders in attracting top talent but also enhances their reputation and competitiveness in the market.
(3) Supporting property developers: It is important to incorporate sustainability considerations into the development of new buildings. This involves integrating green building practices and technologies from the early stages of planning and design, including the process of retrofitting the building if necessary.

Those three interconnected aspects operate within a regulatory environment that encompasses both incentive and disincentive schemes to enforce the objectives. By implementing the strategic-level urban policies that covers the operational-level management procedures, Jakarta can make significant strides towards a greener and more sustainable future.

5. Conclusion

5.1. The "Greenification" of Jakarta

Jakarta's journey towards sustainability is well underway, especially in the sector of real estate. The city has made substantial progress in green building certifications, particularly in the CBD area, witnessed economic benefits from green-certified properties, and implemented urban policies to drive sustainability. This concentration of green-certified buildings reflects the city's business-centralized nature and its alignment with global sustainability goals, including those set by the Paris Agreement. By embracing technology, fostering collaborations, and formulating strategic-level policies, Jakarta can continue its path towards a greener future, contributing to global sustainability efforts and achieving its own targets for carbon reduction.

The economic implications of green-certified properties are also noteworthy in Jakarta. The market demand for green-certified commercial offices, the globally most valued and active real estate sector, has been considered strong, with tenants willing to pay premium rental rates for various offices located in the CBD area. This demand has been driven by growing awareness of sustainability and the willingness of occupiers to prioritize green buildings. The market value and price of green-certified offices have remained relatively higher than non-green offices, even in the face of market fluctuations and the COVID-19 pandemic. This resilience underscores the value and reputation associated with sustainability contribution from the private sector.

5.2. Technology and Policy for Sustainable Investment

To further advance sustainability in Jakarta, technology and policy recommendations are essential. Investing in sustainable technologies and data-driven solutions can lead to more effective and efficient real estate developments. Collaborations between companies, sectors, and experts in sustainability can yield innovative solutions and drive progress. Balancing efforts between new construction and retrofitting is crucial, as retrofitting existing buildings is necessary to achieve carbon reduction targets.

Strategic-level urban policies must be formulated to support Jakarta's sustainability goals. Creating an investment climate that attracts financial institutions and encourages green investments is crucial. Driving corporate actions and raising awareness among corporations about the importance of net-zero targets and sustainability is necessary to position them as market leaders. Supporting property developers in integrating green building practices and technologies from the early stages of planning and design, including retrofitting existing buildings, is essential for achieving sustainability objectives. Despite being considered just a small step in Jakarta's commercial property innovation, it has the potential to be a giant leap for Indonesia's sustainable investment.

The successful implementation of these recommendations will require a regulatory environment that provides both incentives and disincentives. Incentive schemes can encourage compliance with sustainability objectives, while disincentive measures can discourage unsustainable practices. Jakarta can make significant strides towards a better "greenification" and more sustainable future by aligning environmental-oriented technology and policy to strategic-level urban policies. Recommended initiatives and actions for sustainable investment include:

- ESG and NZE Strategies: Designing a strategy to translate commitments into a detailed action plan and conduct assessment to evaluate companies on how advanced they are in achieving sustainability.
- Energy Efficiency and Renewable Energy Supply: Reducing energy consumption, increasing energy efficiency, and installing alternative sources of energy to claim carbon credits.
- Retrofitting and Future Proofing: Prioritizing assets that are considered underperforming, identifying potential building retrofit strategy, and investing in asset facilities enhancement.
- Health and Wellbeing: Improving the health and wellbeing of the tenants/occupiers, as well as using human-centric design to encourage movement, collaboration, and productivity.
- Innovations and Digital Transformation: Adopting smart technology to track, monitor, analyse, and report sustainability data and carbon footprint.

6. References

Building and Construction Authority - Green Mark Certification Scheme. bca.gov.sg.

de Vries, J.J., Nijkamp, P. and Rietveld, P., 2000. *Alonso's general theory of movement: Advances in spatial interaction modeling* (No. 00-062/3). Tinbergen Institute Discussion Paper.

Green Building Council Indonesia - Certified Buildings. gbcindonesia.org.

Green Building Information Gateway - Green Certifications in Indonesia. gbig.org.

Howard, E., 1965. *Garden cities of to-morrow* (Vol. 23). MIT Press.

Jacobs, J., 1992. The death and life of great American cities. 1961. *New York: Vintage*.

JLL - Trends & Insights: Real Estate Intelligence Service (REIS). jll.co.id.

JLL IP, Inc., 2021. *Asia Pacific Insights Summary, Sustainable Real Estate: From Ambitions to Actions.*

JLL IP, Inc., 2022. *Research Report, Indonesia's Journey Towards Sustainable Real Estate.*

JLL IP, Inc., 2023. *Global Research, The Future of the Central Business District.*

McCann, P., 2001. Urban and regional economics. *OUP Catalogue*.

McHarg, I.L. and American Museum of Natural History, 1969. *Design with nature* (pp. 7-17). New York: American Museum of Natural History.

Moran, D., Kanemoto, K., Jiborn, M., Wood, R., Többen, J. and Seto, K.C., 2018. Carbon footprints of 13,000 cities. *Environmental Research Letters*, 13(6), p.064041.

O'Sullivan, A., 2003. Urban economics. *Boston, Mass.: McGraw-Hill/Irwin*.

Pisman, A., De Nocker, L., Dugernier, M., Pennincx, I., and Van Damme, L., 2015. 'Analysis on financial consequences of spatial decisions: Framework and case studies', *The 51st ISOCARP World Planning Congress.* International Society of City and Regional Planners, 5-7 May 2015.

Stampfl, B., 2010. 'Green buildings for sustainable cities', *The 46th ISOCARP World Planning Congress*. International Society of City and Regional Planners, 19-23 September 2010.

Taylor, P., Derudder, B., Saey, P. and Witlox, F. eds., 2006. *Cities in globalization: Practices, policies and theories*. Routledge.

UN-Habitat, 2021. *Cities and Pandemics: Towards a More Just, Green and Healthy Future*.

U.S. Green Building Council - LEED Rating System. usgbc.org.

Zimmermann, J., and Burkholz, K., 2019. 'Sustainable real estate development in the age of e-commerce – Implications of the structural change and resulting changed requirements for retail property', *The 55th ISOCARP World Planning Congress.* International Society of City and Regional Planners, 9-13 September 2019.

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Paper Index

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Case Study Report

A geospatial business intelligence model for integrated quantitative assessment of urban and land ecosystem resources in Italy

The city of Rome case study

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Abstract

In this case study, authors propose and test a geospatial data model supporting planning activities and spatial management in the Metropolitan area of Rome. The actual urban context of the city of Rome is highly complex and impacted by several diverse regulations that intersect the residential and industrial areas with archeological, and cultural, landscape and forest, blue and green spaces. Built areas are highly characterized by natural, urban and cultural heritage assets affected by diverse concurring risks.
New directions in planning discipline and practice adopt a holistic approach aimed at giving functionality to landscape and ecosystems for sustainable land uses, restoring ecological balances, providing ecosystem services, socio-economic benefits linked to attractiveness and identity of places, the reconnection and regeneration of marginal and degraded areas.
Authors propose a GIS-based methodology supporting territorial planning and management activities according to criteria established by landscape and hydrogeologic risk features. Existing planning and management regulations are the theoretical substrate for the preparation of a homogeneous data model to support geospatial analysis.

Keywords

Urban planning, Rome, GIS, Multi-criteria analysis, landscape

1. Introduction

In this case study, we propose and test a geospatial business intelligence model supporting planning activities and spatial management in the Metropolitan area of Rome. The actual urban context of the city of Rome is highly complex and impacted by several diverse regulations that intersect the residential and industrial areas with archeological, and cultural, landscape and forest, blue and green spaces (Spasiano & Nardi, 2019; Nardi et al., 2021). Built areas are highly characterized by natural, urban and cultural heritage assets affected by diverse concurring risks (Nardi et al., 2021).

New directions in planning discipline and practice adopt a holistic approach aimed at giving functionality to landscape and ecosystems for sustainable land uses, restoring ecological balances, providing ecosystem services, socio-economic benefits linked to attractiveness and identity of places, the reconnection and

regeneration of marginal and degraded areas (de Groot et al., 2010; Geneletti, 2011; Tenberg et al., 2012; Agnoletti, 2014; De Montis, 2014; Valles-Planells et al., 2014; Purkarthofer et al, 2021). In particular, new directions in land-use and urban planning tend to integrate the management of hydrogeological hazards with the development and organization of anthropic systems (Mysiak et al., 2013; Smith et al., 2014; Ran & Nedovic-Budic, 2016).

The implementation of IT tools and data-driven methodologies is essential for the simulation and evaluation of different scenarios and for making informed decisions according to environmental, economic and social sustainability criteria (Lathrop & Brown, 1998; Robinson & Brown 2009; Green et al., 2010; Cervelli et al., 2020)

In this study, we propose a GIS-based methodology supporting territorial planning and management activities according to criteria established by landscape and hydrogeologic risk features. Existing planning and management regulations are the theoretical substrate for the preparation of a homogeneous data model to support geospatial analysis.

The analytical model considers 4 geospatial domains related to constrained zoning areas as relevant geographic features protected by Italian law: (1) Water, (2) Archeology, (3) Natural green areas and (4) Landscape. These geospatial domains are here adopted as input variables for defining a geospatial index to guide strategic and integrated planning.

The development of the proposed data model aims to provide a supporting cognitive framework for systematizing planning activities for decision-makers, stakeholders and researchers involved in planning research activities in the context of digitalization of the society.

The purpose of this work is to set up a data model to support reconnaissance activities of areas subject to planning based on the characteristics of environmental and human systems. In Italian planning legislation, a constraint constitutes a well-defined area subject to a protection regime for reasons that mainly include exposure to environmental risk and hazard factors and susceptibility, historical-cultural interest, and environmental interest. The identification of such areas determines urban planning practices in Italy. Urban transformation and regeneration processes must consider the risk factors and the expressive and identity aspects of the territory, as a result of historical interactions between human societies and the environment that shape the forms and characterize the socioeconomic uses of the territory.

A multi-criteria analytical approach is adopted with GIS tools and raster grid cell that synthetizes landscape value by numerical format, obtained from open geospatial data describing zoning constraints areas. Multi-criteria analysis is implemented for recognizing and assessing homogeneous zoning areas that can address territorial plans in the Metropolitan Area of Rome.

The overlapping and intersections of these features point out the interactions between environment, historical settlements and consolidated land use that generate landscape features and values.

The innovation that this contribution is intended to bring is the development of new models to support urban governance according to environmental and social sustainability criteria and the adoption of landscape and nature-based solutions. GIS-based reconnaissance of constraints is used to identify and classify spatial values (in terms of cultural and environmental variety and richness) on the urban and rural spaces; relevant interactions between human and environmental systems; ecosystem services; and all those areas where urban transformations may be most impactful on local balances.

Table 1 summarizes the main tools in urban and land use planning in Italy. The government and management of the territory and its transformations fall to regions and local authorities, operating, however, within a national legal framework provided by Legislative Decree 42/2004 (Cultural Heritage and Landscape Code) and Legislative Decree 152/2006 (Environmental Regulations). These decrees provide

operational guidelines for land planning and management and for the management of urban transformation processes at regional and local levels according to specific sectoral domains.

Transformative actions on the urban spaces, however, have large-scale impacts and require a holistic approach to planning and management. By bringing together GIS data processed and made available in the form of open data by relevant public administrations, this study proposes a data model to support spatial analysis.

Plan instrument	Legal references	Scopes and functions
Regional Landscape Territorial Plan (PTPR)	D.Lgs. 42/2004 – Cultural Heritage and Landscape Code LR 24/98 – Landscape planning and protection of property and areas subject to landscape constraints	• Recognition of areas subject to planning • Recognition and delimitation of buildings, sites or areas of outstanding value and public interest • Analysis of landscape characteristics and society-environment interrelations • Analysis of territorial transformative processes • Definition of proper measures for govern and manage urban transformation developments and regeneration
Hydraulic Assessment Plans (PAI)	D.lgs. 152/2006 – Environmental regulation	• Study of the physical environment and the anthropogenic system • Definition of land and water protection regulations, hazard and risk assessment • Planning of interventions and development of risk mitigation methodologies
Metropolitan Area General Plan	Metropolitan City Resolution n.1/2018	• Definition of guidelines to address urban plans and coordinate rural-urban relations
Urban General Regulatory Plan		• Regulation on building activities and urban development

Table 1. Scheme of the main urban and territorial planning instruments in Italy. Source: Authors

2. Explanation of the context (study area)

The Metropolitan City of Rome is a territorial and administrative entity of more than 5,300 km^2, consisting of 121 municipalities around the peri-urban belt of Rome's Capital City (figure 1). Nearly 4.5 million inhabitants reside within it, including nearly 3 million in the Capital area (Nardi et al., 2021). Rome and its metropolitan area constitute a complex urban ecosystem that rests on a rich natural and cultural heritage stratified over time along the hydrogeological arrangements of the Tiber River basin. The Tiber River has been the pivot of a civilization developed over time, influencing the urban and socioeconomic development of Rome and its peri-urban area. This complexity is nowadays accentuated by a strong and uncontrolled urbanization process that has affected the metropolitan area since the 1950s (Nardi et al., 2021). The urban shape appears, at present, discontinuous and diffuse overlapping with rural and agricultural areas, areas of archaeological, naturalistic and landscape interest and areas exposed to hydrogeological risk factors. The overlap between urbanized areas, areas at risk and areas of public interest often results in conditions of marginality, abandonment and fragility of the urban spaces.

The General Regulatory Plan of Rome and the General Plan of the Metropolitan Area are subordinate to the indications of the Regional Landscape Territorial Plan of the Lazio Region, adopted in 2007 to implement the provisions of Regional Law 24/98. The integration of the different planning plans, in the context of the Rome Metropolitan Area, concerns: (1) identification of urban development areas; (2) management of building areas or areas sublet to land use transformation; (3) identification of compatible land use for agricultural or tourism-recreational purposes; (4) integration of transport and infrastructural networks in the landscape assets.

Landscape features and risk factors thus become strategic assets in strategic planning processes. Their identification and mapping are necessary for setting strategies for redevelopment and regeneration of the urban environment.

The PTPR acts as an integrative tool to the hydrogeological planning plans (in Italian, *Piani di Assetto Idrogeologico-PAI*). The latter are specifically drawn up for the defense of soil, population, residential and productive settlements at risk through hydraulic regulation. Their connection with the PTPR is found in the identification of threats to the maintenance of the peculiar characteristic of landscape and in the protection and maintenance interventions to the elements classified as historical and cultural value.

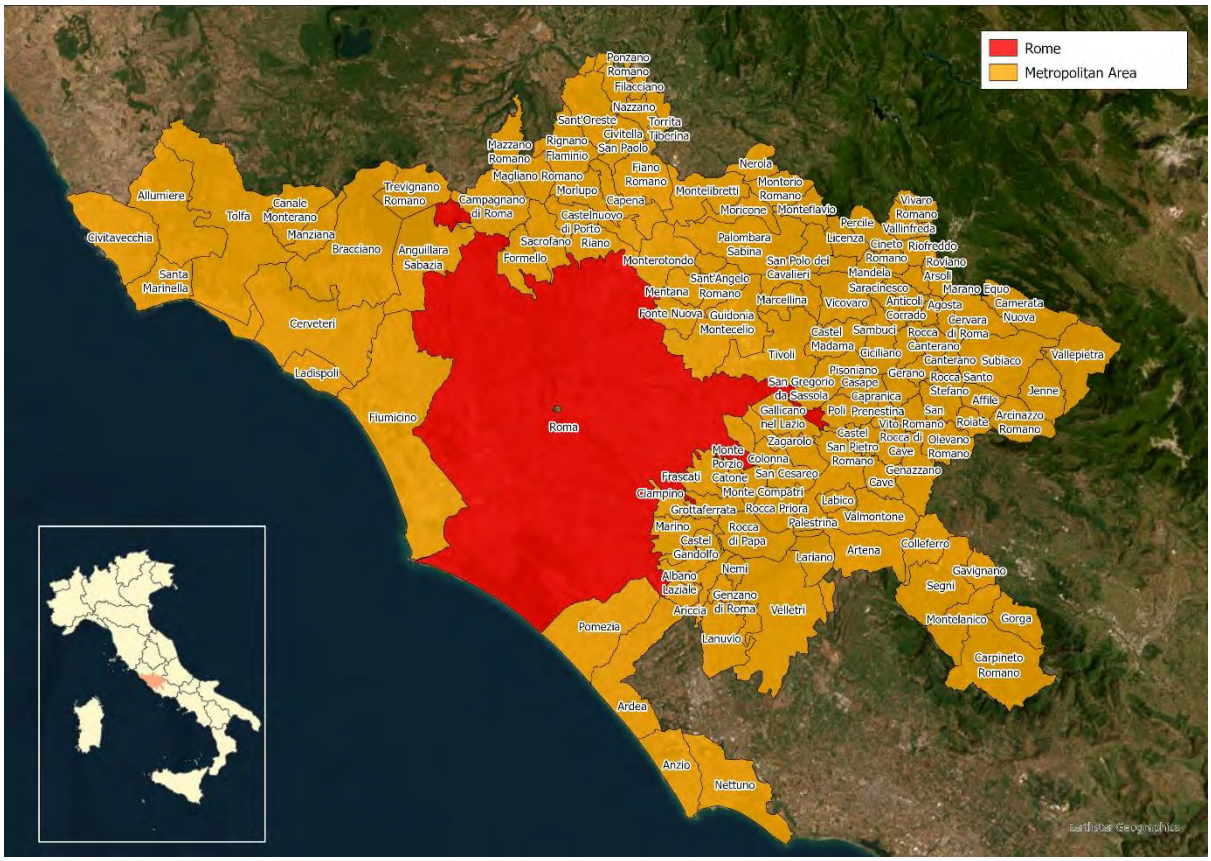

Figure 2. The Metropolitan Area of Rome (case study area). Source: Authors

3. The project approach (data & methods)

The conceptual GIS-based model involves the use of geographic open data. This model consists of the following steps (figure 2) based on methodology tested in (Spasiano & Nardi, 2019).

- Geographic data collection
- Setting up the data model
    - Homogenization of data within the 4 domains
    - Conversion into raster numeric cells
- GIS Multi-criteria analysis

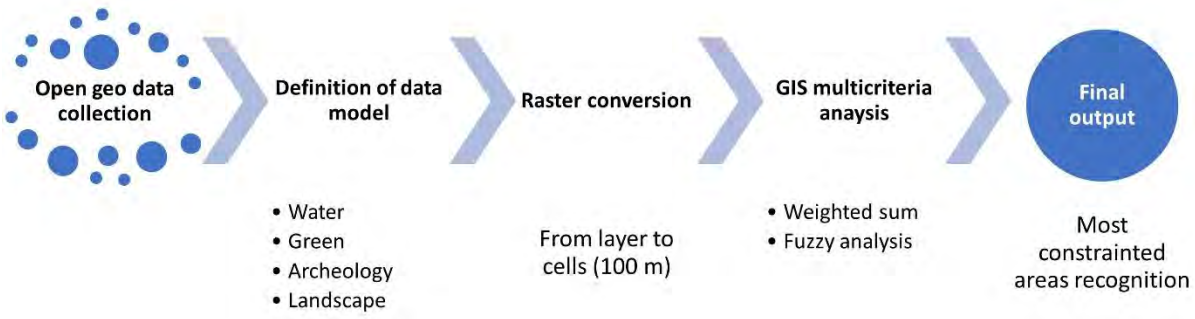

Figure 2. The methodology work flow. Source: Authors

3.1 Geographic data collection

The data used in the realization of the conceptual model refer to the Regional Landscape Territorial Plan (PTPR) of Lazio (2007) and the risk maps of the Basin Authorities (AdB), within the PAI. First, the model provides a selection of vector data in polygonal format, related to areas under constraint. It is acquired from the regional Open Data Lazio portal, under a Creative Common Attribution 4.0 (CC BY 4.0) license.

3.2 Setting up the data model

Table 2 shows the organization of the data model. The model involves, first, the standardization of source data in the UTM WGS 84 32 N projection system to facilitate subsequent analytical operations and visualizations in the GIS environment. Next, the subdivision and unification of the same into homogeneous thematic layers through merge functions (figure 3). Finally, the set-up of the data model is completed with the transformation of the homogeneous layers into raster cells of size 100x100m, to implement subsequent analytical processing based on detailed resolution in accordance with the original data dimensions of the layers. The conversion of vector layers into raster cells is functional for the computation of spatial values in the GIS environment.

Layer	Data origin	Legal plan
1. Water	Union framework of risk maps under Directive 200760CE Union framework of maps dangerous according to Directive 200760CE PTPR-Table B-Respect zone PTPR-Table B-Coast of lakes PTPR-Table B-Coast sea	PAI/PTPR
2. Green	Natura 2000 Network PTPR-Table B-Protected areas PTPR-Table B-Humid zones PTPR-Table B-Altitude 1200	PTPR

	PTPR-Table B-Woods VT PTPR-Table B-Woods RM PTPR-Table B-Woods LT PTPR-Table B-Woods RI PTPR-Table B-Woods FR PTPR-Table B-Geomorphological respect	
3. Archeology	PTPR-Table B-Respect of archeological points PTPR-Table B-Archeological decrees PTPR-Table B-Archeological lines respect PTPR-Table B-Archeological areas	PTPR
4. Landscape	PTPR-Table B-Single goods (a,b) PTPR-Table B-Encompassing goods (c,d) PTPR-Table B-Reclamation channels PTPR-Table B-Respect of lines PTPR-Table B-Respect of rural points PTPR-Table B-Villages areas PTPR-Table B-Old town respect PTPR-Table B-Agricultural areas PTPR-Table B-Civic use	PTPR

Table 2. The data model scheme. Source: Authors

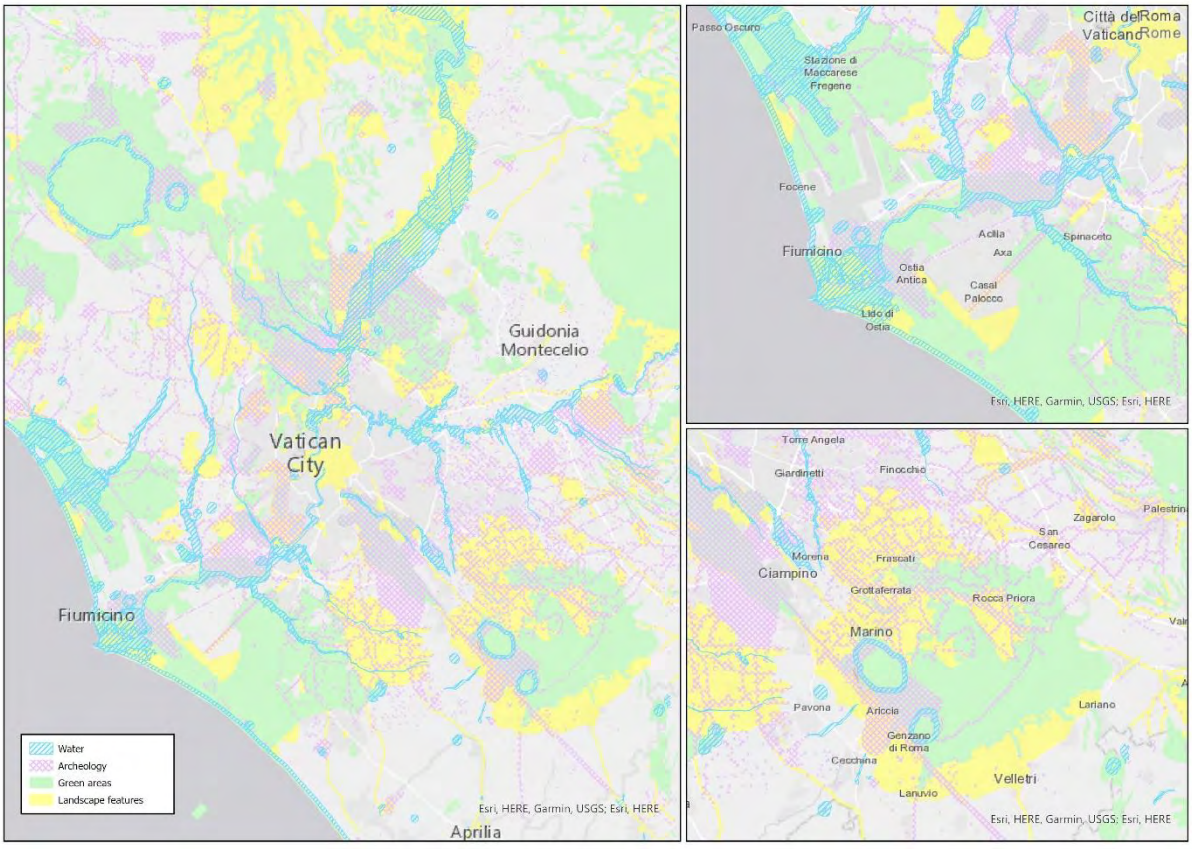

Figure 3. General framework of the constrainted areas. Source: Authors

3.3 GIS multicriteria analysis

The conceptual model involves a multi-criteria analysis of descriptive layers on landscape and risk factors articulated in two steps:

1. Weighted sum (weighted sum) to map overlapping between two or more constrained areas.
2. Fuzzy membership (fuzzy memebership) to define and classify homogeneous areas.

4. Results

Figure 4 illustrates the output layer generated by the multi-criteria analysis implemented in the GIS environment. The weighted sum provides a reconnaissance of overlaps between constraints of different types. The fuzzy analysis reclassifies the obtained values within a continuous range between 0 and 1 in order to identify hotspots associated with the highest values. Hotspots identify those areas that are most constrained, potentially subject to particular protection regimes and land uses.

In Figure 4, the final raster output is combined with the satellite image in order to provide an understandable interpretation of the results. The figure highlights areas with pronounced environmental and anthropogenic features that determine land use patterns. The hotspots reflect the concentration of high values given by the overlap of the layers. The value of each individual cell is determined by the total number of constraints that fall on it.

From an urban planning perspective, hotspot areas can guide urban redevelopment and regeneration processes by mapping resources and interactions within environmental and human systems.

However, the results presented must be interpreted under an experimental perspective. Indeed, the analysis performed is based on the assignment of default weights for the sole purpose of illustrating the technical implications of the methodological procedure. The methodology is set up to be flexible and adaptable in different geographical contexts and purposes.

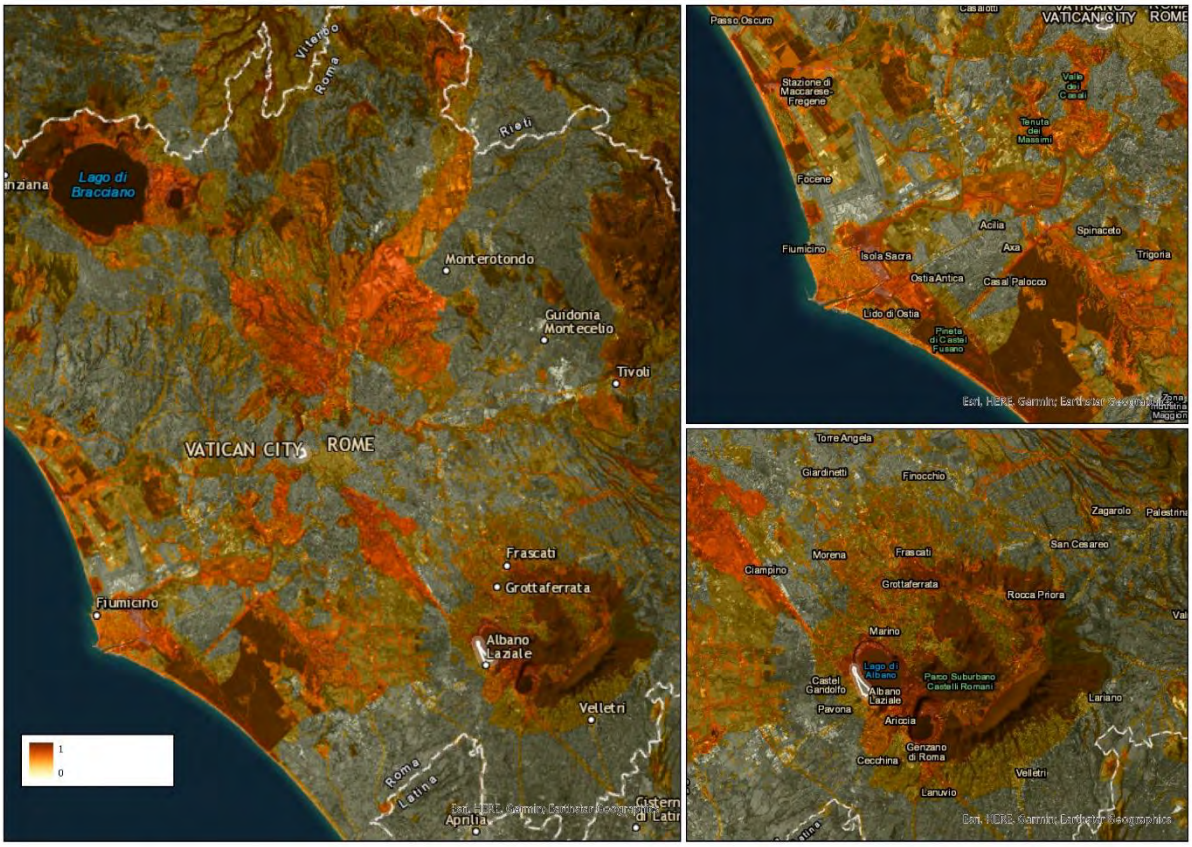

Figure 4. Final index outputs: hotspots areas. Source: Authors

5. Conclusions

In this case study, we presented a data model for the implementation of multicriteria analysis integrated in GIS to support urban planning activities. We tested this model on the case study of the Metropolitan City of Rome, as a complex and stratified geographical reality due to the coexistence and overlap of urbanized areas, areas of environmental, historical-archaeological and landscape interest.

The increasing availability of open geographic data allows the implementation of quantitative geospatial analysis, albeit according to a holistic survey approach, aimed at systemizing environmental, morphological, anthropic, and historical-cultural components that determine forms, characteristics and relationships within urban spaces.

However, the work also revealed critical aspects. Critical aspects depend first on the inhomogeneity and quality of the available data. Another critical aspect is the lack of established references and criteria for assigning weights in multi-criteria analyses.

For this reason, this contribution merely describes and tests the data model. The model, however, takes as variables the structural characteristics of the territory, providing a basic cognitive and analytical tool for governance and decision making.

The goal is to demonstrate how adequate structuring of geospatial information-accompanied by functional advances in GIS tools and technologies-can contribute to the implementation of performative analyses capable of deepening the relationships between elements in geographic space that define the evolutionary structures of the urban assets.

The main implications of this study concern local governments, which are responsible for land use planning and management of human settlements (residential and industrial). The model is proposed as a support tool for the reconnaissance and evaluation of territorial capital, as a strategic asset for new business intelligence models oriented on the enhancement of resources and relationships characterizing the local identity (Camagni & Capello, 2009; Amodio et al., 2019; Blecic et al., 2023).

Reconnaissance of land capital and value is an essential aspect of land use definition and mitigation of competing and often conflicting economic and collective interests.

Moreover, the model is proposed as a tool for reconnaissance of homogeneous areas in terms of landscape and environment. In this perspective, it is proposed as a tool to support local governments in assigning constraints and limits to be observed in urban transformation and expansion processes.

The definition of homogeneous zones in planning has impacts that transcend the scope of the public sector. This model is intended to provide support to professionals and stakeholders in reconnaissance activities of ecosystem services, identification of best location factors for human settlements or activities, and support for tourism and recreation activities from a sustainability perspective (Wolff et al., 2015; Baró et al., 2016).

This study paves the way for the direct stakeholders and citizens engagement in urban planning and monitoring (Horlings et al., 2021; Spasiano et al., 2021). Future implementations of the model may come from the observations provided by local stakeholders in the form of VGI (Guerrero et al., 2016) or through Participatory GIS techniques (Canedoli et al., 2017; Kahila-Tani et al., 2019), highlighting problems and critical issues related to the management of urban spaces from different perspectives.

6. References

Agnoletti, M. (2014). 'Rural landscape, nature conservation and culture: some notes on research trends and management approaches from a (southern) European perspective', *Landscape Urban and Planning*, 126, 66-73

Amodio, T., Bencardino, M., Iovino, G., & Siniscalchi, S. (2019). 'Emerging topics in Italy: the territorial capital value' *Bollettino della Società Geografica Italiana*, 75-89.

Baró, F., Palomo, I., Zulian, G., Vizcaino, P., Haase, D., & Gómez-Baggethun, E. (2016). Mapping ecosystem service capacity, flow and demand for landscape and urban planning: A case study in the Barcelona metropolitan region. *Land use policy*, *57*, 405-417.

Blečić, I., Cecchini, A., Saiu, V., & Trunfio, G. A. (2022, July). 'Evaluating Territorial Capital of Fragile Territories: The Case of Sardinia'. In *International Conference on Computational Science and Its Applications*, Cham: Springer International Publishing, pp. 531-545

Camagni, R., & Capello, R. (2013). 'Regional competitiveness and territorial capital: a conceptual approach and empirical evidence from the European Union' *Regional studies*, *47*(9), 1383-1402.

Canedoli, C., Bullock, C., Collier, M. J., Joyce, D., & Padoa-Schioppa, E. (2017). Public participatory mapping of cultural ecosystem services: Citizen perception and park management in the Parco Nord of Milan (Italy). *Sustainability*, *9*(6), 891.

Cervelli, E., Scotto di Perta, E., & Pindozzi, S. (2020). 'Identification of marginal landscapes as support for sustainable development: GIS-based analysis and landscape metrics assessment in southern Italy areas', *Sustainability*, *12*(13), 5400.

De Groot R.S., Alkemade R., Braat L., Hein L. & Willemen L. (2010). 'Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making', Ecological Complexity, 7, 3, pp. 260-272

Geneletti, D. (2011). 'Reasons and options for integrating ecosystem services in strategic environmental assessment of spatial planning', *International Journal of Biodiversity Science, Ecosystem Services & Management*, 7(3), 143-149.

Greene, R., Luther, J. E., Devillers, R., & Eddy, B. (2010). 'An approach to GIS-based multiple criteria decision analysis that integrates exploration and evaluation phases: Case study in a forest-dominated landscape', *Forest Ecology and Management*, *260*(12), 2102-2114.

Guerrero, P., Møller, M. S., Olafsson, A. S., & Snizek, B. (2016). Revealing cultural ecosystem services through Instagram images: The potential of social media volunteered geographic information for urban green infrastructure planning and governance. *Urban Planning*, *1*(2), 1-17.

Horlings, L. G., Lamker, C., Puerari, E., Rauws, W., & van der Vaart, G. (2021). Citizen engagement in spatial planning, shaping places together. *Sustainability*, *13*(19), 11006.

Kahila-Tani, M., Kytta, M., & Geertman, S. (2019). Does mapping improve public participation? Exploring the pros and cons of using public participation GIS in urban planning practices. *Landscape and urban planning*, *186*, 45-55.

Lathrop Jr, R. G., & Bognar, J. A. (1998). 'Applying GIS and landscape ecological principles to evaluate land conservation alternatives', *Landscape and urban planning*, *41*(1), 27-41.

Mysiak, J., Testella, F., Bonaiuto, M., Carrus, G., De Dominicis S., Ganucci Cancellieri, U., Firus, K., Grifoni, P. (2013). 'Flood risk management in Italy: challenges and opportunities for the implementation of the EU Floods Directive (2007/60/CE)', *Natural Hazards and Earth Systems Sciences*, 13, 2883-2890.

Nardi, F., Spasiano, A., Bartoccini, U., & Annis, A. (2021). 'The value and the need of nature-based solutions for resilient urban ecosystems: from citizen engagement to novel Nexus perspectives for fair and safe use and development of natural and urban resources Insights from the city of Rome (Italy) water resource and risk management programs'. In *Proceedings of the 57th ISOCARP World Planning Congress 57th ISOCARP World Planning Congress Planning Unlocked: New Times, Better Places, Stronger Communities Hybrid format Congress 28 October 2021-11 November 2021* (pp. 1833-1843). ISOCARP.

Ran, J., & Nedovic-Budic, Z. (2016). 'Integrating spatial planning and flood risk management: A new conceptual framework for the spatially integrated policy infrastructure', *Computers, Environment and Urban Systems*, *57*, 68-79.

Robinson, D. T., & Brown, D. G. (2009). 'Evaluating the effects of land-use development policies on ex-urban forest cover: An integrated agent-based GIS-approach', *International Journal of Geographical Information Science*, *23*(9), 1211-1232.

Smith, H. M., Blackstock, K. L., Wall, G., & Jeffrey, P. (2014). 'River basin management, development planning, and opportunities for debate around limits to growth', *Journal of Hydrology*, *519*, 2624-2631.

Spasiano, A., & Nardi, F. (2019). 'A GIS-based fuzzy analysis for mapping the touristic potential in Lazio Region (Italy)', *J-Reading-Journal of Research and Didactics in Geography*, *1*, 41-54.

Tengberg, A.; Fredholm, S.; Eliasson, I.; Knez, I.; Saltzman, K.; Wetterberg, O. (2012). ,Cultural ecosystem services provided by landscape: assessment of heritage values and identity', *Ecosystem Services*, 2, 14-26

Vallés-Planells, M., Galiana, F., & Van Eetvelde, V. (2014). 'A classification of landscape services to support local landscape planning', *Ecology and Society*, *19*(1).

Wolff, S., Schulp, C. J. E., & Verburg, P. H. (2015). Mapping ecosystem services demand: A review of current research and future perspectives. Ecological Indicators, 55, 159-171.

Case Study Report

A web-based geospatial service promoting landscape, cultural and economic assets of Amatrice after the devastating 2016-2017 central Italy earthquake

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Abstract

In this case study, the authors illustrate a prototype web GIS solution for the relaunch of economic activities and tourism development in the city of Amatrice (Central Italy) following the earthquake events of 2016-2017. The peculiar characteristics of the economy and the local landscape make Amatrice a suitable example for strategies of regeneration and development of small towns in rural inland areas. The development of a web GIS prototype for the relaunch of economic and tourist activities in Amatrice has the purpose, therefore, to make available location intelligence tools and services to provide basic mapping to public administrations and decision-makers in the exercise of the functions of land use management and governance, with particular regard to the rehabilitation and connection of rural inland areas. Secondly, the web GIS performs tourist promotion functions aimed at a general user (citizens, tourists) to support user experience in the local landscape.
In fact, the prototype is equipped with tools for data query, visualization and export of results. At the theoretical and methodological level, the contribution offers a model of data and GIS functions that can be replicated in other geographical contexts characterized by rurality and marginality.

Keywords

webGIS, tourism, central Italy, open data, urban regeneration

1. Introduction

This paper presents the outcomes of scientific research and technology development activities for the purpose of designing webGIS solutions for the revitalization of economic activities based on slow tourism and the enhancement of cultural heritage in the Amatrice area following the earthquake events of 2016-2017.

Amatrice represents a special case study. Its marginality depends, first, on its geographical location in the center of Italy and the morphology of its mountainous landscape. This characteristic currently places

Amatrice in a marginal position with respect to major infrastructure networks and tourism flows. The seismic events of recent years have contributed to exacerbate this marginality.

In the context of strategic programming set on paradigms of slow tourism and enhancement of local resources, cultural and environmental heritage, associated with local traditions and productions, represent a unique and non-reproducible capital for the revitalization of territories (Amodio et al., 2019; Prezioso et al., 2021; Blecic et al., 2023). Such strategies are adapted both in contexts of geographic marginality and in reconstruction processes following disasters and environmental disasters, such as earthquakes (Baldi, 2018). Recent programmatic guidelines such as the Inner Areas Strategy (2014) and the Strategic Tourism Development Plan (2017) provide the programmatic framework within which to design and implement local development strategies on the peculiarities of territories.

Geospatial knowledge can, therefore, play a basic function in setting strategies aimed at enhancing and revitalizing tourism in the city (Meini et al., 2017; Macchia et al., 2022; Spasiano et al., 2022). The development and use of web GIS platforms are widely used in urban planning and promotion of tourism activities in the area (Spasiano & Nardi, 2019). Several studies point out the centrality of tourist routes in the revitalization of local economies and tourism with the support of GIS data and tools (Meini et al., 2012; Favretto et al., 2014).

2. Case study area

Amatrice is a small community located in the Lazio region of central Italy, and is nestled in an agricultural valley near the Gran Sasso National Park. It is approximatey 105 km northeast of Rome, 210 km southeast of Florence, and 70 km from the coast of the Adriatic Sea. Amatrice is at an elevation of 955 m, and beautiful views of Mount della Laga can be seen from the village. Amatrice is a town of rich historical, archeological, and natural features with unique cultural heritage and scenic landscapes.

The historical city center was an important pole for trade, communication, and commerce. The location along the Via Salaria made Amatrice a crossroads of trade and commerce over time between Rome and the Adriatic Sea. The natural heritage of Amatrice is characterized by major peaks of the Gorzano Mountains (2458 m), Pizzo di Selvo (2419 m) and important water resources such as rivers and high mountain lakes (Scandarello and Secco). The area includes the Gran Sasso and Laga Mounts National Parks - a significant part is considered as a Site of Community Importance (SCI) by the European Union

In this geographical context, the set of local traditions and knowledge find expression in the agro-pastoral and productive activities spread throughout the territory, constituting its socioeconomic structure (Belluso, 2012; Sabatini 2020). These activities are part of a context of cultural and environmental richness, which finds tangible expression in the forms of the landscape, land uses and toponymy that attests to a peculiar cultural vibrancy throughout history (Belluso, 2012; Sabatini, 2020).

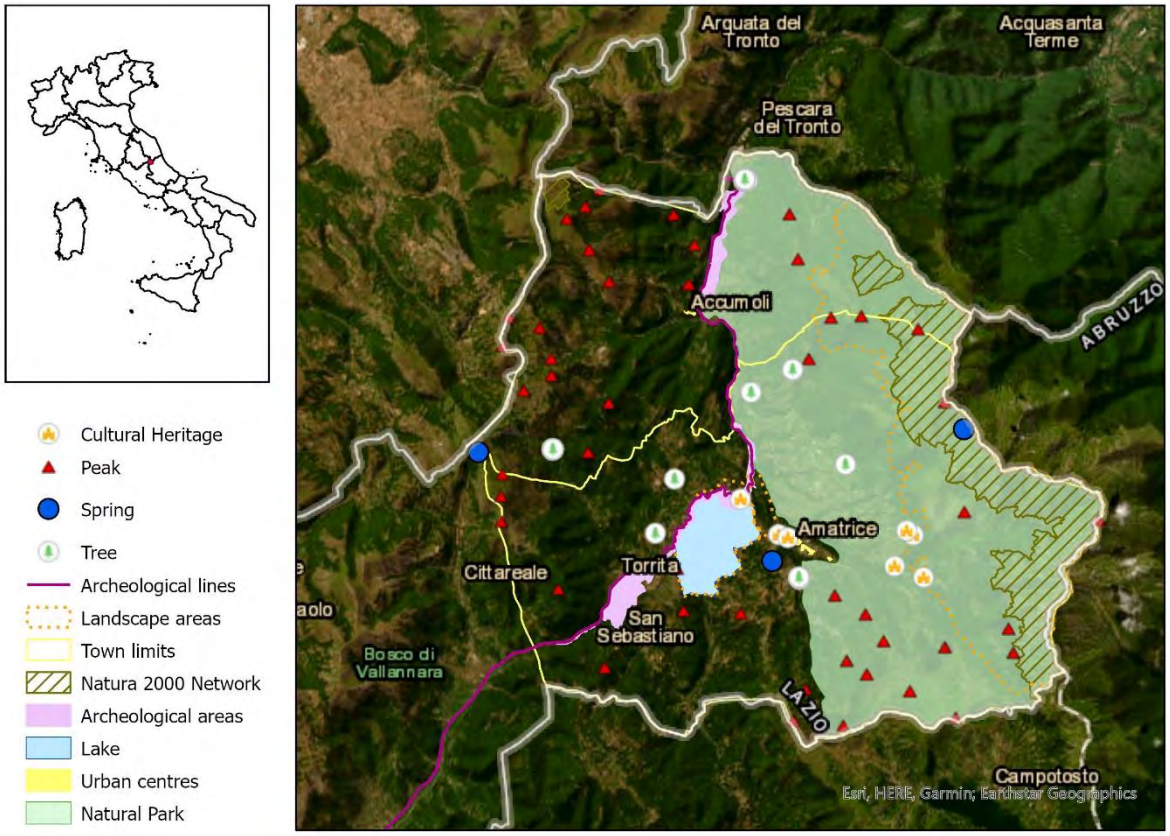

Figure 1. Area of study. Source: Authors.

3. Methods and data model

The prototype of the webGIS was born with the need to create a platform for the interaction of digital content and for the promotion of tourism in Amatrice as a factor of local relaunch, facilitating the accessibility and enjoyment of natural, cultural and productive resources in the area.

The solution is presented as a digital cartographic support tool for tourists and local actors, integrating geographic data different in format, content and source, descriptive of the landscape, environmental and economic-productive structures of the local context.

3.1 Open data sources

Institutional open data platforms provided a first layer of useful data to reconstruct the general layout of the study area. For the creation of the webGIS, we relied mainly on data from the Geoportal of the Lazio Region and the Italian National Institute of Statistics (ISTAT). From the former, data on environmental and landscape constraints under the 2007 Regional Landscape Territorial Plan (PTPR) and lists of environmental and cultural assets under protection were downloaded; the latter, on the other hand, provided the spatial and administrative bases at the municipal level. To this group of data, others related to built-up area and hydrology were added from the Regional Technical Map at a scale of 1: 5,000. These data sources enabled the overall cognitive picture of the Amatrice area to be reconstructed. The data was downloaded in formats compatible with GIS software. To complete the basic framework, we integrated data from the Open Street Map online user community (Haklay & Weber, 2008) regarding the road network.

3.2 Further data sources

Additional data were sourced through the active involvement of local stakeholders and associations. By means of a sample survey, we set up a geospatial dataset for different types of activities such as agritourisms, bed & breakfasts, campsites, restaurants, and farms dedicated to the production and trade of typical gastronomic products of Amatrice. This recognition provided the exact location of the activities, which were concentrated not only in the historic center of Amatrice but distributed around the various hamlets and towns in the municipal area, testifying to the close connection of production and tourist accommodation activities with the local environmental and landscape complexity.

Finally, to complement the webGIS data model, we integrated data on the Amatrice trail network, courtesy of the local Alpine Club. GPS tracks on the trail network fall under the umbrella of VGI, which are field surveys by volunteer users that provide geolocated information on elements, processes, and information about the area (Goodchild, 2007; Sui et al., 2012).

The integration of data on the trail network of the local Alpine Club section is aimed at systematizing data on production and accommodation facilities in the context of Amatrice. In the post-seismic reconstruction activity, in fact, the trails play a role in reconnecting attractive factors with a view to revitalizing local tourism according to criteria of sustainability and respect for environmental and social balances.

Web GIS data model	
Sources	**Layers**
Italian National Statistics Institute (ISTAT)	Administrative limits
	Toponymy points
Lazio Region Open Data	Buildings
	Level curves
	Hydrography
	PTPR – Archeological Points
	PTPR – Monumental trees
	PTPR - Geosites
	PTPR – Protected Areas
	PTPR – Archeological areas
	PTPR – Landscape interest areas
Open Street Map	Road network
Volunteered geographic Information (VGI)	Trekking trail
	Restaurants, farms and socioeconomic activities

Table 1. Data model of the geospatial service. Source: Authors

4. Tools and function of geospatial service

The prototype consists of a web application in which all the data previously described were collected and put into system, with the addition of some useful tools for navigation and interactive consultation of content, known by the technical term widgets. These widgets are able to increase the functionality of the solution to support the user experience. Below, we report the main functionalities designed for the use of web GIS:

1. Layer list, which is a list of all the data that can be viewed in the application, so that users can turn the various layers on or off based on their navigation and viewing needs and based on the location of interest.
2. Info summary, related to food service activities. This feature allows the display of only the dining establishments in the portion of the map that the user is viewing, updating automatically through the movement of the cursor and through the scale of the map. It also provides a list of the names of the activities, with the possibility of opening informational pop-ups for displaying additional information about the data displayed, such as description of the selected element, information about the environmental and cultural heritage, contact details and opening hours of the accommodation and tourist facilities, and availability of products on site.
3. Info summary related to natural and cultural heritage. This feature has the same technical features as the previous one, the only difference being that it provides data and queryable information on attractions and landscape settings. It provides lists of cultural and environmental assets along the route selected by the user.
4. Trail chart, by means of which the user can select the route of his or her interest and through a real-time generated graph, can check the elevation of the trail at any point along the entire route, its elevation difference, and its total length.
5. The last widget inserted allows the user to view the map through a wide selection of different basemaps, which allows the user to customize the view of the content according to their needs.

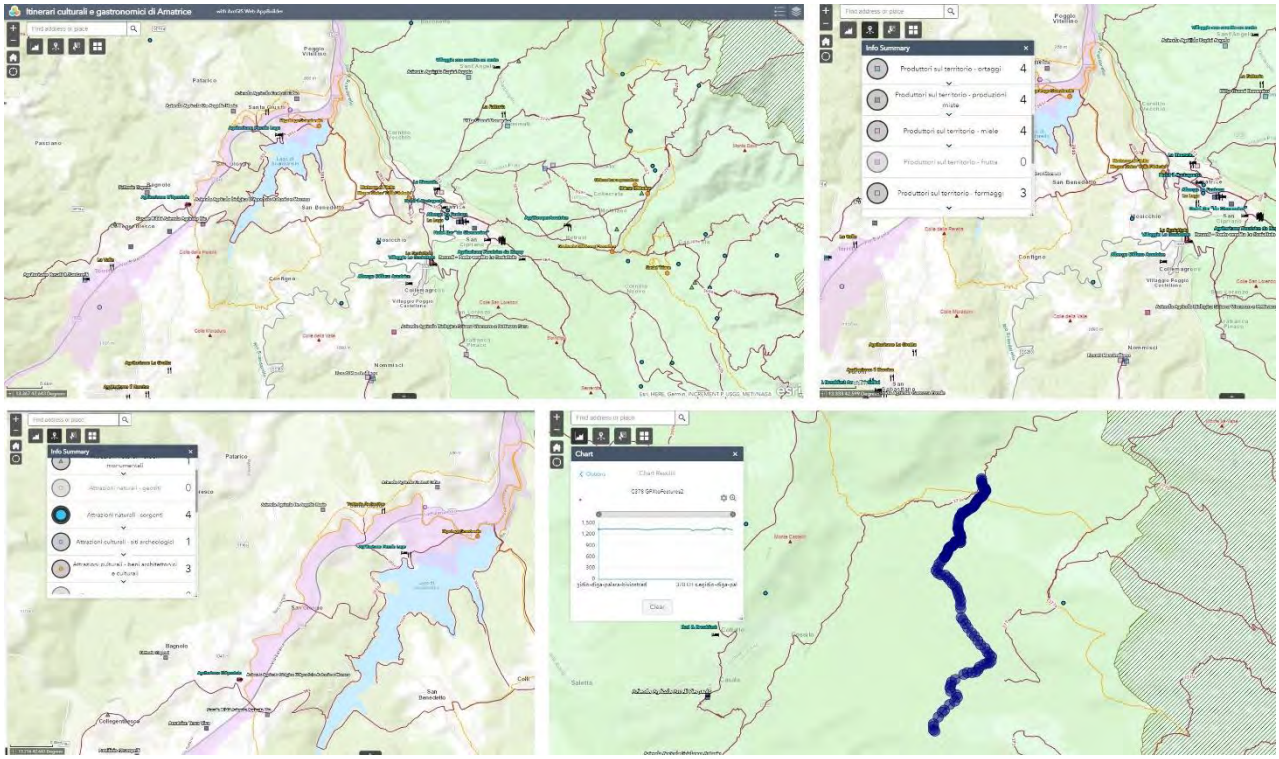

Figure 2. Extracts from the web app and examples of widgets to support the user experience. Source: Authors.

5. Conclusions (broader impacts)

Thus, the development of a prototype web GIS for the revitalization of economic and tourism activities in Amatrice aims to make available location intelligence tools and services to provide basic mapping to public administrations and decision makers in the exercise of land management and governance functions, with particular regard to the redevelopment and connection of inland rural areas. Second, web GIS performs tourism promotion functions aimed at general users (citizens, tourists) to orient themselves within the territory.

The navigation tools are equipped with features that can provide immediate feedback to the user and ensure operability for field or back-office activities. In particular, the prototype is equipped with tools for querying data, visualizing and exporting results. At the theoretical and methodological level, the contribution offers a GIS data and function model that can be replicated in other geographic contexts characterized by rurality and marginality.

6. References

Italian Cohesion Agency (2014). Strategia Nazionale per le Aree Interne: definizione, obiettivi, strumenti, governance.

Amodio, T., Bencardino, M., Iovino, G., & Siniscalchi, S. (2019). 'Emerging topics in Italy: the territorial capital value' *Bollettino della Società Geografica Italiana*, 75-89.

Baldi, B. (2018), La Strategia Nazionale delle Aree Interne: innovazione, policy transfer e ricostruzione post-sismica, *Rivista Italiana di Politiche Pubbliche*, Il Mulino, 2/2018, pp. 161-190

Belluso, R. (2012). *I food-scapes del Lazio. La geografia dei piatti tipici regionali tra cultura e tradizione*, Carocci Editore, Roma.

Blečić, I., Cecchini, A., Saiu, V., & Trunfio, G. A. (2022, July). 'Evaluating Territorial Capital of Fragile Territories: The Case of Sardinia'. In *International Conference on Computational Science and Its Applications*, Cham: Springer International Publishing, pp. 531-545

Favretto A., e Mauro G. (2014). Itinerari per un turismo alternativo: dal Web alla portabilità mobile, *Bollettino della Associazione Italiana di Cartografia*, 151/2014, pp. 46-58.

Goodchild, M. F. (2007). Citizens as sensors: the world of volunteered geography. *GeoJournal*, *69*, 211-221.

Haklay, M., & Weber, P. (2008). Openstreetmap: User-generated street maps. *IEEE Pervasive computing*, *7*(4), 12-18.

Macchia, A., Spasiano A., Bartoccini U. e Nardi F., (2022). Un web-GIS per la rinascita di Amatrice: percorsi escursionistici e gastronomici. In Allegra A., Capecchi G. e Malagnini F. (eds.), *Made in Italy, cibo e ospitalità. Culture e tecniche* (pp. 257-264), Franco Cesati Editore, Florence.

Meini M. e Nocera R., (2012). Criteri di progettazione di itinerari turistici in paesaggi agro-culturali, *Annali del Turismo*, Geopress Edizioni Novara, 1

Meini, M., Di Felice G. e Nocera R. (2017). Mappare le risorse delle aree interne: potenzialità e criticità per la fruizione turistica, *Bollettino della Associazione Italiana di Cartografia*, 161, pp. 4-21

Ministero dei Beni e delle Attività Culturali e del Turismo (2017). Piano Strategico di Sviluppo del Turismo 2017-2022.

Prezioso, M., Addis, M., Bolici, F., D'Orazio, A., Diana, G., Leonardi, S., et al. (2021). *Riprogrammare la crescita Territoriale. Turismo sostenibile, rigenerazione e valorizzazione del patrimonio culturale*. Bologna, Pàtron.

Sabatini F. (2020). Amatrice: storia e storie di una comunità elastica. In L. Bindi (eds.), *Le vie della transumanza. Un patrimonio bio-culturale per la rigenerazione territoriale* (pp. 293-311). Palladino Editore, Ripamolisano (CB).

Spasiano, A. e Nardi, F. (2019), A GIS-based fuzzy analysis for mapping the touristic potential in Lazio Region (Italy), *J-Reading - Journal of Research and Didactics in Geography*, 1, pp. 41-54

Spasiano A., Nardi F. e Monti S., (2022). Open data e informazioni geografiche digitali per la pianificazione e lo sviluppo territoriale. In Allegra A., Capecchi G. e Malagnini F. (eds.), *Made in Italy, cibo e ospitalità. Culture e tecniche* (pp. 245-256), Franco Cesati Editore, Firenze.

Sui, D., Elwood, S., & Goodchild, M. (Eds.). (2012). *Crowdsourcing geographic knowledge: volunteered geographic information (VGI) in theory and practice*. Springer Science & Business Media.

Case Study Report

Co-created Positive Energy Districts

Activating local actors for a common roadmap

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Abstract

The Energy Balance for Positive Energy Districts (PED) is equating the energy needs (caused by people) and the energy production (technology). Yet, most energy transition projects have been concentrating on technical aspects and the implemented projects are not yet truly positive throughout the year. This study will discuss ways of involvement of citizens in the pathways of PEDs.

In the European Network PEDEDUNET and in our international project PED-ACT, we have been experiencing how citizens are systemically excluded in the process of establishment of a PED. The technology is evolving, newer applications can involve different sources of renewable energies, calculate them in price and quantity, yet the PEDs are not having the hoped importance or impact in the energy transition ambitions. This is due to lack of involvement of affected people in the project, progress, and process. At the same time, there are worries and power imbalances among citizens (building owner versus building user like tenants), which results in no participation or involvement. With a quadruple helix approach, we have been approaching 5 different communities in 5 different European geographies, all managed top down in terms of energy planning, production, and delivery, and found different recipes to have the citizens take part in the PED evolution.

The energy sector is perceived as a technological field, where lots of citizens have very little knowledge or any rights to make decisions. If we keep this top-down culture, we cannot profit from the potential contribution of many citizens and rely only on the capacities of a few decision makers like in the last decades. Especially in PED projects, the citizens are expected to change their behaviours (in energy consumption) to enhance energy flexibility, but they are not an involved actor of the process. If we do not change this dynamic, there is not much relieve technology can bring into the energy transition agenda.

Learning objectives resulting out of our PED-ACT project are:

1 : a clear role for citizens in PEDs
2 : a clear say for citizens in PEDs
3 : a clear reward system for citizens in PEDs

Keywords

co-creation with citizens and their representatives, energy transition with all, positive energy districts, collaboration pathways, quadruple helix in PEDs

1. Introduction

Approximately 40% of the energy used worldwide is consumed in buildings (Kolokotsa et al., 2011). In an initial phase the aim the positive energy concept was to create positive energy buildings, to solve the energy demand on a very specific building. Nowadays buildings can perform on their own plot sustainable,

use zero-net energy, be circular, be grid-friendly. Positive-energy buildings utilise thermal simulation models of the buildings which allow to equip the buildings for integrated control and optimization tools. Already in 2009, the EU Parliament has requested that by 2019 all new buildings have to be optimized to zero-energy and emission standards (European Parliament, 2009), which is still not implemented throughout Europe. Recently the focus has expanded from individual houses to seeking possibilities of city districts and neighbourhoods (Magrini et al., 2020) to become positive. In 2018, EU launched the programme "Positive energy districts and neighbourhoods for sustainable urban development" with an aim to support the planning, deployment, and replication of 100 Positive energy districts (PEDs) by 2025. Therefore, big attention has been given to cities in the last decade, as they have extensive potentials to ensure the sustainability transition. (Gireesh et al., 2023) In these multi-layered societies, the urge to combat challenges of climate change are very dominant and many projects and a big portion of the national and international funds go towards cities. For projects the urban tissue is broken down to districts and neighbourhoods. Within cities these manageable units present a manageable size and complexity to test new approaches in the sustainability journey (Good et al., 2017; Magrini et al., 2020). An improved and optimised urban unit has the potential to reduce energy use and consequently decrease the greenhouse gas emissions. We have been analysing the approach of several PED projects and the users and citizens are mentioned in most of them, yet the core focus lies within the technological solutions. Our focus therefore is to elaborate on the people and the communities, to bring forward new partnerships which can handle in a collaborative manner the becoming of a PED.

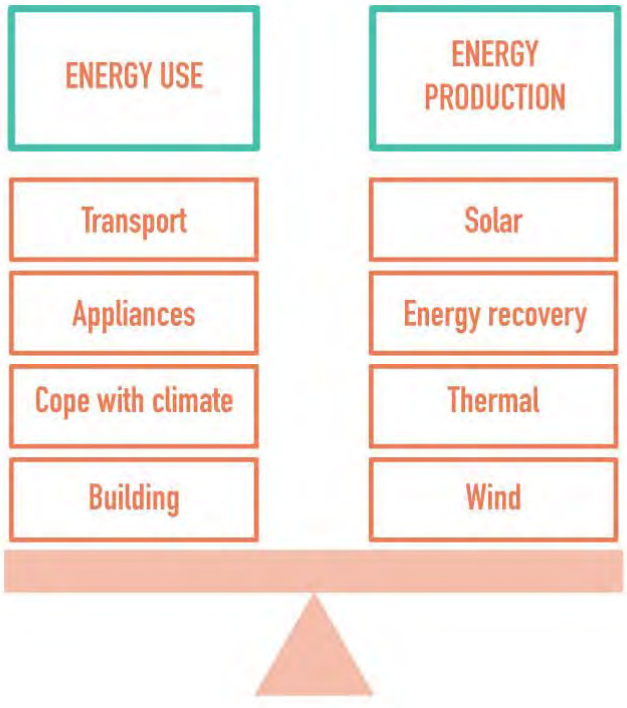

Figure 1. Balancing the Energy consumption and production

1.1. Incentives regarding PEDs

There are many incentives that are directly and indirectly related with PEDs. European Energy Research Alliance (EERA) is the largest energy research community in Europe with 250 universities and public centres from 30 European countries, with 17 joint programs (EERA), with the mission of fostering energy research for achieving climate neutrality by 2050 (Soutullo et. Al., 2020). Energy Performance of Buildings Directive (EPBD) highlights the importance of altering Europe's building stock to become energy efficient and decarbonized by 2050 (Brozovsky et. al. 2021).

The SET (Strategical Energy Technology) Plan Action 3.2, "Smart Cities and Communities" is promoting the development of low carbon technologies in fast and cost-competitive ways (Clerici Maestosi et. al. 2021). Also, the Horizon Programme is funding research projects in this field. Based on these incentives and programmes, it is possible to interpret that in different societies of the EU the potentials of the PED concept are seen as a major opportunity. The aim is also to strengthen the projects outlook towards mitigating climate change and degrading the effects of the building sector regarding it (Brozovsky et. al. 2021).

1.2. The PED-ACT project

Positive Energy District (PED) is important for city development. PED-ACT focuses on the process optimization for enhanced stakeholders' cooperation and reinforced decision-making. PED-ACT contribute to standardisation of the database of existing PEDs (planned, designed, or implemented) with a focus on Sweden, Turkey and Austria. PED-ACT further learns from the database and creates digital PED references by mapping stakeholders' needs and priorities in cities of Borl nge (Sweden), Ume (Sweden), Ankara (Turkey), Karsiyaka (Turkey) and the community Schönbühel-Aggsbach (Austria). PED-ACT pursues bilateral learning and co-design strategies among different municipalities for wide replication of cocreated PED roadmaps towards 'climate-neutrality and smart cities' goals.

2. Social aspects of PED

PED developers know that the social aspects are at the one hand one of the main success factors and the main challenges at the same time (Krangs s et al., 2021, Baer et. al., 2021). Nevertheless, the social aspects regarding PED development (along with microclimate) remains to be one of the least researched topics in the field (Brozovsky et. al., 2021). It is of utmost importance that citizens and end need to change their behavioural pattern from passive mode to 'active prosumption' or "prosumers" (Bossi et. al., 2022; Ahlers et. al., 2019). The term "prosumer" is derived from 'PRO-ducer and con- SUMER, which refers to consuming energy, while also producing energy surplus to be shared with neighbours (Magrini et al., 2020). Also, the term "energy citizenship" is resembling the term 'prosumer'. To allow this role-shift to happen the PED projects need to develop this new role the projects have to develop a collective and inclusive space for participation and engagement of citizens (Olivadese et. al., 2021). The social aspect differs from context to context very much and needs to be catered to the local conditions and player's needs, as well as capacities. Within the project we are working in three different national contexts with very specific conditions and legal frameworks.

2.1. Austrian national context – the energy communities

In Austria, the legal change in 2021 favoured the creation of energy communities throughout the country. Despite the initial challenges (contracts with energy suppliers, getting technical devices or technicians, or delivery ques for solar panels, organisation form and structure, slow acquisition of members, administration barriers, financial hurdles, to name a few), many energy communities popped up in remote places, yet with very limited impact on energy transition aims of the country.

In this context, especially motivated communities struggle with administration hurdles and are stuck with the lack of capacities in smaller municipalities. The Austrian Case is the energy community Schönbühel-Aggsbach, an NGO (currently 1 prosumer, 13 consumers) and aims to grow as and develop from bottom up a PED, by bringing the different energy sources (water & sun) together, with a variety of small local actors (aim: 40 prosumers, 180 consumers).

The energy community is interlinked with regional players, and the regional collaboration could improve the impact of small municipalities in the energy transition, while improving the natural habitat and take on the cultural heritage to future generations.

Energy specifications 2022

Schönbühel-Aggsbach has currently (growing) 21.200MWH energy demand per year, half used for housing and the other for mobility. Only ¼ of the demand is covered with renewables. For the 2050 sustainability plans they need to reduce the demand to half and use fully renewable energy. The region is a protected heritage landscape, and windmills and water turbines are due to regulations not an option with the regular solutions. Due to the location the solar energy seems to be the favourable one. The solar energy collection is widely possible on private roofs, but the surfaces are rather small and not effective in creating surplus energy. The community needs to increase cost-effectiveness of energy production and find eventually new ways to deal with heritage regulations and potentially opt for thermal energy sources, while initiating collaboration with other municipalities in the district and region.

Vision and goal:

Develop a just governance and business model, which allows local communities to cross-finance their environmental and cultural projects, while sharing sustainably locally produced energy to an affordable price.

Policy implication:

Enhance and advance the energy community legacy with bottom-up PED development, financial instruments, funding instruments, regional collaboration possibilities (beyond the borders of the municipality).

2.2. Swedish national context – the Nordic demands

Building retrofitting is critical to achieve PED status in an area, especially when these are located in colder climates with denser population (Bruck et al., 2022b). It is difficult to reach positive energy buildings in Nordic urban areas if all energy demands of the building are included (Rehman et al 2022).

In Sweden, the Government intends to introduce a climate declaration requirement when buildings are constructed, which will enter into force on 1 January 2022. It aims to promote the transition towards more sustainable construction with reduced climate impact and to develop a national database that can help set minimum requirements based on a life-cycle perspective (Climate Act Sweden, 2022). However, there is no obligation for a network concession to transfer electricity from one property to another (Fastighetsägarna, 2022). In the district heating sector, energy and carbon dioxide taxes are levied on the supply, import, and production of fossil fuels for heating purposes (Renewable Energy Policy, 2017). Renewable energy sources are exempt from these taxes (Hållbarhetskriterier, 2010).

In this context, we selected a housing neighbourhood in Borlänge and Umeå to develop two distinctive roadmaps with the local universities in lead and in collaboration with the local actors. The municipal housing organisations are partners in both cities and there is not yet a scenario, how the local tenants could be involved in the PED development, as they have no decision rights in the process so far. These local players constellation can be found throughout the country and a good roadmap could help many neighbourhoods to become positive as a result.

Energy specifications 2022

The neighborhood in Borlänge and Umeå have a target to achieve carbon-neutrality by 2030. All the main energy supply to buildings, transportation, district heating etc, will be zero-carbon or renewable based source. But industry is excluded from this plan.

Vision and goal:

Develop an inclusion model, which engages citizens and tenants in the energy transition and allow perhaps to initiate such processes in other municipalities from bottom up.

Policy implication:

Borlänge and Umeå Municipalities have adopted an environmental strategy with ambitious targets for climate mitigation, energy efficiency and renewable energy. These two cities are part of the innovation programme Viable Cities – 'Climate Neutral City', which gathers 23 Swedish cities with the aim of reaching climate neutral cities by 2030. Borlänge and Umeå are together with the other cities a part of Viable Cities Transition Lab, which is a learning process, including recurring national fora with other cities and stakeholders. The aim is to explore and shape theory and methods of change as well as building distributed knowledge and expertise as a basis for action to enable accelerated climate and sustainability transition in cities.

2.3. Turkish national context – the Mediterranean potential

Since Türkiye is outside of the EU but is strongly linked with funding opportunities as an Associate member and some collective sustainability goals, retrofitting Turkish settlements to achieve energy positivity is critical to reduce the emissions. The districts in southern Europe have a better feasibility (economic viability) of PED projects (Bruck et al 2022a) and developing such projects in this favoured climate have rather complications from legal and political standpoints.

In Turkey, the centralised governing model, financial challenges, as well as property owner model leaves less space for local or bottom-up development of PED projects. At the same time local resources (wind, water, solar, thermal) are promising for local renewable energy production and the population has deep memory of energy poverty in the past, as in the 80's and 90's the energy shortage was challenging for homes and industry at the same time.

In this context, two dominantly residential neighbourhoods are identified as PED boundaries in Ankara and Karşıyaka, a district municipality within Izmir Metropolitan City boundaries. PED boundary selection in both contexts was carried out by the municipalities, Middle East Technical University (METU), İzmir Institute of Technology (IIT) and Demir Energy, while building and energy systems modelling, and scenario analysis is performed by METU. The pilot area in Ankara consists of 55 low-rise, single-family residential buildings, with 19.300 m2 floor area. All buildings were constructed in 1980s, therefore they adhere to the building's codes on that era. Two alternative sites are being considered in Karşıyaka. The first alternative consists of two buildings with 6500 m2 residential and 2000 m2 office area. The area was built in 2018, meaning that it adheres to the most recent building codes regarding envelope materials. The mix of commercial and residential areas was another positive feature towards energy positivity. The second alternative was built in 1993 and consists of 21 residential buildings. All sites have rooftop PV potential. Opportunities for PV instalments will be considered on other neighbouring buildings that are managed by the municipality.

Local stakeholders will be integrated in co-design activities to raise awareness and sustain energy transition in the neighbourhoods.

Energy specifications 2022

Izmir is selected as one of the NetZeroCities that aims to be carbon neutral by 2030. Aligned with this ambition, Karşıyaka developed SECAP

Vision and goal:

Reduce the energy demand in the existing building stock in both cities and meet the demand with on-site renewable energy production, as much as possible.

Policy implication:

Karşıyaka Municipality is a member of many international organizations such as the Covenant of Mayors (CoM), Healthy Cities Association, European Energy Cities Network and Healthy Cities Network. Strategic plan of Karşıyaka Municipality, covering the years 2019-2024, identifies many strategies in order to produce services with a sustainable and healthy environment understanding that increases the quality of life, protection from climate change and its effects in order to create a more sustainable city. Aligned with this goal, it is aimed to adapt to the climate by increasing the use of renewable energy and focusing on sustainable environmental decisions.

The last Sustainable Energy and Climate Action Plan (SECAP) of Karşıyaka Municipality was prepared in 2021. In the plan, action topics such as buildings, energy, waste, transportation in order to reduce greenhouse gas emissions, and protection of water resources, public health, disaster management, green areas within the scope of adaptation to climate change were determined and 32 actions, mostly on energy, were planned to be implemented. The Plan emphasized the importance of solar energy and geothermal energy in order to increase the use of renewable energy, and actions were shaped accordingly.

The strategic plan for 2020-2024 of the Metropolitan Municipality of Ankara, the capital of Turkey, has set its vision as "To be the leading capital city in a developing and changing world while making the capital of the Republic a liveable, sustainable brand city by protecting its historical, cultural and environmental values." In line with this vision, "To create a city that protects the ecological balance, supports biodiversity, is based on effective waste management and renewable energy policies, has adopted sustainable environmental management, and is aware of the negative effects of climate change."

Ankara Metropolitan Municipality became a member of the Covenant of Mayors in 2021. In the Sustainable Energy and Climate Action Plan (SECAP), projections and scenarios were prepared for the next 10-year periods, and it was determined that greenhouse gas emissions will increase up to 400% if no measures are taken according to the worst scenario. Priority and high targets have been set for greenhouse gas mitigation, especially in the buildings and transportation sectors. Strategies such as converting municipal buildings into energy efficient buildings, implementing green building standards, realizing LED conversion in all public spaces and according to the needs of citizens, and implementing incentives for buildings with Energy Identity Certificates have been developed. At the same time, city-specific projects are being developed to reduce greenhouse gas emissions by increasing rail connections and encouraging the use of electric vehicles and public transportation. Within the scope of adaptation to climate change, regional projects are also being implemented to improve infrastructure, ensure water management, and implement sustainable land use decisions in the city, which has faced floods many times.

3. Collaborative PED planning approach and method

Challenges within and inspiration for PED projects

All cases in this collaboration are typically top-down managed and there is no collaboration or communication culture, to manage and handle the energy transition with the citizens. This co- creation with bottom-up initiatives and involving them in the development of Positive Energy Districts is in our opinion an overlooked key element for successful and impactful PEDs.

In this collaboration we are developing a database for Positive Energy Districts and helping communities and decision makers in selected cities/towns of Austria, Sweden and Türkiye, to find appropriate roles and paths to work collectively on the energy transition. From the point of the citizens, there is a big gap of what the people's role and contribution could be in the energy transition of our nations. We are looking in three aspects of citizens to develop their roles in the PED development:

- a clear role for citizens in PEDs
- a clear say for citizens in PEDs
- a clear reward system for citizens in PEDs

In Planning and policymaking (within the field of energy transition) the citizens and their organisations are overlooked. At the same time there is no-true PED in Europe so far, we believe one reason is the lacking people's collaboration. As the PED needs to balance energy needs and energy production, throughout the day and year, the important half of the PED relies on the people, who are (for instance as renters) excluded from planning such or implementing such.

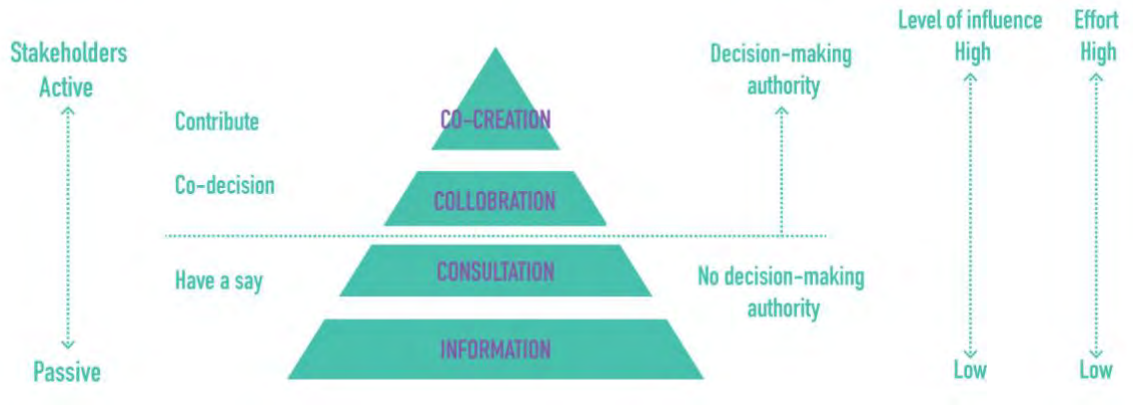

Figure 2: stakeholder engagement pyramide

True participation goes beyond the mere legitimisation of existing planning. It must create open spaces in which citizens can get involved. Especially in the case of urban transitions, this also requires political willingness and openness of the experts to innovate own practices. On the one hand, people must be made aware of the possibilities which would be the result of their participation and at the same time this "promise" has to be sincere and applicable. In addition, low-threshold access to the case process must be created, and linguistic, spatial and cultural barriers must be dismantled in order to enable very different people and population groups to participate and contribute to decisions and the design. Successful participation depends on whether all relevant stakeholders have been identified and involved, but also what they can contribute to the process.

Division of labour in the sense of cooperation means dividing a task into different subtasks so that different people or groups of people can work on them in parallel, also the citizens can fulfil subtasks in a true collaboration. Beforehand, consultation and mediation are necessary to define the common goal and to clarify who can or will do what. Responsibilities are always clearly traceable within the cooperative working process. Participation in sum refers first of all in general terms to the involvement of people in decisions that affect them directly or indirectly. It is about listening to their opinions and ideas and taking them into account, as well as involving them in the creation or implementation of solutions. The degree of involvement defines the role and the main aim of the participation process.

The ladder of intensity in participation can be divided in four main types of working together with citizens.

- information,
- consultation,
- cooperation and
- co-creation

In very complex cases and when there is little knowledge or expertise within the citizen group about the topic, the participation methodology is mainly used for **information** purposes. The main aim here is

awareness rising, communicating the content to the citizens etc. As there are little requirements from the participants, this way of participation can be addressed to a wide audience.

When there is a feedback expectation from the citizens, on mainly pre-elaborated solution proposals, the participation elevates the citizens to the experts who live in the relevant context and the participation act transforms to a citizen **consultation**. Their opinion is validated with this act.

If the citizens are able to fulfil even certain tasks or roles within the transformation process, the participation evolves into a **cooperation**. Requirement for this is of course, that the necessary expertise is available among the audience.

In the most intense participation form, the citizens are involved in a way, that they can **co-create** and design collectively the solution in quest.

Next to knowledge and expertise among citizens, the intensity of the participation is also a legal, financial and ethical issue and has to be framed differently from the beginning. The process leaders have to be careful to not to promise to little engagement (effort) and overburden the participants with ongoing demands. Also promising the co-creation of a solution, while there are no frameworks or resources to fulfil this promise, can upset the citizens. Next to the involvement degree the involvement sequences are determining the fruitful participation.

Top-down versus bottom-up

Decisionmakers, business owners and property owners have clear expertise, budget, and other resources to develop a PED project, while the communities have to live in such PED's and are not involved in the process and can't shape the solutions in a way that it supports their way of life or where they can proactively contribute with solutions to the transition as well. On the other hand, community developed projects like the energy communities are struggling with expertise, budget, and other resources to employ solutions, which can have a real contribution to the energy transition. From this perspective, bringing both approaches can cause difficulties but create enormous synergies. Yet the way to link the bottom-up with top-down is very tricky and challenging, as the players have different sensitivities and power schemes.

3.1. PED-ACT's Quadruple Helix Approach

Prioritising greater public involvement in PED processes is in PEDACT in line with the Quadruple-Helix approach (Sch tz et al., 2019; Carayannis and Campbell, 2009). This approach is used to democratise knowledge and allow social innovation in the PED development process. The partners are engaging the governmental, research, business, and civil society sectors in the creation of the roadmap to become a PED. PEDACT is creating a framework, which allows to co-design with the local communities, which consist of cross-departmental task force, investors, landowners, young professionals, and service providers next to citizens. In PED-ACT we will be defining with the local stakeholders, which participation framework we will be employing (information, consultation, cooperation or co-creation)

3.2. PED Test Designing

PED Test designing is an informal planning procedure which is employed with the selected cases in PEDACT to develop a roadmap and scenarios under different conditions. It is particularly suitable in the exploration processes (Scholl, 2017). We gain valuable insights to prepare and complement the roadmaps and scenarios. By employing this method in 5 different cases, we create deeper knowledge and synergies. Therefore, the test designing procedure supports the partners to take future project decisions in a comprehensive way. A clear role definition and expectations description is created from the beginning in the testing phase, to explore the challenges and opportunities of the scenarios.

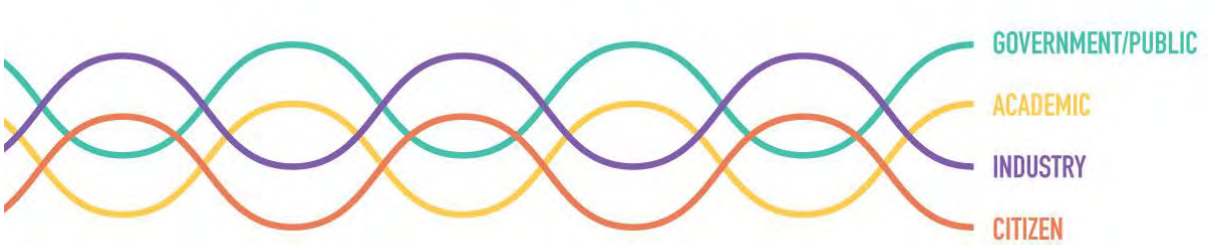

Figure 3. Collaboration in quadruple helix model

The quadruple helix approach has in all cases of PED-ACT different stakeholder constellations. In Sweden project partners are the municipality, housing provider and energy provider. The country is a predominantly renting-housing-market. Therefore, the citizens role here is very limited due to the limited decision-making potentials. In the Swedish context project partners will employ the information model for participation.

In Turkey on the other hand, the housing market consists of big portion individual house-ownership. That means there are many stakeholders, which need to be coordinated. At the same time, all transition topics are handled with central governing model and top-down. Due to local culture, and novelty of PED concepts in the country, the partners will use the model of information, with their citizen engagement activities.

In Austria, the energy community, as representant of informed citizens of the energy transformation agenda, have the interest and preliminary knowledge about the topic. The aim here is to create a collaboration within this project and perhaps aim to co-create the future scenarios with the energy community for the region. The rural housing market consist of predominantly individual homeowners, so the local participation work will entail also information-based participation for wider audiences.

4. PED designing a roadmap

4.1. Test designing process

Figure 4. PED-ACT process

Phase 1:

The designing process is informed through a clear pathway, which is followed in all 5 cases. Following a kick-off process with bilateral exchanges, talks among stakeholders the local needs, actors and opportunities are mapped. The academic and technical partners support the local actors in the selection

of a proper PED demonstration area and with energy modelling. In bilateral interviews, potential roles within the energy transition paths are defined for the local actors.

Phase 2:

The outcomes of the first phase are presented and discussed with the local community, with an open invitation to take up a role in the scenario, as well as to define the goals of the roadmap. The outcomes of the first phase have to be concrete enough to show potentials of participation and engagement, but flexible enough to further shape the roadmap collectively. After this open invitation workshop, roles and partnerships are further developed and key milestones for the scenarios defined collectively.

Phase 3:

In bilateral collaborations the scenarios are developed to be a part paths of a comprehensive roadmap to become a PED.

Phase 4:

The last public event is the moment, where the cohesive roadmap is handed over to the local actors, and potential supporters (e.g. funding givers) are invited to participate in the implementation phase.

4.2. Test designing process

The PEDACT project has so far generated a positive response from decisionmakers at local and regional level as well as the communities. The potential regional impact can be also recognized since the approach is multipliable. PED development in such contexts has been a major challenge for the five involved municipalities and communities. This way of collaborative working, creation of organisational capacities and develop methodological processes is promising for further replications.

Thanks to the approach and adopted method, this designing process illustrates how knowledge and innovation can be developed through and inclusive exchange culture. The stakeholders of future PEDs will profit from the experience and new input infiltrated by the actors of the Quadruple Helix Model. This approach makes the design community centred and responsive to local needs and challenges. Due to the current energy crisis, developments have to create synergies and involve citizens from the beginning in the transition. The PEDACT Project builds internal capacity in the municipalities with bringing different groups of actors together and involving them in a common roadmap, which clear roles and paths for all actors. This way of thinking will allow municipalities to properly adjust the aims, needs and resources.

In this context we recommend to further elaborate the citizens roles and make the offers for them clearer, so they have a realistic chance to participate, engage and perhaps innovate.

1 : a clear role for citizens in PEDs
2 : a clear say for citizens in PEDs
3 : a clear reward system for citizens in PEDs

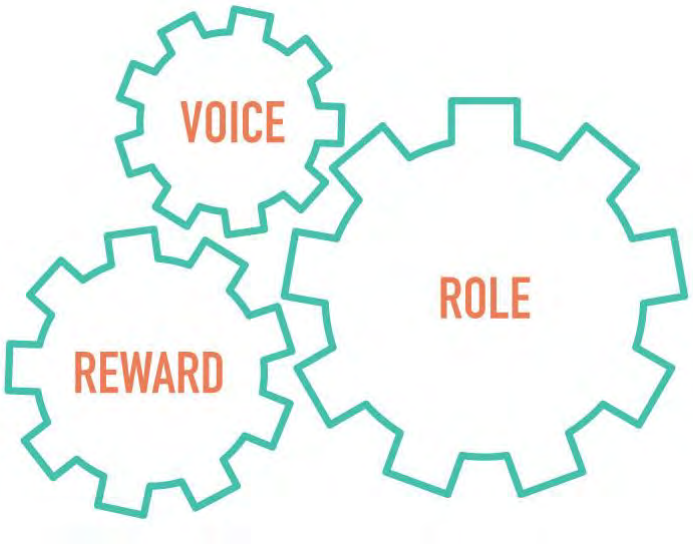

Figure 5.Pillars for stakeholder engagement

Role

Any roadmap has to have clear **roles** with expectations, expertise, duties and recommendations… perhaps with best case descriptions. Very much like in a theatre play: the opportunities of various roles can be appealing for citizens to be engaged with fewer resources. This aspect of the actors is very often forgotten in the common roadmaps, but are in our opinion crucial to have a citizen collaboration.

Voice

Especially citizens are kept on short notice and have to choose between predefined ideas in the process of engagement. This leads to engagement fatigue. If the process gives active role to the citizens, then it has to be clear that they have an own voice, with own interests and benefits, complaints, ideas, restrictions and demands. There must be a clear concept how they can have their voice heard, how the communication and decision process work in this design and how much they can influence the decision making and where the limits are. Disappointing citizens in this field will lead to tensions and perhaps to losing the citizens engagement – which in a PED project can lead to unsuccessful PED results.

Reward

Very much connected be being heard is also the topic of reward. The citizens consist of people who consume energy, who produce things with the energy… at the same time they might be educators, artist, shipowners, SME's, developers, innovators…. etc. Their individuality and therefore sources of motivation differ a lot. Having a conclusive idea how to reward which role with what kind of activity is very important. And this is obviously not only limited to financial rewards but any sorts of rewards.

5. Conclusions

The energy crisis was one of the greatest challenges for the PED-ACT societies in the last two years. There were some greatest lessons learned, which lead to higher sensitivity and awareness among citizens. This is a fruitful base to start the work with citizens, even though in different capacities and constellations in all three project countries. It as an experimental approach and the initial work looks promising.

The collaboration workshops highlight many unresolved issues and greater power imbalance, which need to be addressed and debated to a better satisfaction for the participants. The various views of a broad variety of stakeholders, with their diverse abilities, resources, ideas, and commitments are urgently needed

in the PED development as a common practice. The relevant decisions need to be made with a broader consensus and thus a greater capacity and quickly. This process needs to be orchestrated from the outside.

Even though the PED-ACT project works on a common database, to build relationships with different social and interest groups is more important than ever. The partners are aiming to develop digital support for operating social groups, not the other way around. Based on the lessons learnt the energy transition must be rethought. We need to make room for the increased attention to power imbalances and ensure that a just participation culture can be established, which allows good solutions to be implemented – not the solutions of the powerful only. So, beyond the technological solutions and emerging energy agenda, one of the most striking impacts of the energy crisis is the need to acknowledge citizens empowerment, to be able to better respond to future crises.

Acknowledgement

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References

Climate Act Sweden, 2022 "Climate declaration for new buildings - Boverket." https://www.boverket.se/en/start/building-in-sweden/developer/rfq-documentation/climate-declaration/ (accessed Sep. 05, 2022).

D. Kolokotsa, D. Rovas, E. Kosmatopoulos, K. Kalaitzakis, 2011. A roadmap towards intelligent net zero- and positive-energy buildings, Solar Energy, Volume 85, Issue 12, 2011, Pages 3067-3084, ISSN 0038-092X, https://doi.org/10.1016/j.solener.2010.09.001.

Bernd Scholl (2017). *Building Actor Relationships and Alliances for Complex Problem Solving in Spatial Planning*: The Test Planning Method, disP - The Planning Review, 53(1): 46-56. Online: https://www.tandfonline.com/doi/abs/10.1080/02513625.2017.1316544. (Accessed: 12 July 2023)

Carayannis, E. G., & Campbell, D. F. (2009). 'Mode 3'and'Quadruple Helix': toward a 21st century fractal innovation ecosystem. *International journal of technology management*, *46*(3-4), 201-234.

Hållbarhetskriterier, 2010 "Lag (2010:598) om hÃllbarhetskriterier för biodrivmedel och biobrä slen Svensk författningssamling 2010:2010:598 t.o.m. SFS - Riksdagen." https://www.riksdagen.se/sv/dokument-lagar/dokument/svensk-forfattningssamling/lag-2010598-om-hallbarhetskriterier-for_sfs-2010-598 (accessed Sep. 05, 2022).

European Parliament, 2009. Available at: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0001:0015:EN:PDF (Accessed: 12 July 2023)

Fastighetsägarna, 2022 “Så kan du dela el i lokala n t - Fastighetsäga na.” https://www.fastighetsagarna.se/aktuellt/webbinarier/sa-kan-du-dela-el-i-lokala-nat/ (accessed Sep. 05, 2022).

Nair, G., Mattsson, M., Delice, E., Gursel Dino, I. (2023). Review of positive energy districts: Definition, frameworks, incentives, regulatory aspects, replication and regional contexts, Available at: PED-ACT platform. (Accessed: 12 July 2023)

Renewable Energy Policy, 2017 “Renewable energy policy database and support: sources.” http://www.res-legal.eu/search-by-country/sweden/sources/t/source/src/act-no-19841052/ (accessed Sep. 05, 2022).

Sch tz, F., Heidingsfelder, M. L., & Schraudner, M. (2019). ‘Co-shaping the future in quadruple helix innovation systems: uncovering public preferences toward participatory research and innovation’. *She Ji: The Journal of Design, Economics, and Innovation*, 5(2), 128-146. . Online: https://www.sciencedirect.com/sdfe/reader/pii/S2405872618301394/pdf (Accessed: 12 July 2023)

JPI Urban Europe., 2020a. SET Plan Action 3.2, "White Paper on Reference Framework for Positive Energy Districts and Neighbourhoods". Available: https://jpi-urbaneurope.eu/ped/

N. Good, E. A. Mart nez Cese a and P. Mancarella, 2017a- "Ten questions regarding smart districts," *Building and Environment,* vol. 118, pp. 362-376, 2017.

PED Programme Management of JPI Urban Europe. 2020b, "Europe towards Positive Energy Districts, First Update," 02 2020. [Online]. Available: https://jpi-urbaneurope.eu/wp-content/uploads/2020/06/PED-Booklet-Update-Feb-2020_2.pdf.

Bossi, S., Gollner, C., Theierling, S., 2020. "Towards 100 Positive Energy Districts in Europe: Preliminary Data Analysis of 61 European Cases," Energies. 22, no. 13.

Zhang, X., Penaka, S. R., Giriraj, S., S nchez, M. N.. Civiero P. , Vandevyvere, H., 2021. “Characterizing positive energy district (PED) through a preliminary review of 60 existing projects in Europe,” *Buildings,* vol. 11, p. 318.

Good N, Mart nez Cese˜na EA, Mancarella P, Monti A, Pesch D, Ellis KA., 2017b. Barriers, challenges, and recommendations related to development of energy positive neighborhoods and smart energy districts. In: Energy Positive Neighborhoods and Smart Energy Districts: Methods, Tools, and Experiences from the Field. Elsevier Inc.; p. 251–74. [6] Becchio C, Bottero MC.

Lindholm, O., Rehman, U.H., Reda, F., 2021. Positioning Positive Energy Districts in European Cities, *Buildings,* vol. 11, no. 1, p. 10.

Hedman, ., Rehman, U.H., Gabald n, A., Bisello, A., Albert-Seifried, V., Zhang, X., Guarino, F., Grynning, S., Eicker, U., Neumann, H.-M., Tuominen, P., Reda, F., 2021. "IEA EBC Annex83 Positive Energy Districts," *Buildings,* vol. 11, no. 3.

Hoornweg, D., Sugar, L., Gomez, C.L.T., 2020. "Cities and Greenhouse Gas Emissions: Moving Forward," *Urbanisation,* vol. 5, no. 1, pp. 43-62, 2020.’

JPI Urban Europe, "SET Plan ACTION nr3.2 Implementation Plan. Europe to become a global role model in integrated, innovative solutions for the planning, deployment, and replication of Positive Energy Districts," 06 2018. [Online]. Available: https://jpi-urbaneurope.eu/wp-content/uploads/2018/09/setplan_smartcities_implementationplan.pdf.

Magrini, A., Lentini, G., Cuman, S., Bodrato, A., Marenco, L., 2020. "From nearly zero energy buildings (NZEB) to positive energy buildings (PEB): The next challenge - The most recent European trends with some notes on the energy analysis of a forerunner PEB example," Developments in the Built Environment, vol. 3.

Boudon, M., L'Helguen, E., De Tommasi, L., Bynum, J., Kouramas, K., Ridouane, E.H., Real Life Experinece-Demonstration sites (Chapter 7)

Moa, M, Nair G., Lundberg, L., Kordas, O., Olofsson, T., An exploratory study on Swedish experiences with Positive Energy Districts (under review).

Derkenbaeva, E., Vega, S.H., Hofstede, G.J., van Leeuwen, E., 2022. Positive energy districts: Mainstreaming energy transition in urban areas. Renewable and Sustainable Energy Reviews 153, 111782.

Alpagut, B., Aky. rek, ., Mitre, E.M., 2019. Positive Energy Districts Methodology and Its Replication Potential. Proceedings 2019, 20, 8; doi:10.3390/proceedings2019020008.

Neumann, H-M., et al., 2021. Qualitative Assessment Methodology for Positive Energy District Planning Guidelines. Sustainability in Energy and Buildings 2021.

Söderström P., 2021 Svensk författningssamling - förordning om ndring i förordningen (2007:215) om undantag fr n kravet p n tkoncession enligt ellagen (1997:857). [Online].

Vandevyvere, H., Ahlers, D., Wyckmans, A., 2022. The Sense and Non-Sense of PEDs—Feeding Back Practical Experiences of Positive Energy District Demonstrators into the European PED Framework Definition Development Process. Energies. https://svenskforfattningssamling.se/sites/default/files/sfs/2021-11/SFS2021-976.pdf.

Uspenskaia, D., Specht, K., Kondziella, H., Bruckner, T., 2021. "Challengers and Barriers for Net-Zero/Positive Energy Buildings and Districts - Empirical Evidence from the Smart City Project

SPARCS," Buildings 11.
Angelakoglou, K., Kourtzanadis, K., Giourka, P., Apostolopoulos, V., Nikolopoulos, N.,

Kantorovitch, J., 2020. "From a Comprehensive Pool to a Project-Specific List of Key Performance Indicators for Monitoring the Positive Energy Transition of Smart Cities - An Experience-Based Approach," Smart Cities, 705-735.

Yurui, H., Yuchen, Y., Vahid M, N., 2019. Assessing the potential of energy retrofitting and renewables in the campus of Lund University. Cold Climate HVAC 2018: Sustainable buildings in Cold Climates.

Lausselet, C., Lund, K.M., Brattebø, H., 2021. LCA and scenario analysis of a Norwegian net-zero GHG emission neighbourhood: The importance of mobility and surplus energy from PV technologies. Building and Environment.

Nematchoua, M.K., Sadeghi, M., Reiter, S., 2021. Strategies and scenarios to reduce energy consumption and CO2 consumption in the urban, rural and sustainable neighbourhoods. Sustainable Cities and Society.

Ahlers, D., Driscoll, P., Wibe, H., Wyckmans, A., 2019. Co-creation of Positive Energy Blocks. 1st Nordic conference on Zero Emission and Plus Energy Buildings.

Belda, A et al., 2022. Reviewing Challenges and Limitations of Energy Modelling Software in the Assessment of PEDs Using Case Studies.

Bruck, A., Ruano, S.D., Auer, H., 2022a. One piece of the puzzle towards 100 Positive Energy Districts (PEDs) across Europe by 2025: An open-source approach to unveil favourable locations of PV-based PEDs from a techno-economic perspective. Energy 124152.

Moreno, A.G., V lez, F., Alpagut, B., Hern ndez, P., Montalvillo, C.S., 2021. How to Achieve Positive Energy Districts for Sustainable Cities: A Proposed Calculation Methodology. Sustainability.

Sabine, J., Saleh, M., Regina, B., 2021. Developing a locally balanced energy system for an existing neighbourhood, using the 'Smart Urban Isle' approach. Sustainable cities and Society 64.

Söder, L et al., 2018. A review of demand side flexibility potential in Northern Europe. Renewable and Sustainable Energy Review.

Ter s-Zubiaga, J et al., 2020. Cost-effective building renovation at district level combining energy efficiency & renewables - Methodology assessment proposed in IEA EBC Annex 75 and a demonstration case study. Energy and Buildings.

Jepsen, B.K.H; Haut, T.W., Jradi, M. 2022. Design, modelling and performance evaluation of a Positive Energy District in a Danish island. Future Cities and Environment.

Haase, M., Baer, D., 2020. Towards Climate Neutrality through Integrated Energy Planning – a Cross-Country Comparison and Case Study Analysis of Positive Energy District Concepts between Switzerland and Norway.

Nguyen , M.T., Batel, S., 2021. A Critical Framework to Develop Human-Centric Positive Energy Districts: Towards Justice, Inclusion, and Well-Being. Frontiers in Sustainable cities.

Baer, D., Loewen, B., Cheng, C., Thomsen, J., Wyckmans, A., Temeljotov-Salaj, A., & Ahlers, D. (2021). Approaches to social innovation in Positive Energy Districts (peds)—a comparison of Norwegian projects. Sustainability, 13(13), 7362. https://doi.org/10.3390/su13137362

Brozovsky, J., Gustavsen, A., Gaitani, N. (2021). Zero emission neighbourhoods and Positive Energy Districts – a state-of-the-art review. Sustainable Cities and Society, 72, 103013. https://doi.org/10.1016/j.scs.2021.103013

Parag, Y., Sovacool, B. K. (2016). Electricity Market Design for the Prosumer Era. Nature Energy, 1(4). https://doi.org/10.1038/nenergy.2016.32

El Rahi, G., Etesami, S. R., Saad, W., Mandayam, N. B., & Poor, H. V. (2019). Managing price uncertainty in prosumer-centric energy trading: A prospect-theoretic Stackelberg game approach. IEEE Transactions on Smart Grid, 10(1), 702–713. https://doi.org/10.1109/tsg.2017.2750706

Rodr guez-Molina, J., Mart nez-N ez, M., Mart nez, J.-F., & P rez-Aguiar, W. (2014). Business models in the smart grid: Challenges, opportunities and proposals for prosumer profitability. Energies, 7(9), 6142–6171. https://doi.org/10.3390/en7096142

Olivadese, R., Alpagut, B., Revilla, B. P., Brouwer, J., Georgiadou, V., Woestenburg, A., & van Wees, M. (2021). Towards energy citizenship for a just and inclusive transition: Lessons learned on collaborative approach of positive energy districts from the EU horizon2020 smart cities and communities projects. The 8th Annual International Sustainable Places Conference (SP2020) Proceedings. https://doi.org/10.3390/proceedings2020065020

Tuerk, A., Frieden, D., Neumann, C., Latanis, K., Tsitsanis, A., Kousouris, S., Llorente, J.,

Heimonen, I., Reda, F., Ala-Juusela, M., Allaerts, K., Caerts, C., Schwarzl, T., Ulbrich, M., Stosch, A., & Ramschak, T. (2021). Integrating plus energy buildings and districts with the EU Energy Community Framework: Regulatory Opportunities, barriers and technological solutions. Buildings, 11(10), 468. https://doi.org/10.3390/buildings11100468

Clerici Maestosi, P., Andreucci, M. B., Civiero, P. 2021. Sustainable urban areas for 2030 in a post-covid-19 scenario: Focus on innovative research and funding frameworks to boost transition towards 100 positive energy districts and 100 climate-neutral cities. Energies, 14(1), 216. https://doi.org/10.3390/en14010216

Erba, S., Pagliano, L., 2021. Combining Sufficiency, Efficiency and Flexibility to Achieve Positive Energy Districts Energies, 14, 4697. https://doi.org/10.3390/ en14154697.

Vigna,I., Pernetti, R., Pasut, W., Lollini, R., 2018. New domain for promoting energy efficiency: Energy Flexible Building Cluster. Sustainable Cities and Society 38, 526-533.

Jensen, S.Ø., Marszal, A.J., Lollini, R., Pasut, W., Knotzer, A., Engelmann, P., Stafford, A., Reynders, G. 2017. IEA EBC Annex 67 Energy Flexible Buildings. Energy and Buildings 155, 25–34.

Huber, M., Dimkova, D., Hamacher, T., 2014. Integration of wind and solar power in Europe: Assessment of flexibility requirements. Energy 69, 236-246.

Bruck, A., Ruano, S.D., Auer, H. 2022b. Values and implications of building envelope retrofitting for residential Positive Energy Districts. Energy & Buildings 275, 112493.

Bruck, A., Casamassima, L., Akhatova, A., Kranzl, L., Galanakis, K., 2022c. Creating Comparability among European Neighbourhoods to Enable the Transition of District Energy Infrastructures towards Positive Energy Districts. Energies 15 (3) https://doi.org/10.3390/en15134720

Rehman, H.U., Hasan, A., Reda, F., 2022. Challenges in reaching positive energy building level in apartment buildings in the Nordic climate: A techno-economic analysis. Energy & Buildings 262, 111991.

Nzengue, Y., Boishamon, A.D., Laffont-Eloire, K., Partenay, V., Abdelouadoud, Y., Zambelli, P., D'Alonzo, V., Vaccaro, R., 2017. Planning city refurbishment: An exploratory study at district scale how to move towards positive energy districts – approach of the SINFONIA project.

IEEE International Conference on Engineering, Technology and Innovation. Castillo-Calzadilla, T., Alonso-Vicario, A., Borges, C.E., Martin, C., 2021. The Impact of e- Mobility in Positive Energy Districts. Environmental Science proceedings.

Rodr guez, L.R., Duminil, E., Ramos, J.S., Eicker, U., 2017. Assessment of the photovoltaic potential at urban level based on 3D city models: A case study and new methodological approach. Solar Energy 146, 264-275.

Nouvel, R., Kaden, R., Bahu, J-M., Kaempf, J., Cipriano, P., Lauster, M., Benner, J., Munoz, E.,

Tournaire, O., Casper, E., 2015. GENESIS OF THE CITYGML ENERGY ADE. Cisbat. 931–936. http://dx.doi.org/10.5075/epfl-cisbat2015-931-936

Krangs s, S.G., Steemers, K., Konstantinou, T., Soutullo, S., Liu, M., Giancola, E., Prebreza, B., Ashrafian, T., Murauskaite, L., Maas, N., 2021.Positive Energy Districts: Identifying Challenges and Interdependencies. Sustainability, 13(19), 10551; https://doi.org/10.3390/su131910551.

Vandevyvere, H.; Connolly, T.; Tencar, J.; Bandli, R.; Leppin, L.; Aky rek, .; Stewart, D., 2019a. PED Definition Development. In Proceedings of the JPI UE workshop, Vienna, Austria, 3 April 2019.

Vandevyvere, H.; Reynders, G.; Baeten, R.; De Jaeger, I.; Ma, Y., 2019b The Trade-Off between Urban Building Stock Retrofit, Local Renewable Energy Production and the Roll-Out of 4G District Heating Networks. Case Study Modelling for 9 Urban Districts in Flanders, Belgium. Position Paper EnergyVille. https://www.energyville.be/en/press/trade-between-urban-building- stock-retrofit-local-renewable-energy-production-and-roll-out-4g

Lausselet, C., Lund, K.M., Brattebø, H., 2021. LCA and scenario analysis of a Norwegian net-zero GHG emission neighbourhood: The importance of mobility and surplus energy from PV technologies, Building and Environment 189, 107528, ISSN 0360-1323, https://doi.org/10.1016/j.buildenv.2020.107528.

Jepsen, B.K.H., Haut, T.W. and Jradi, M., 2022. Design, Modelling and Performance Evaluation of a Positive Energy District in a Danish Island. Future Cities and Environment, 8(1), p.1. DOI: http://doi.org/10.5334/fce.146

Soutullo, S., Aelenei, L., Nielsen, P. S., Ferrer, J. A., & Gon alves, H. 2020. Testing platforms as drivers for positive-energy living laboratories. Energies, 13(21), 5621. https://doi.org/10.3390/en13215621

Civiero, P., Pascual, J., Arcas Abella, J., Bilbao Figuero, A., Salom, J. 2021. Pedrera. positive energy district renovation model for large scale actions. Energies, 14(10), 2833. https://doi.org/10.3390/en14102833.

Wiik, M. K., Fufa, S. M., Andresen, I., Brattebø, H., Gustavsen, A. 2019. A Norwegian zero emission neighbourhood (ZEN) definition and a ZEN key performance indicator (KPI) tool. In IOP Conference Series: Earth and Environmental Science, 352 p. 12030). https://doi.org/10.1088/1755-1315/352/1/012030

Case Study Report

The structural health monitoring technology of urban cultural heritage based on climate change impact

Case of Chinese masonry pagoda

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Abstract

Urban heritage architecture is an important part of urban culture. Because cultural heritage, such as Chinese masonry pagodas, has hundreds of years of history, and most of the heritage buildings are severely deteriorated. These architectures are less resilient to environmental and climate change than new urban buildings. Extreme climate change in recent years has presented a challenge for urban heritage protection. Chinese masonry pagoda has a higher risk of collapse than other heritages. This literature will compare two current structural health monitoring technology of Chinese masonry pagodas through the case study. Additionally, it will introduce a monitoring technology of climate change's impact on the structural health of urban cultural heritage. This technology will contribute to the protection of urban heritage and urban heritage plan.

Keywords

Urban heritage architecture; Chinese masonry pagodas; Climate change; Structural health monitoring technology

1. Introduction

China has a long history and culture. Heritage architecture is the symbol of Chinese historical culture as well as the landmark of urban culture. Therefore, the protection of urban historical relics is an important task of current urban planning. Chinese government conducted a legal framework to protect the heritage architecture. According to article 2 of the Law of the People's Republic of China on the Protection of Cultural Heritage (LPCH), the nation should preserve cultural heritage of historical, artistic, or scientific value, and cultural heritage, which has scientific value. The law was effective from 1982. Additionally, the rules for the implementation of the Law of the People's Republic of China on the protection of cultural heritage has published in 1992. These two laws are legal frameworks for heritage protection (Chan and Ma, 2004).

The Chinese pagoda is one of the Chinese heritage architectures. Chinese pagodas were introduced to China from India during the Han Dynasty and have developed into the current morphological structure after a long history (Zhang, 2009). Chinese pagodas have a high risk of collapse because of their slender

structure (Abruzzese, Miccoli and Yuan, 2009). Masonry pagodas are the majority of the existing ancient pagodas in China (Wang and Yuan, 2012). Therefore, this literature will provide a case study for two current existing structural health monitoring technology of masonry pagodas and present a structural health monitoring technology based on climate change.

2. Case study

2.1. The structural health monitoring technology based on the ambient vibration measurement.

The ambient vibration measurement is also called the pulsation method. This method is applied to obtain the natural frequency of the structure by detecting the structural vibration induced by environmental factors (Lu, 2017). This method acquires the natural vibration period of each floor of the pagoda by installing acceleration sensors on each floor. As the structure is damaged, the stiffness, damping, and other parameters of the structure will change. The natural vibration period is related to the stiffness and mass of the structure. Therefore, the engineers can detect the change of the natural vibration period of each layer of structure to obtain whether damage situation of each floor. Deng and Peng (2012) obtained the change in the natural vibration frequency of the pagoda for four years through ambient vibration measurements and assessed the change in stiffness of the pagoda for four years by comparing the 4 years' natural frequency of the pagodas. In addition, Li et al. (2009) detected the effect of reinforcement works on the stiffness of the pagoda by measuring the dynamic properties of the pagoda at different stages of reinforcement.

The detection technology is economical and straightforward. It can be widely used for structural damage detection of all kinds of heritage structures. But the method still has many limitations. This method requires ambient vibration measurements of the structure at different stages and a comparison of the changes in natural vibration frequencies to assess the damage situation of the structure. Therefore, this method is unable for real-time detection of structural damage. On the other hand, this method just could detect the general damaged areas of the structure, like which layer is damaged.

2.2. The structural health monitoring technology based on Neural Network.

Traditional structural health monitoring technology mainly monitors structural health in real-time through sensors and stores various data in the cloud. However, the large amount of data makes it difficult to classify and interpret (Wang et al., 2022). So Wang et al. (2022) developed a structural health monitoring technology based on Neural Network. This Neural Network is trained by the Virtual Optimal Sensor Placement method. This technology realizes the classification of data generated in real-time and is applied to predict the collapse of ancient Pagodas (Wang et al., 2022).

This technology improves the efficiency of data classification and identification for structural health monitoring techniques. But data training requires a high time expenditure. The traditional structural monitoring technology monitors the deformation of heritage in real-time through sensor technology, but the structural health of heritage is not just about vibration-induced deformation. Structural health can also be seriously affected by the effects of structural corrosion and structural weathering, which are induced by climate change. On the other hand, the structural health of heritage will also be affected by

the environment. This literature will discuss a structural health monitoring technology, which could be applied to monitoring the climate change impacts on structure. It could identify environmental factors that affect the structural health of heritages and provide feedback to the government and planners.

3. The structure of technology

Masonry is a two-phase composite material, which is consisted of blocks and mortar (Zhou, Ma and Zhang, 2010). The damage reason of masonry pagodas based on environmental effects are as follows: The first reason is earthquakes. China has a large amount of seismic fault zone. Therefore, the probability of collapse and damage of ancient pagodas in seismic zone areas is extremely high. Secondly, weathering is the main phenomenon of damage to ancient pagodas caused by climate change. The masonry pagoda has been exposed to air and rainwater for a long time and weathering has occurred (He, 2018). The third environmental reason is environmental vibration induced by human factors, such as vehicles on city roads, subways, and engineering works. The damage to other heritage architecture is similar to that of the ancient pagoda. It can be concluded that the main damage reason of the heritage is divided into vibration damage and weathering damage. The damage characteristics of vibration damage are partial collapse, overall collapse, and wall cracking. Weathering is mainly performed by physical weathering, chemical weathering, and biological weathering. Physical weathering is mainly generated by the thermal expansion and contraction of the material. Chemical weathering is produced by the chemical reaction between the material of heritage and air or rainwater. biological weathering is caused by the plants that grow on heritage (He, 2018).

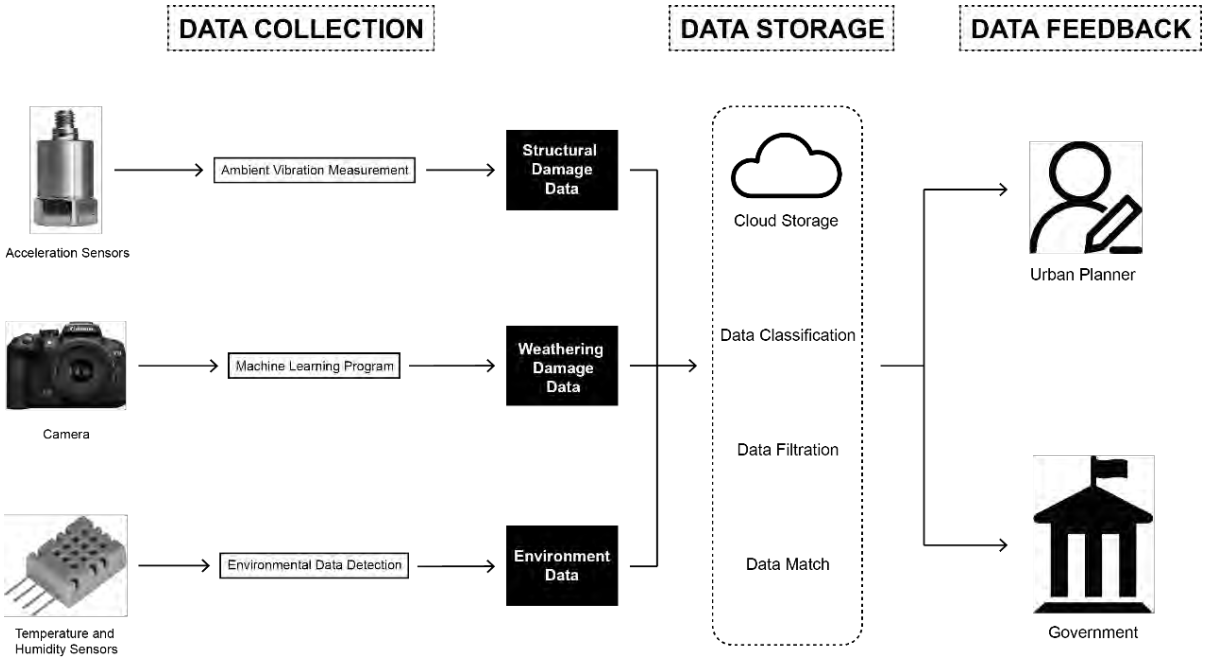

Figure 1. Structure of system.

According to Figure 1, this system is divided into three parts: data collection, data storage, and data feedback. The vibration damage is detected by installing displacement sensors and acceleration sensors in each component of the heritage. The sensor system monitors the deformation of different areas of the

building caused by vibrations. Weathering monitoring is mainly done by cameras and machine learning algorithms. Since weathering changes the surface features of a building, the program can be trained to identify weathering and the degree of weathering by inputting a large number of weathering images into the program. The data of the weathering is collected by the camera. As thermal expansion and contraction and rainfall are the reasons for the weathering of the heritage site, temperature and humidity sensors are installed around the site to monitor changes in the physical environment around the heritage. To promote data transfer, all data collection devices use wireless data transmission. All data will be automatically uploaded to the system cloud. The system matches the uploaded data and feeds it back to the user. The feedback system consists of two main clients. One is for the planner, and another is for the government.

4. Application on planning and heritage

This system will provide the damage status of the heritage collected by displacement sensors and cameras. So the government will connect related agencies to maintain the heritage. The damage to the heritage caused by the planning is divided into the urban traffic factor and the green environment factor. Because vibrations generated by earthquakes are much greater than in urban traffic facilities. Therefore, acceleration sensors can be used to screen the vibrations of urban traffic. The data collected by the acceleration sensor is matched in real-time to the data collected by the displacement sensor. The planner could assess the impact of the current traffic system on the heritages in the conservation area by comparing the displacement sensor data with the vibrations caused by urban traffic. The system assesses the speed of weathering of the heritage under different climatic conditions by matching temperature and humidity sensor data with weathering data in real-time. Since weathering is a long process, the system shares data on the degree of weathering and climatic conditions of heritage sites of the same era in different cities of China by uploading these data on the system cloud and sending these data to the planners. The planners could compare the weathering and climatic conditions of heritage buildings of the same era in different areas to obtain the most suitable environmental conditions for heritage. Plants could regulate the temperature and humidity of the environment. So the planner could create the most appropriate environmental conditions for the heritage site by controlling the green area around the site.

5. Conclusion

Urban heritage is an essential part of urban culture and the most vulnerable urban architecture. Protecting urban heritage is to preserve urban culture. The literature assesses current structural health detection technologies through case studies and discusses technology for structural health monitoring of heritage based on the effects of climate change. The system classifies data on structural damage caused by environmental and human factors by matching the data from different sensors. On the other hand, the system introduces machine learning algorithms to obtain identification of the weathering effects on the structure and to filter the most suitable climate conditions for the heritage. This technology could provide the database for future planning of urban heritage conservation areas. However, the technology still has many challenges. The technology applies many sensor systems. Therefore, it needs to study the optimal installation position and the optimum number of different sensors to save on monitoring expenses. Another major challenge is to reduce the impact of the monitoring system on the heritage. The walls of the heritage site are very fragile. So it is quite easy for engineers to cause damage to structures, such as walls, when installing sensors. The research will improve the technical solution in the future based on the challenges.

6. References

Abruzzese, D., Miccoli, L. and Yuan, J. (2009) 'Mechanical behavior of leaning masonry Huzhu Pagoda', *Journal of Cultural Heritage*, 10(4), pp. 480-486.

Chan, W.Y. and Ma, S.Y. (2004) 'Heritage preservation and sustainability of China's development', *Sustainable development*, 12(1), pp. 15-31.

Deng, H. and Peng, J.B. (2012) 'The Application of Vibration Testing in Jinaozhou Pagoda Protection', *Applied Mechanics and Materials,* 204, Trans Tech Publications Ltd. pp. 4562-4568.

He J.S. (2018) *The simulation analysis of seismic performance for Ningshousi pagoda.* Master's thesis. Lanzhou Jiaotong University. Available at: https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CMFD201901&filename=1018235773.nh (Accessed at: 01 April 2018). (In Chinese)

Li, S.W. *et al.* (2009) 'Assessment of repairs and strengthening of a historic masonry pagoda using a vibration-based-method', *Journal of structural engineering*, 135(1), pp. 67-77.

Lu, X.Y. (2017) *Evaluate the seismic performance of the structure of the Xiaoyan Pagoda by using IDA.* Master's thesis. Xi'an University of Architecture and Technology. Available at: https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CMFD202002&filename=1017735809.nh (Accessed at: 01 April 2017). (In Chinese)

Wang, C. and Yuan, J.L. (2012) 'Seismic strengthening technology and durability analysis of ancient masonry pagodas', *Applied mechanics and materials*, 166, Trans Tech Publications Ltd. pp. 2143-2150

Wang, P. *et al.* (2022) 'Preliminary Study of a Neural Network Procedure for the Timely Detection of the Collapse of Historical Cultural Heritage Structures', *2022 IEEE International Workshop on Metrology for Living Environment (MetroLivEn)*. IEEE. pp. 242-246

Zhang, M.Q. (2009) *The Architectural Features Research of Bashu Ancient Pagodas.* Master's thesis. Chongqing University. Available at: https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CMFD2009&filename=2009149019.nh (Accessed at: 01 May 2009). (In Chinese)

Zhou, Z.X., Ma, J.S. and Zhang, H. (2010) 'Nonlinear Finite Element Analysis of Seismic Performance of Bailin Temple Pagoda', *Industrial Construction,* 40(02), pp. 74-76+63. doi:10.13204/j.gyjz2010.02.003. (In Chinese)

Case Study Report

The role of digital twins for building resilient communities

Case of Dublin

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Abstract

'Resilience' is an overarching term subsuming capacity of any society to deal and adapt with new changes in existing systems. 'Digital' is rapidly becoming a new order of life, especially with urban solutions labelled more and more as 'smart', in rhetoric hopes of achieving a high quality of life. Digital twins are one such emerging technology, focussing to create virtual replicas of physical assets, and systems, with advanced data analytics and prediction capabilities in real-time. For cities, they can result in cost efficiencies, operational efficiencies, better urban management, and informed decision-making. However, for communities, they can aid in better participation, accessibility, and inclusive communication, which could result in localization of sustainable development goals, and improved levels of acceptance for a just and green transition, thus eventually building more resilience within communities. Realising their potential role in decision-making, Dublin City Council's smart cities unit has collaborated with the Science Foundation of Ireland's ADAPT Research Centre for AI-Driven Digital Content Technology on a two-year long targeted project for developing a digital twin framework. The project started in December 2022 with core objective to adopt a human-centric approach for future engagement frameworks. It is unique in terms of its collaborative and multi-stakeholder structure.

Keywords

City Digital Twins, Community Engagement, Stakeholder Collaboration, Smart City Use Cases, Resilient Communities

1. Project Motivation

Different departments of Dublin City Council (DCC) have been experimenting with state-of-the-art 3D modelling technologies such as drones, building information models and LIDAR scanners for surveying, mapping, and data collection. This data is further being used for planning across various thematic challenges such as energy consumption, urban planning, public engagement, environment, tourism, and infrastructure management to support its vision for a dynamic, sustainable city, that is future-ready, built on thriving, inclusive neighbourhoods, and communities, a strong economy, a vibrant cultural life, and compact, connected growth (Dublin City Council, 2020). Also, there is a noticeable growing interest towards the use of digital twins for modelling climate change (DestinE system and digital twin for oceans), sustainable freight management, policy making (DUET, PoliVisu, COMPAir projects) and skills for citizen engagement (the European Network of Living Labs – EnoLL) under the Europe's Digital Decade framework to ensure a smoother adoption of digital by its member states (Government of Ireland, 2018; European Commission, 2020, 2021; Digital Europe, 2021a, 2021b).

A local digital twin (LDT) is more than a digital representation of a city's physical assets, systems and processes targeting a bidirectional information exchange between them (European Commission, 2020;

Shahat, Hyun and Yeom, 2021). Ideally, they are supposed to be living models representing a system throughout its lifecycle (Sepasgozar, 2021; Botín-Sanabria *et al.*, 2022; Caprari *et al.*, 2022). This new emerging technology offers possibilities of advancement from traditional 3D city models towards AI-driven living city models to simulate urban system(s), improve city management and explore new user-interfaces between communities, public authorities, service providers and researchers (European Commission, 2020; Digital Europe, 2021b; Botín-Sanabria *et al.*, 2022). Realizing its potential for territorial planning, DCC's smart cities unit has partnered with the ADAPT SFI Research Centre for AI-Driven Digital Content Technology at Maynooth University, on a 2-year long targeted project, which started in December 2022, to explore its potential as a decision-support and engagement tool (ADAPT Centre, 2022). It aims to develop an ethical framework for using LDTs and trial proof of concept for stakeholder and community engagement.

1.1. Case of (Smart) Dublin

Smart Dublin is an initiative launched by the four local authorities in the Dublin region with an aim to future-proof the region by trialling, testing, and scaling innovative solutions to tackle issues ranging from climate change to increasing digital divide (Dublin City Council, 2017). The programme uses a district (testbed) approach for developing and deploying proof of concept solutions in strategically selected locations where innovation projects can be fast-tracked. Smart Docklands was the first smart district under the Smart Dublin umbrella, launched in 2018, further followed by the launch of Smart DCU, Smart Dun Laoghaire, Smart Balbriggan and Smart D8 (Smart Dublin: Homepage). Dublin city is also an active member of the EUROCITIES network, Bloomberg Philanthropies, Harvard Tech City Innovators Forum, Cities Today institute, the European Commission's Mission for 100 climate-neutral and smart cities, Lving-in.EU and UN's Cities Coalition for Digital Rights, and has been involved in various European Horizon 2020 Projects (Operandum, Senator), and INTERREG project (Building an ecosystem to generate opportunities in open data). **Figure 1** illustrates various smart districts under the Smart Dublin umbrella.

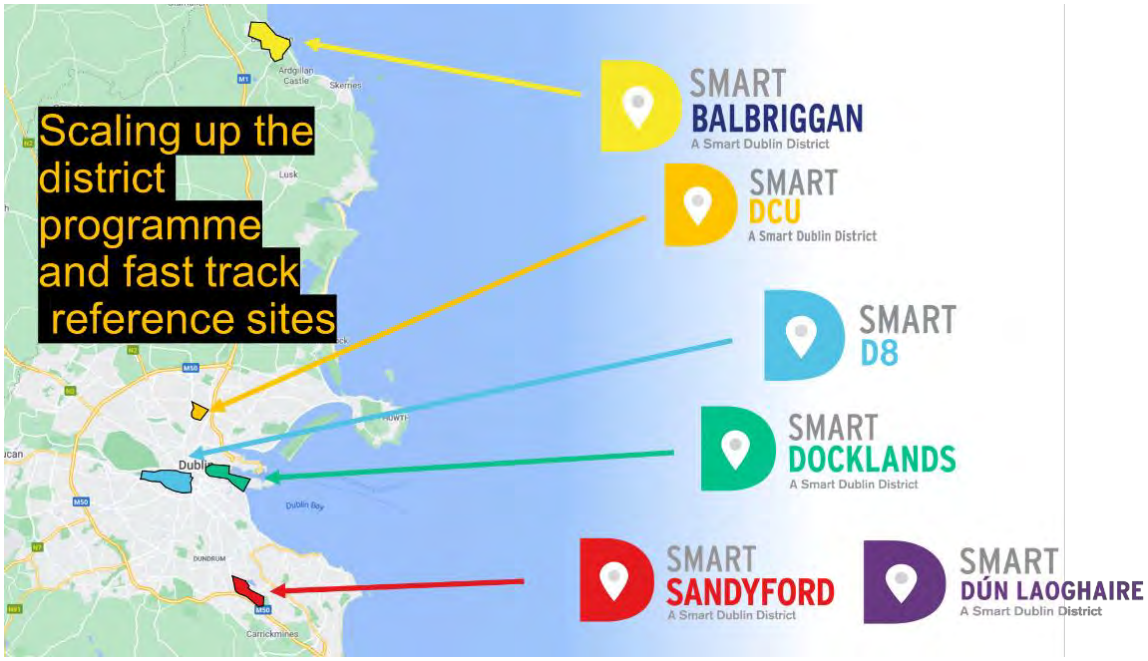

Figure 1: Smart Districts. Source: Smart Dublin.

Many cities around the world such as Singapore, Zürich, Utrecht, Wellington, and Helsinki are already building their digital twins using 3D environments for improving quality of life, city services, local governance, mobility, and environmental conditions (Schrotter and Hürzeler, 2020; Abdeen and Sepasgozar, 2022; Anshari and Hamdan, 2022). Smart Dublin also realises a massive opportunity to leverage LDT technology for improving communication with its key stakeholders and communities on

future projects and investments planned for the city. In 2019, it organized a 3D Hackathon event by releasing an open-source 3D model of the Docklands Strategic Development Zone and recently, in 2023, it launched Google AirView Hackathon by releasing over 50 million air quality measurements at 5 million locations across the city. It has also been exploring GIS-based platforms such as Cesium ion and ESRI's ArcGIS, gaming engines such as Epic's TwinMotion and the use of VR/AR for increasing the value of existing models.

1.3. Research Need and Objectives

Cities are complex 'human' systems, where multiple dimensions interweave at economic, social, environmental, institutional, and cultural levels. Although there are many definitions of 'resilience', but all of them have 'capacity' as a common element, which is a positive attribute that can be built and acquired by cities, communities, or organizations (Figueiredo, Honiden and Schumann, 2018). This capacity comprises of certain actions, such as adapt, resist, absorb, transform, change, recover and prepare, in the event of any shocks, stresses, hazards, or high-risk situations (Béné *et al.*, 2012). For European cities and citizens, this term also considers the changes brought about by digital innovation, demographic change, climate change, globalization, and migration (Manca, Benczur and Giovannini, 2017). With a global focus on just and green transition leaving-no-one-behind, a participatory governance is required at the core to build public acceptance and trust in new localised changes, to build their absorptive, adaptive, and transformative capacities (Béné *et al.*, 2012). OECD's resilience framework also identifies participation of communities and other stakeholders in urban planning initiatives as crucial to enhance urban resilience (Figueiredo, Honiden and Schumann, 2018).

While the concept of digital twins has existed for decades, it is recently becoming prominent in urban planning (European Commission, 2020). LDTs can visualize data from different stakeholders simultaneously in an integrated, interactive, and 3D ('real life') way. Because of this, they have the potential to include a wider range of citizens in decision-making processes for territorial planning, because they can make technical plans more 'visual', comprehensive, and interactive for different people, and organizations. The Digital Twin for Engagement (DT4E) project intends to explore use-cases to innovate, trial and test digital twin solutions for better engagement at urban scale while considering the learning and adaptive capacities of implementing agencies, technology providers and local communities. It is expected to support goals of participatory governance, inform decision-making and raise awareness about the possibilities that could arise when working in a virtual environment (World Economic Forum, 2022).

Some of the anticipated implementation challenges fall under the category of data governance (storage, sharing/open-data, management, acquisition, advanced processing capabilities), lack of trained staff, interoperability, ethical concerns (privacy, data protection, safe handling of data, equity, participatory democracy, transparency, accountability, non-discrimination of data, content/algorithms, impact on balance of power between government) and scaling solutions to city level (complex multi-domain data, financial constraints, lack of political support) (Cardullo, Di Feliciantonio and Kitchin, 2019; Botín-Sanabria *et al.*, 2022; Saeed *et al.*, 2022). DT4E will understand these challenges and underlying opportunities, develop, and evaluate interventions and propose roadmaps to progress the future digital twin ecosystem at DCC. The project has the following three goals -

1. To identify, evaluate and advance existing 3D modelling technology towards digital twin ecosystems for effective stakeholder and community engagement.
2. To engage with and encourage collaboration of all stakeholders in the development and deployment of LDTs across identified sectors and applications.
3. To evaluate and mitigate ethical challenges in deploying LDT technology.

2. Mapping Digital Twin Ecosystem at DCC

The first phase of this project analyses and compiles the ongoing digital twin projects at DCC. DCC is actively using drone-captured data for generating 3D models. Also, the Smart Tourism programme, supported by DCC and Fáilte Ireland is exploring immersive engagement solutions through its Dublin Discovery Trails app (**Figure 2**). From a more technical standpoint, DCC's climate action unit has developed a digital twin for assessing the full carbon impact and efficiency of renovation strategies, over three different time periods for one of its social housings (dashboard in **Figure 3**) (Integrated Environmental Solutions Ltd, 2022). Another interesting use-case is developed by Dublin Fire Brigade to test a digital twin for emergency response, shown in **Figure 4**, to collate and display risk-critical information about high-impact sites in Dublin. There are plans to explore cloud services, Internet of Things device feeds and Simultaneous Location and Mapping of internal details of buildings.

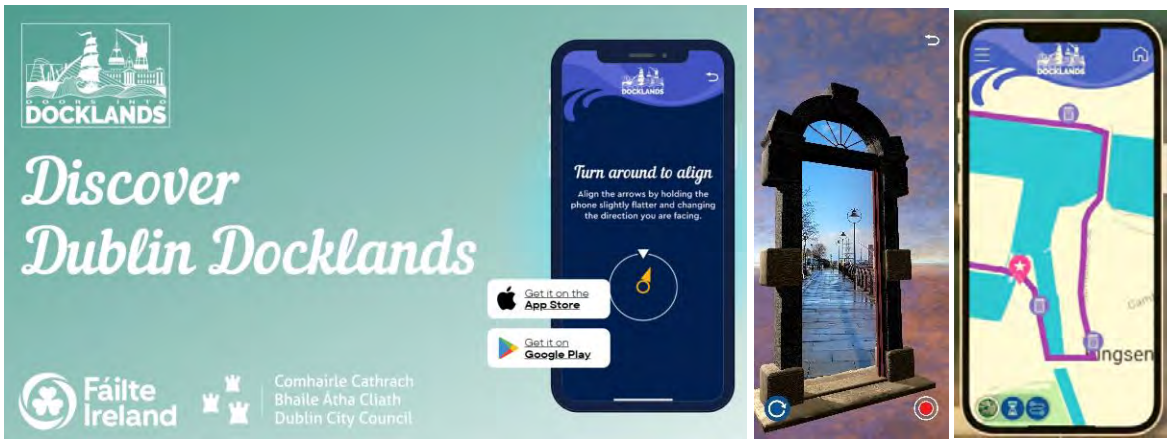

Figure 2: Smart Tourism's App using AR technology. Source: Dublin Discovery Trails App

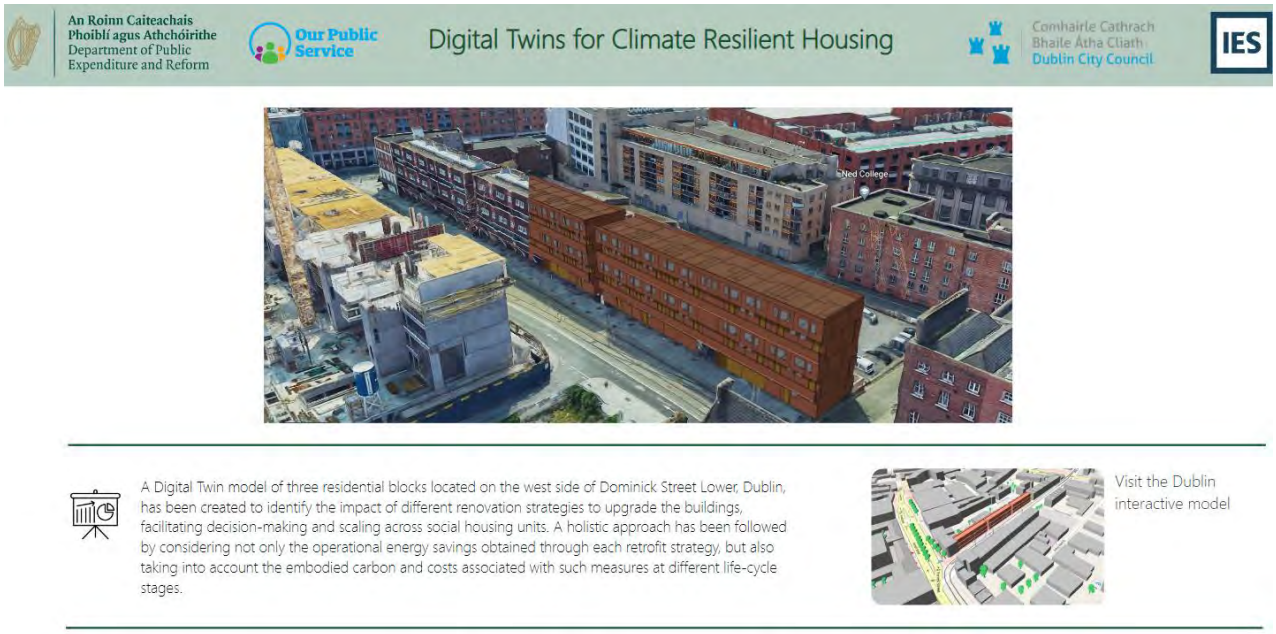

Figure 3: Digital Twin for Climate Resilient Housing. Source: IES Decarbonisation Roadmap Dashboard

Figure 4: Dublin Fire Brigade Digital Twin Model for BOC Gas. Source: Bentley OpenCities Planner Screenshot

Smart cities unit is also enabling the development of LDTs for enhanced visualization and data value for civic engagement through its smart districts' collaboration. The smart DCU district is building Ireland's first higher education digital campus, with the first phase of rapid prototyping of a 3D version of the university campus, both indoors and outdoors, overlaid with some light sensor data and 360-degree views, as illustrated in **Figure 5.** In its next phase, use-cases towards an adaptive campus environment using immersive technologies are expected. Smart Docklands is another district, which has procured a 3D block model with varying levels of detail, a VR model and a reality mesh captured using drone and LIDAR technology (White et al., 2021). **Figure 6** illustrates a proof of concept for Dockland's digital twin.

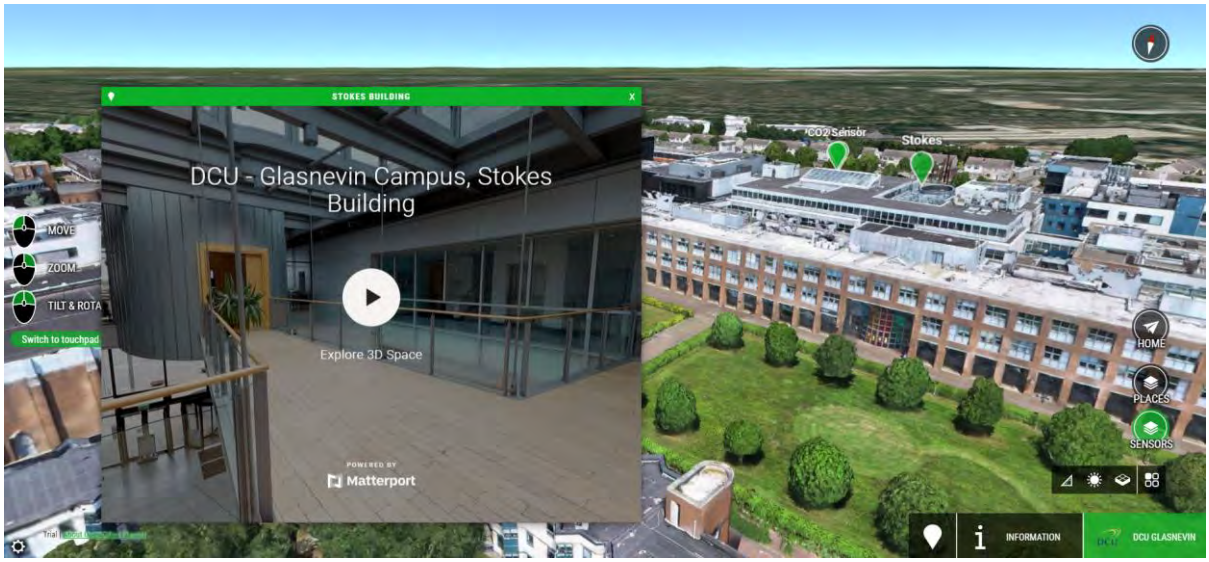

Figure 5: Smart DCU Digital Twin of Glasnevin Campus. Source: Bentley OpenCities Planner screenshot

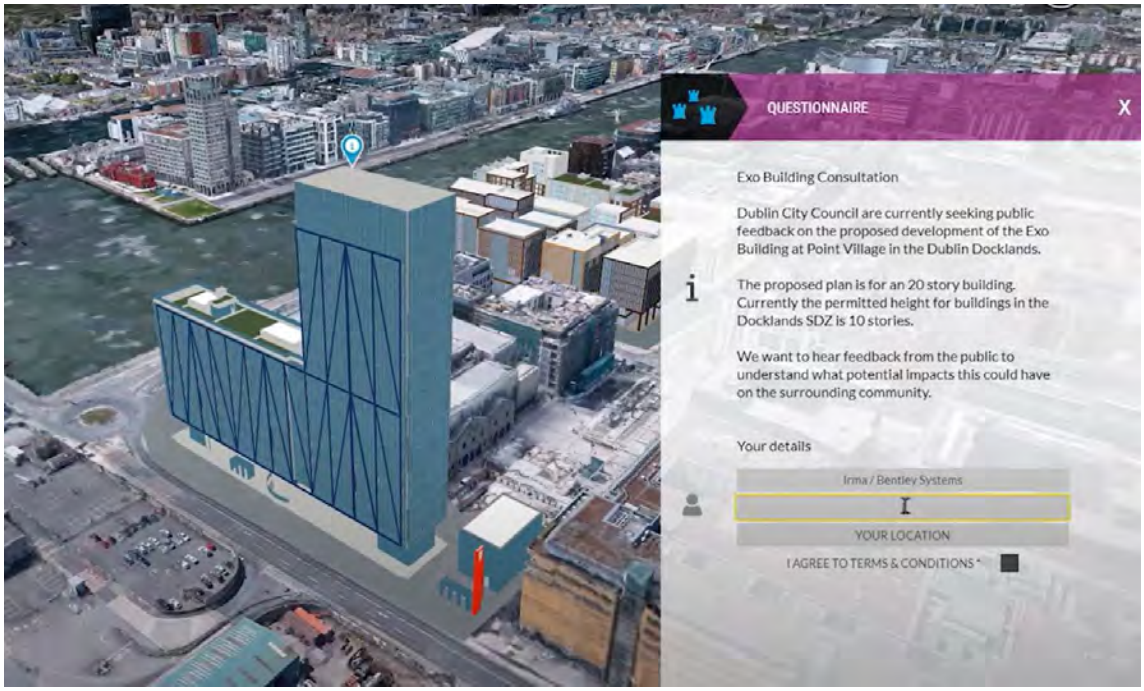

Figure 6: Pilot for Citizen Feedback for Docklands Model. Source: Bentley OpenCities Planner Screenshot

3. Proposed approach

As mentioned, there are some practical challenges in deploying LDTs. Therefore, a strategic approach is proposed for a phase-wise implementation towards insightful twins. Some foundational questions about data requirements, integration platforms, data governance, ethical concerns, and building essential collaborations for impactful use cases need to be answered. A possible implementation journey and work-streams are illustrated in **Figure 7** and **Figure 8** respectively.

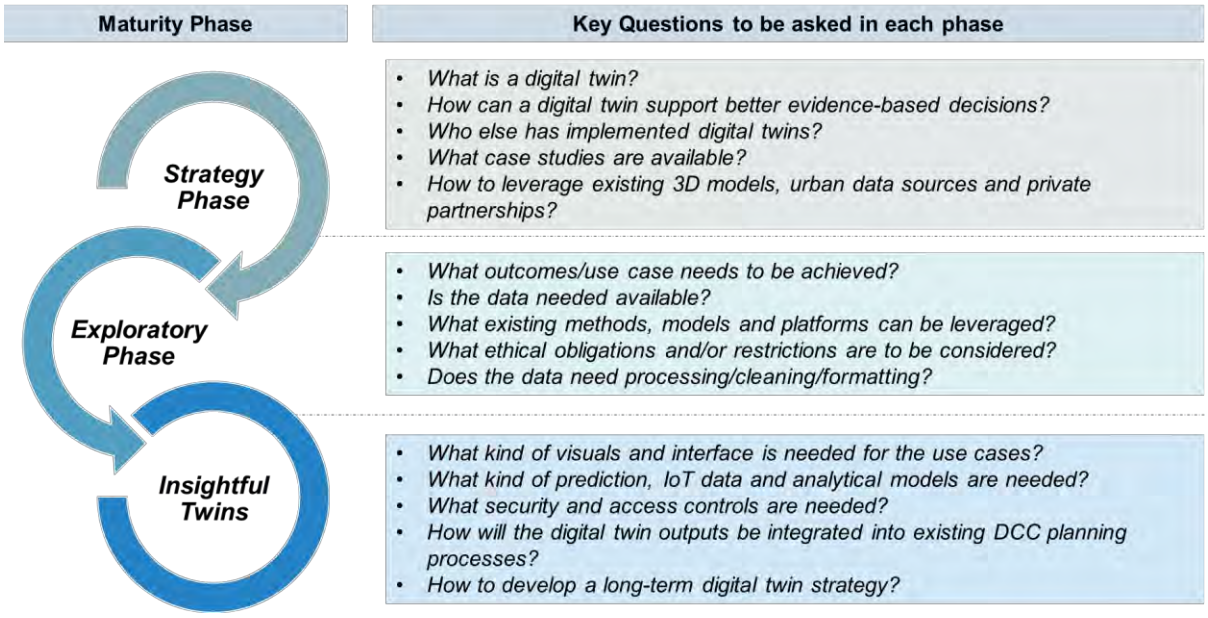

Figure 7: Suggestive Implementation Journey. Source: Authors

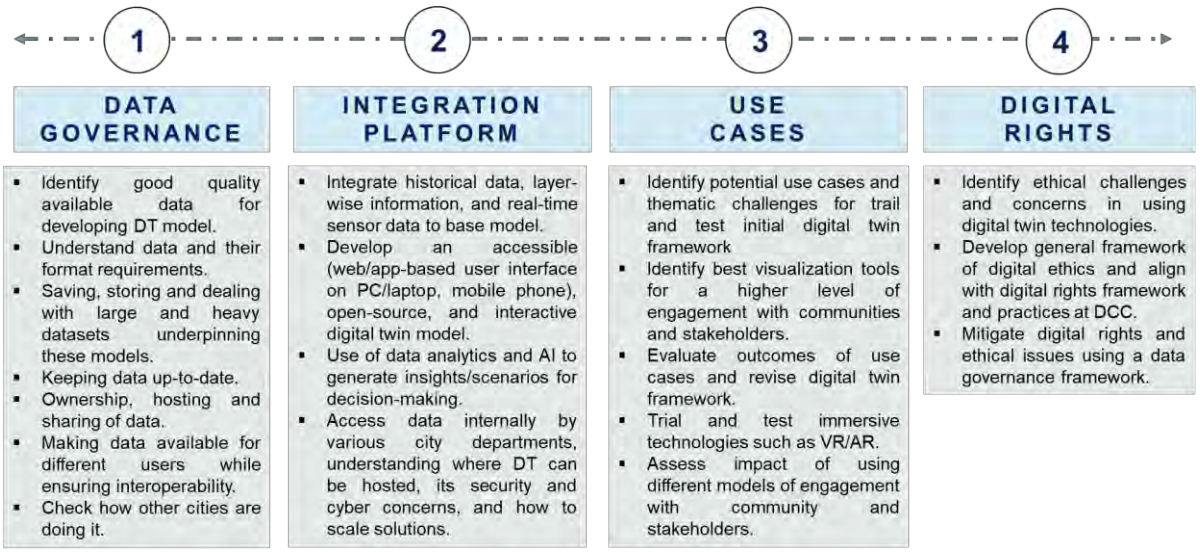

Figure 8: Proposed Work Streams. Source: Authors

The potential use-cases can be broadly classified as Type I and Type II. Type I use-cases are essentially visual and interactive twins, with a strong purpose to engage with non-technical target groups (Alessi *et al.*, 2020; Parker, Tomitsch and Fredericks, 2020; Abdeen and Sepasgozar, 2022). Examples of this include the extension of Smart DCU digital twin model into Unreal Engine for autism-friendly navigation, overlaying validated future flooding scenarios on the Docklands digital twin and complementing the process of public consultation for active travel project schemes in Dublin (claimed to be one of the largest investments in Europe). The emphasis will be to harness the potential of digital prototypes using 3D models, spatial layers, and design renderings for community engagement. Presently, the information shared with the public is very technical, insufficient, and difficult to understand the overall process and timelines, leading to final proposals. Also, many times, it is not designed to meet the needs of different age-groups, abilities, and genders.

Type II use cases target technical or semi-skilled stakeholders who need these models for informed planning decisions and situational awareness. Examples of this include using the proposed digital twin for emergency response by Dublin Fire Brigade for personnel training, and prospects of developing a multi-thematic planning use case for Smart D8 (a health and wellness district) by identifying planning relationships between different datasets such as air quality, parks and green area density, health and social services, active travel routes, housing, noise, community initiatives and other infrastructures. Key questions for identifying the type of digital twin depends on target audience, purpose and added engagement value desired from them. For instance, an immersive solution may work better for community engagement while an advanced analytical dashboard/platform is probably required by public departments. These use-cases are currently in the exploratory phase and use engaged research principles (Campus Engage, 2022). For evaluation of prototype models, stakeholder workshops, interviews and citizen think-ins will be explored.

4. Expected Outcome and Broader Impact

One of the key priorities for Ireland is to transition to a low-carbon and climate-resilient society by 2040, and projects such as Active Travel Network are of special relevance because of their explicit focus on the overall societal well-being. At city scale, building resilience within communities can be understood to make them adaptive to these new changes, which makes the role of local public authorities even more critical to foster policies towards positive socio-economic-environmental outcome of sustainability, cohesion and prosperity of a society (Wardekker, 2022). These long-term goals also depend on building innovative

communication channels between citizens and service providers (Digital Europe, 2021a; Anshari and Hamdan, 2022). DT4E expects to bridge this gap by employing evidence-based research, for developing inclusive planning solutions. For DCC, it expects to assist in creative and agile community engagements based on a robust governance and ethical framework for LDTs, while streamlining planning processes and induce effective stakeholder collaborations.

5. Funding acknowledgement

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6. References

Abdeen, F.N. and Sepasgozar, S.M.E. (2022) 'City Digital Twin Concepts: A Vision for Community Participation', in. MDPI AG, p. 19. Available at: https://doi.org/10.3390/environsciproc2021012019.

ADAPT Centre (2022) *SFI ADAPT Centre and Dublin City Council Collaborate to Advance a Citizen-Centric and Sustainable Smart Dublin*.

Alessi, M. *et al.* (2020) 'A data visualization solution for the smart city to exploit environmental data by means of 3d buildings', in *2020 5th International Conference on Smart and Sustainable Technologies, SpliTech 2020*. Institute of Electrical and Electronics Engineers Inc. Available at: https://doi.org/10.23919/SpliTech49282.2020.9243831.

Anshari, M. and Hamdan, M. (2022) 'Enhancing e-government with a digital twin for innovation management', *Journal of Science and Technology Policy Management* [Preprint]. Available at: https://doi.org/10.1108/JSTPM-11-2021-0176.

Béné, C. *et al.* (2012) *Resilience: New Utopia or New Tyranny? Reflection about the Potentials and Limits of the Concept of Resilience in Relation to Vulnerability Reduction Programmes*, *IDS Working Papers*. Wiley. Available at: https://doi.org/10.1111/j.2040-0209.2012.00405.x.

Botín-Sanabria, D.M. *et al.* (2022) 'Digital Twin Technology Challenges and Applications: A Comprehensive Review', *Remote Sensing*, 14(6). Available at: https://doi.org/10.3390/rs14061335.

Campus Engage (2022) *A How to Guide- Engaged Research Framework*.

Caprari, G. *et al.* (2022) 'Digital Twin for Urban Planning in the Green Deal Era: A State of the Art and Future Perspectives', *Sustainability (Switzerland)*, 14(10). Available at: https://doi.org/10.3390/su14106263.

Cardullo, P., Di Feliciantonio, C. and Kitchin, R. (eds) (2019) *The Right to the Smart City*. Emerald Publishing Limited. Available at: https://doi.org/10.1108/9781787691391.

Digital Europe (2021a) *Digital Action = Climate Action - 8 ideas to accelerate the twin transition*. Available at: https://smarter2030.gesi.org/downloads/Full_report.pdf.

Digital Europe (2021b) *DIGITALEUROPE's response to the Digital Decade consultation*. Available at: www.digitaleurope.org.

Dublin City Council (2017) *Smart Dublin*.

Dublin City Council (2020) *Dublin City Council Corporate Plan 2020-2024*.

European Commission (2020) *Digital twins for cities*. Available at: https://euregionsweek2020-video.eu/video/digital-twins-for-cities.

European Commission (2021) *Local Digital Twins : Forging the Cities of Tomorrow*.

Figueiredo, L., Honiden, T. and Schumann, A. (2018) *Indicators for Resilient Cities*. 2018/02. Available at: https://doi.org/10.1787/6f1f6065-en.

Government of Ireland (2018) *Project Ireland 2040 - Building Ireland's Future*.

Integrated Environmental Solutions Ltd (2022) *Digital Twin Modelling for Climate Resilient Housing*. Available at: www.iesve.com.

Jabareen, Y. (2013) 'Planning the resilient city: Concepts and strategies for coping with climate change and environmental risk', *Cities*, 31, pp. 220–229. Available at: https://doi.org/10.1016/j.cities.2012.05.004.

Manca, A.R., Benczur, P. and Giovannini, E. (2017) *Building a Scientific Narrative Towards a More Resilient EU Society- Part 1: a Conceptual Framework*. Available at: https://doi.org/10.2760/635528.

Parker, C., Tomitsch, M. and Fredericks, J. (2020) 'Smart engagement for smart cities: Design patterns for digitally augmented, situated community engagement', in *Shaping Smart for Better Cities: Rethinking and Shaping Relationships between Urban Space and Digital Technologies*. Elsevier, pp. 177–200. Available at: https://doi.org/10.1016/B978-0-12-818636-7.00010-X.

Saeed, Z.O. *et al.* (2022) 'Future City, Digital Twinning and the Urban Realm: A Systematic Literature Review', *Buildings*. MDPI. Available at: https://doi.org/10.3390/buildings12050685.

Schrotter, G. and Hürzeler, C. (2020) 'The Digital Twin of the City of Zurich for Urban Planning', *PFG - Journal of Photogrammetry, Remote Sensing and Geoinformation Science*, 88(1), pp. 99–112. Available at: https://doi.org/10.1007/s41064-020-00092-2.

Sepasgozar, S.M.E. (2021) 'Differentiating digital twin from digital shadow: Elucidating a paradigm shift to expedite a smart, sustainable built environment', *Buildings*. MDPI AG. Available at: https://doi.org/10.3390/buildings11040151.

Shahat, E., Hyun, C.T. and Yeom, C. (2021) 'City digital twin potentials: A review and research agenda', *Sustainability (Switzerland)*. MDPI AG. Available at: https://doi.org/10.3390/su13063386.

Smart Dublin: Homepage (no date).

Wardekker, A. (2022) 'Framing "Resilient Cities": System Versus Community Focused Interpretations of Urban Climate Resilience', in O.F. González Castillo et al. (eds) *Urban Resilience: Methodologies, Tools and Evaluation: Theory and Practice*. Cham: Springer International Publishing, pp. 17–30. Available at: https://doi.org/10.1007/978-3-031-07586-5_2.

White, G. *et al.* (2021) 'A digital twin smart city for citizen feedback', *Cities*, 110, p. 103064. Available at: https://doi.org/10.1016/J.CITIES.2020.103064.

World Economic Forum (2022) *Digital Twin Cities: Framework and Global Practices - Insight Report*.

Research Paper

Using Bayesian Networks to Guide Spatial Layout for Urban Design

A Conceptual Framework and Case Visualization

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Abstract

Spatial layout is usually the starting point of urban design, as well as the basic research for exploring future urban development. This study proposes a method tool and conceptual framework for urban spatial layout guidance using Bayesian networks (UBNGUSL). This method integrates the spatial layout points of urban structure, road network, block characteristics and building morphology into a network. The importance and potential of UBNGUSL is demonstrated using Jiangbei New Area in Nanjing, China, as a case study. The results show that the spatial layout is most sensitive to block volume ratio and land use. The generated results of Jiangbei New Area present a centrally coherent spatial layout scheme. UBNGUSL can be regarded as a conceptual example of machine learning-assisted urban planning and design, and explores the possibility of applying AI and Machine Learning in the field of urban design.

Keywords

Bayesian network, spatial layout, machine learning, urban design, probabilistic inference

1. Introduction

In recent years, urban planners and decision makers have been using multi-source big data analysis to support the scientific basis of planning decisions. By observing the spatio-temporal distribution of multi-source big data in the city, city managers can get a more refined picture of the operational state of a high-frequency city. However, as Michael Batty points out in his book 'Inventing Future Cities', data-driven urban research is a depiction of the 'current state' of urban development (Batty, 2018). Going back to the original intention of urban design, what we want is to 'create' the 'future vision' of the city. This means that planners' use of data is no longer about inducing spatial 'patterns', but about mining spatial 'intelligence' and applying this 'intelligence' to urban design practice. To this end, this study proposes and tests a concept of "letting data make decisions" using Artificial Intelligence (AI) and Machine Learning (ML) methods.

The spatial layout is usually the starting point for urban design and a fundamental research basis for exploring future urban development. Traditional urban spatial layout requires planners to propose a preliminary "concept proposal" for the overall scope of the design site, aiming to meet the planning objectives and current conditions of urban design, and to support the subsequent three-dimensional design of urban morphology. This process usually requires extensive professional knowledge and repeated experimentation and modification through traditional design methods. It is therefore an empirical and time-consuming process. However, with the diversification of the scale and types of urban construction activities, subjective judgement alone is not sufficient to support the scientific basis of planning. To improve the efficiency of the whole process, scholars have proposed a method of computationally generated design

guidance for spatial layout (Schwartz et al., 2021). This method establishes a comprehensive and universal computational logic and generation process based on computational design methods. The computational generative method for spatial layout design takes the current terrain or site spatial features as a prerequisite condition and uses a constructed specific process to generate a spatial configuration plan for a specific site. Furthermore, this method is often combined with evaluation and iteration methods, such as multi-objective optimization algorithms (Cicek and Turhan, 2022), genetic algorithms (Troiano and Birtolo, 2014), and spatial syntax (Law and Stonor, 2013), in order to find the optimal solution among a large number of possibilities.

Unlike the 'derive' approach of computational design methods, AI and ML design methods propose an 'induction' approach. This method ensures that the generated design solution is consistent with the training dataset by learning the spatial characteristics from a large urban case library (Ye, Du, and Ye, 2021). The method stores the learned urban knowledge in a neural network or probabilistic network as a model, and generates a spatial layout using the model when prediction is required (Quan, 2022). In addition, another advantage of AI and ML design methods over computational design methods is their ability to "generalise". Generalisation refers to the ability of a trained model to make accurate spatial layout predictions for entirely new design conditions (Zaras, Passalis and Tefas, 2022). This means that compared to the stringent requirements of the general computational design process for different site conditions, AI and ML design methods are more robust when faced with unknown design sites. Therefore, although AI and ML design methods have not yet been clearly positioned in the field of urban design, the overall idea can be understood as 'inducing' the inherent rules of spatial layout in massive and complex data samples and 'generalising' them to new site conditions and design solutions.

To better support the design of science-based sustainable urban environments, this study proposes a methodological tool and conceptual framework called Urban Space Layout Guided by Bayesian Network for Urban Spatial Layout (UBNGUSL). This framework integrates key spatial layout elements of urban structure, street networks, block characteristics and building forms. Using the case study of Jiangbei New District in Nanjing, China, this research demonstrates the importance and potential of UBNGUSL. By training and applying a Bayesian network model, this paper generates and visualises the spatial layout of the case study, including volume ratio layout, building density layout, and more. Building on the conceptual framework of UBNGUSL, this paper explores the potential applications of AI and ML in the field of urban planning and design from an interdisciplinary perspective, contributing to the scientific advancement of spatial layout in urban design practice.

2. Methodology

2.1 Study Data

According to the research objective, UBNGUSL is a Bayesian network model that learns spatial layout characteristics from excellent urban built environment cases to predict future spatial layout possibilities. This study used publicly available land use data (from GlobalLand30, http://www.globeland30.org/Page/EN_sysFrame/dataIntroduce.html?columnID=81&head=product&para=product&type=data) and vector datasets of road networks, blocks and buildings (from OpenStreetMap) as research samples. The minimum research unit for urban spatial layout is usually a single block, which serves as an intermediate spatial scale to collect information on the location characteristics of a single block within the whole area and the morphological characteristics of groups of buildings within a single block (Boeing, 2019).

In this paper, Jiangbei New District in Nanjing, China is selected as the study area (Figure 1). Jiangbei New District is an actual project in the planning stage, waiting to be implemented. Before the national policy on the construction of new districts was issued, this case remained in a state of wilderness. Due to its location

in an urban development 'enclave', the authorities found it difficult to envisage the future construction impact of this case. In fact, Jiangbei New District to some extent reflects the construction problems of most new urban districts in China. The lack of a built environment as an urban context leads to an unreasonable planning and construction process, resulting in a serious mismatch between design effects and real needs. The imbalance of spatial layout is only one of many manifestations of this problem, which can also be seen in the mismatch of land use ratios and the misplacement of ecological green spaces (Yue et al., 2019).

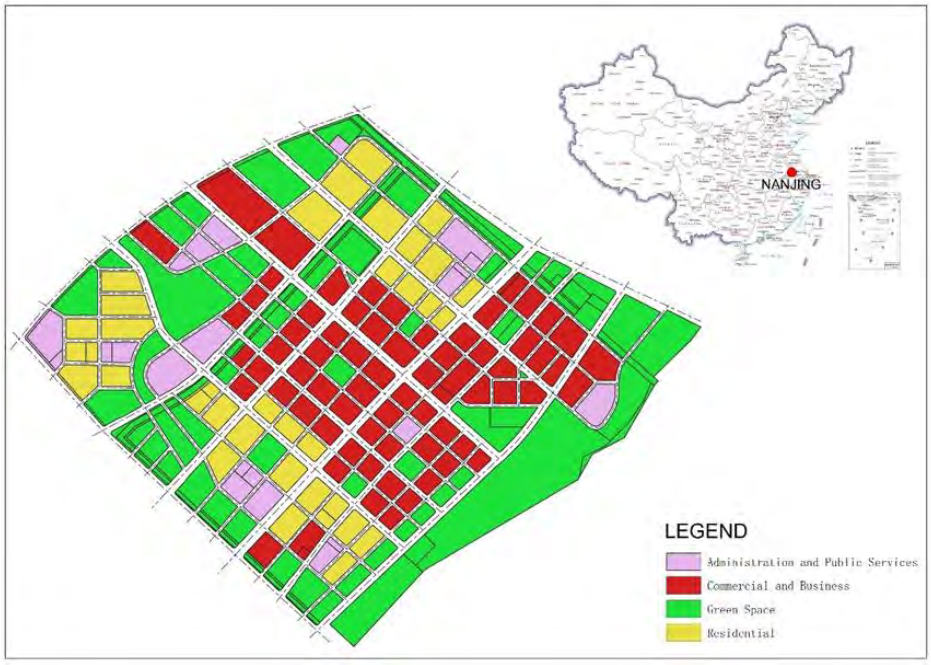

Figure 1. Study area. Different colours represent different land use. Source: Author.

2.2 Conceptual Framework

The purpose of this study is to construct a conceptual framework for machine learning guided urban spatial layout and to summarise the relationship network between different spatial elements in topological urban spatial layout. This conceptual framework will provide the basis for the subsequent construction of the Bayesian network guided urban spatial layout (UBNGUSL) model. The framework consists of (1) the indicator delineation layer, (2) the network building layer, (3) the model training layer, and (4) the prediction generation layer, as shown in Figure 2.

First, the Indicator Delineation layer defines the minimum unit of investigation of the urban spatial layout as a single block. Eighteen block indicators describing the urban spatial layout are proposed, covering both the "global" and "local" dimensions of the block. Second, the network building layer constructs a directed acyclic graph (DAG) with the indicators as nodes based on expert experience and structural learning. As a belief probability model, Bayesian networks consider the possibility of each node in the network under prior information (expert knowledge) when used for prediction and decision making. Third, the machine learning layer trains the model to learn the intelligence and rules of urban spatial layout based on the DAG. Finally, the prediction generation layer uses the trained model to guide the generation of spatial layout for any urban area. The advantage of UBNGUSL is that it can probabilistically infer any other required spatial layout information based on existing information. This means that planners and decision makers can use UBNGUSL to guide the generation of spatial layout for undeveloped urban areas, and to predict the impact of local block adjustments on the overall spatial layout of developed urban areas.

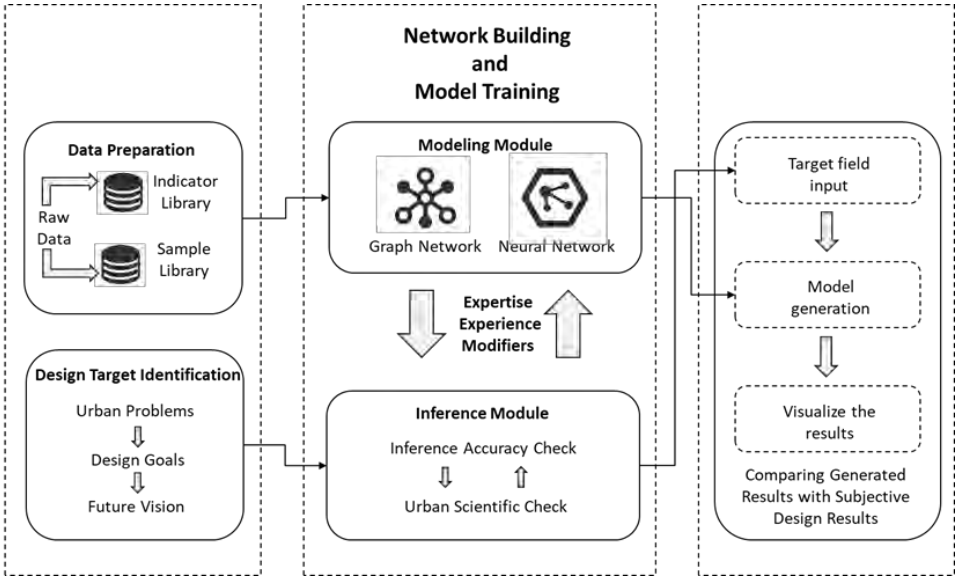

Figure 2. Conceptual Framework. Source: Author.

2.3 Indicator Delineation

According to Feng et al. (2021), the characteristics of different urban spatial layouts are mainly reflected in the differences in the internal morphology of the blocks and the external environmental differences of the blocks. In this study, the indicators are divided into two dimensions: global and local, as shown in Figure 3.

The indicators of the global dimension are used to describe the external characteristics of the research unit in the overall spatial layout, including indicators of the location characteristics of the block, indicators of the adjacent block characteristics, and indicators of the adjacent street characteristics. The local characteristics are divided into two categories: 'Planar Features' and 'Three-Dimensional Features' of the block. Planar feature indicators are used to describe the two-dimensional characteristics of the block's own and internal building layout, such as building density, block area and block boundary. Three-dimensional feature indicators are used to describe the spatial characteristics of the three-dimensional shape of the buildings within the block, such as plot ratio, staggered building height and proportion of high-rise buildings along the street. The specific calculation formulae and sources for each indicator are shown in Table 1.

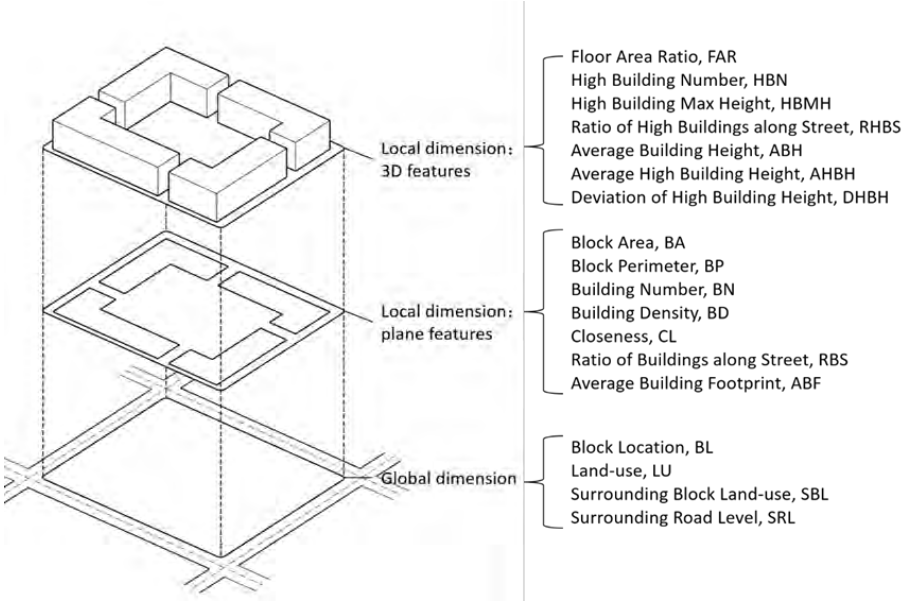

Figure 3. Various indicators contained in different dimensions of UBNGUSL. Source: Author.

Indicator Dimensions		Indicator Name		Description	Calculatio Formula
Global dimension		Block Location	BL	Reflect the location characteristics of the block in the whole area	Number all blocks and store information in the form of an array as a category variable
		Land-use	LU	Block land use type	From GlobalLand30, a Global Land Cover Product from National Geomatics Centre of China (NGCC)
		Surrounding Block Land-use	SBL	Category array of land use surrounding blocks	Statistics
		Surrounding Road Level	SRL	Category array composed of surrounding road grades	Statistics
Local dimension	Planar features	Block Area	BLA	-	Statistics
		Block Perimeter	BLP	-	Statistics
		Building Number	BN	-	Statistics
		Building Density	BD	-	$BD = \frac{\sum_{i=1}^{n} S_{building,i}}{BLA}$
		Closeness	CL	The enclosure of buildings along the street in relation to the whole block	Offset 10 meters inward along the block boundary to form an erosion buffer zone, the proportion of building footprint area in the buffer zone
		Ratio of Buildings along Street	RBS	Ratio of number of buildings along the street to total number of buildings in block.	$RBS = \frac{BN_{along\ street}}{BN}$
		Average Building Footprint	ABF	Average base area of all buildings in the block	$ABFP = \frac{\sum_{i=1}^{n} S_{building,i}}{BN}$
	3D features	Floor Area Ratio	FAR	Reflect the development intensity of the block	$FAR = \frac{\sum_{i=1}^{n} S_{building,i} * N_{floor,i}}{BLA}$
		High Building Number	HBN	Number of buildings with more than 12	Statistics

				floors in the block	
		High Building Max Height	HBMH	Height of the tallest building in the block	$HBMH = \mathrm{Max}(H_{high-building})$
		Ratio of High Buildings along Street	RHBS	Ratio of number of tower buildings along the street to total number of blocks.	$RHBS = \frac{HBN_{along\ street}}{HBN}$
		Average Building Height	ABH	Reflect the overall height characteristic of the building monomers in the block	$ABH = \frac{\sum_{i=1}^{n} BH_i}{BN}$
		Average High Building Height	AHBH	Reflect the characteristic of the overall height of the high-rise buildings in the block.	$AHBH = \frac{\sum_{i=1}^{n} H_{high-building,i}}{HBN}$
		Deviation of High Building Height	DHBH	The standard deviation of the heights of all the skyscrapers in the block reflects the fluctuation and waviness of the height of the skyscrapers in the block.	$DHBH = \sqrt{\frac{\sum_{i=1}^{n}(H_{high-building,i} - AHBH)^2}{HBN}}$

Table 2. The indicator library of UBNGUSL, including description and calculation formula. Source: Author.

2.4 Network Building and Model Training

In the network building layer, this study uses the above indicators as nodes of the UBNGUSL network. In fact, the constructed network structure only represents the representation of the urban spatial layout characteristics reflected by the block, and this network can be either a Bayesian network or a neural network. In this study, the Bayesian network model was chosen partly because it is still widely used in various research fields such as planning and decision support, complex systems modelling, and transportation simulation (Krapu, Stewart, and Rose, 2023).

On the other hand, the Bayesian network model describes the causal relationship between nodes through the relationship between a set of variables and their combined probability distribution, which makes the network structure more understandable and more easily guided by expert knowledge (Abdulkareem et al.,

2019). Compared to neural network models, the Bayesian network structure is relatively concise and less computationally intensive, and the probability relationships between each node usually appear in pairs. This means that when faced with uncertainties in urban spatial layout, other spatial layout features can be predicted based on the existing form information (Wang et al., 2017; Bouzembrak and Marvin, 2019).

In summary, this study focuses mainly on the modelling capability of the Bayesian network, which uses nodes and network structure to deconstruct and describe spatial layout, and the inference capability, which infers unknown spatial layout characteristics based on a credible probability network. In addition, since the indicators proposed in section 2.3 are all directly or indirectly related to the description of urban spatial layout characteristics, this means that all indicators work in the same direction. This is also a prerequisite for constructing a DAG for the Bayesian network. Therefore, the prediction of urban spatial layout by the Bayesian network not only meets the research objectives, but also has theoretical and practical significance.

The construction of a Bayesian network requires two components: (1) a DAG that describes the relationships between indicators, and (2) a conditional probability table (CPT) that describes the strength of the relationships between nodes (Chickering, Heckerman, and Meek, 2012). These two components form the basis of the causal graph used for Bayesian network analysis.

For the DAG, traditional methods for constructing graphs can rely on expert experience or machine learning. However, expert experience can be subjective, and with 18 nodes in this study, the operation can be quite complex. While machine learning is objective and reliable, it can be strongly influenced by the quality of the dataset, leading to problems such as invalid links and overfitting (Kitson et al., 2023). To address this, this study uses machine learning to initially fit the network, and then has experts modify the relationships between local nodes based on their knowledge and experience to obtain the DAG.

In this study, five experts were invited to evaluate and modify the DAG, and their identities and professional backgrounds are shown in Table 2. The training set for this study consists of processed block and building data from Shenzhen Futian New District, Guangzhou Tianhe New District and Shanghai Pudong New Area. Only the block samples within the core area of each new district were selected based on relevant planning, resulting in a total of 436 independent block samples. During the expert modification process, only when all five experts agreed that a particular pair of connection relationships did not exist or was too weak, were these inappropriate pair relationships removed.

Profession	Professional background
professor	Professor of urban planning, has worked in a university in Nanjing for more than 20 years
professor	Professor of geography who has worked in a university for more than 10 years and participated in the preparation of a city's overall plan
Urban Planner	Worked in a class-A urban planning and design research institute, head of department
Urban Designer	Worked in a class-A urban planning and design institute, with more than 20 years of practical experience in urban design
governmental agent	Work in the Bureau of Natural Resources and Planning, with a professional title in urban planning

Table 2. The professional background of the five experts. Source: Author.

The next step is to obtain the relationship parameters of each node in the DAG and construct the CPT. Previous research has often used maximum likelihood estimation (MLE) (Jain and Wang, 2008). While MLE is simple and easy to use, it can lead to overfitting of the data. This means that the training set may not represent the underlying distribution of the data, and MLE is very sensitive to parameter learning for the

CPT (Tsagkanos, 2008). To address this, this study uses Bayesian parameter estimation, which is a method of updating the prior distribution through the likelihood function and the observed data to obtain a relatively reliable posterior distribution (Jaakkola and Jordan, 2000). The entire process of Bayesian parameter learning in this study is performed using the bnlearn package in Python.

After obtaining the DAG and CPT, this study divided the sample set into an 80% training set and a 20% test set for model training. It should be noted that given the large payload required to compute the pairwise probability relationship between continuous variables, this study performed one-hot encoding on the floating-point data indicators in the indicator library to discretize them for ease of computation and explanation.

2.5 Prediction Generation

The previous analysis used the modelling capability of Bayesian networks to investigate urban spatial layout. This approach involves calculating the probability distribution of a set of variables determined by variable observations from the training set and prior knowledge. However, the focus of UBNGUSL is on the inference capability of Bayesian networks in predicting the future state of urban spatial layout. Bayesian network inference uses the posterior probability of the target node based on the connection relationships of nodes in the directed acyclic graph (DAG) and the prior probability of the conditional probability table (CPT). By using the inference capability, we can evaluate the accuracy of the Bayesian network model using real test datasets (Oniśko and Druzdzel, 2013).

$$Accuracy = \frac{\sum_{i=1}^{n} N_{inference,i}}{\sum_{i=1}^{n} N_{test,i}}$$

Specifically, the trained model infers the numerical category corresponding to the maximum likelihood value of each node in the inference network and compares it to the true test set to determine the proportion of correct predictions. Previous research has shown that a model's inference on a corresponding node is considered credible if its accuracy is generally greater than 0.7 (Constantinou and Fenton, 2018).

Assuming that the accuracy test of the model is credible, we can use the Bayesian network model to predict the uncertainty of the spatial layout of the site using the known information of the site. In the case of this paper, UBNGUSL learned the characteristics of the sample urban spatial layout and used this information to predict the spatial layout possibility of the empty blocks in Jiangbei New District. Furthermore, it can also verify the rationality of the existing planning spatial layout schemes.

3. Results and Discussion

3.1 UBNGUSL Network Results

Following the methodology outlined in Section 2.3, machine learning was performed on the training dataset to obtain the DAG of UBNGUSL, as shown in Figure 4, which reveals the complex relationships between the spatial layout features. In this paper, four methods were used for structure learning, namely exhaustive search, hill-climbing search, Chow-Liu tree and tree augmented naive Bayesian. The results showed that the structural relationships of the first three methods were not ideal, with fragmented network relationships and uncorrelated subnetworks observed (Figure 4a, Figure 4b, Figure 4c). Figure 4d shows the network structure induced by the Tree Augmented Naive Bayesian method, which is more realistic and shows stronger overall network integrity than the other methods. The results also showed that the Land Use (LU) indicator was identified as the dominant centre of the network, with most indicators being determined based on LU.

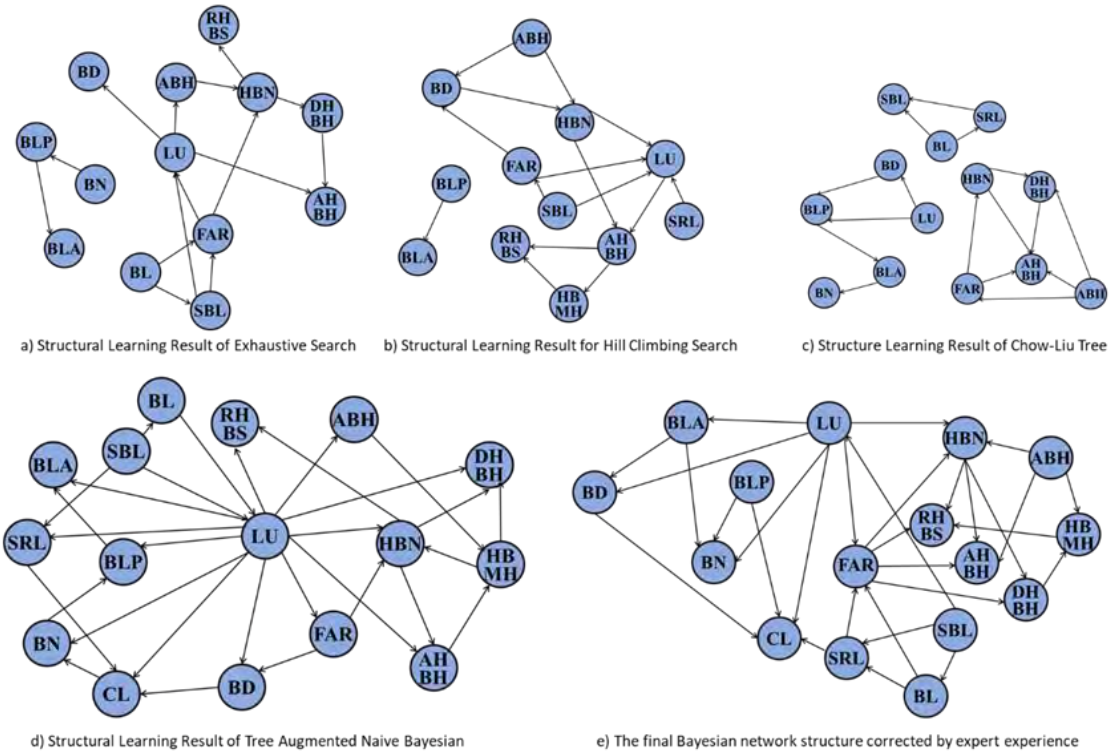

Figure 4. DAG of Bayesian Networks via Structure Learning and Expert Correction. Source: Author.

The DAG of UBNGUSL after expert experience correction is shown in Figure 4e. To prevent the subjectivity of expert knowledge from affecting the objectivity of the structural relationships learned from the training data, Figure 5 shows the confusion matrix between the DAG learned by the Tree Augmented Naive Bayesian method and the final DAG after expert experience correction. The comparison showed a correlation of 86.78% between the two, indicating that the expert experience correction did not significantly alter the original machine learning network. The Bayesian Information Criterion (BIC) values of the two DAGs were also compared, with the expert-corrected DAG having a lower structural score (-4461 versus -2543). As a result, this work ultimately confirmed Figure 4e as the DAG used for UBNGUSL and as the basis for CPT parameter learning.

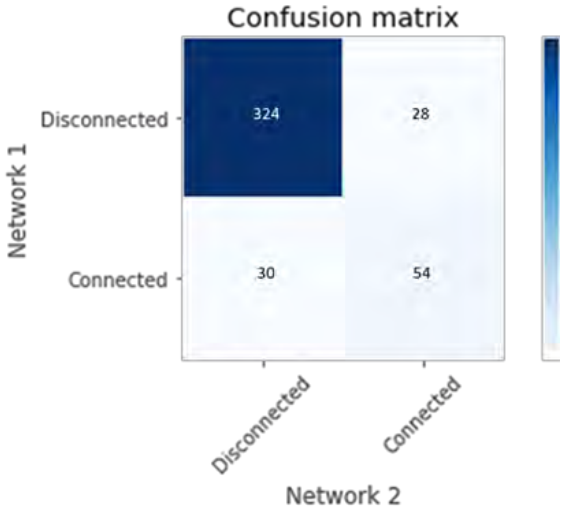

Figure 5. Confusion matrix for comparison between the network obtained by Tree Augmented Naive Bayesian and the network corrected by experts. Source: Author.

Due to the internal correlations of each node, the final network of UBNGUSL is complex. FAR and LU serve as dominant centres of the network and act as intermediaries in causal relationships. Other indicators are influenced by both FAR and LU and are closely related to them. The results show that the dimensionality of the indicators we defined, namely global features, local planar features and local three-dimensional features, have a close internal relationship and mutual causality. The influence between indicators across dimensions mainly depends on the indirect influence of FAR and LU on the whole spatial layout system. This suggests that our dimensionality division and indicator selection have both theoretical and practical significance. However, it should be noted that the networks in Figure 3d and Figure 3e do not include the indicator nodes RBS and ABF. This is because we found a high correlation between the RBS and CL indicators in the previous correlation analysis, and ABF is highly correlated with several indicators. This suggests that these two indicators can be substituted in the network.

3.2 Spatial Layout Prediction of Nanjing Jiangbei New District

Table 3 shows the accuracy results of testing the UBNGUSL network using a 20% test set. Since global indicators and block shape indicators (such as BLA and BLP) are prerequisites for spatial layout prediction (spatial layout features on empty blocks can only be predicted if the block is given), the accuracy of these indicator nodes does not need to be calculated. The results show that the accuracy of the BD, CL and FAR measurements is slightly lower. This may be due to the wide range of continuous values for these three indicators, but the classification categories are limited during discretisation, resulting in lower prediction accuracy (Nojavan A., Qian and Stow, 2017).

Indicators	BL	SBL	SRL	LU	BLA	BLP	BN	BD	CL	FAR	RHBS	HBN	AHBH	ABH	HBMH	DHBH
Accuracy	-	-	-	-	-	-	0.85	0.65	0.62	0.74	1	0.94	0.97	0.77	0.83	0.97

Table 3. Prediction accuracy of each indicator of UBNGUSL network based on 20% test set. Source: Author.

Overall, the results of the UBNGUSL network model are satisfactory. We then applied the model to an actual planning case in the Jiangbei New District of Nanjing. We used data on planned roads, blocks and land use in Jiangbei New District provided by the local Natural Resources Bureau, which has been made public. Figure 6 shows the distribution of the remaining ten spatial layout indicators generated by UBNGUSL in Jiangbei New District.

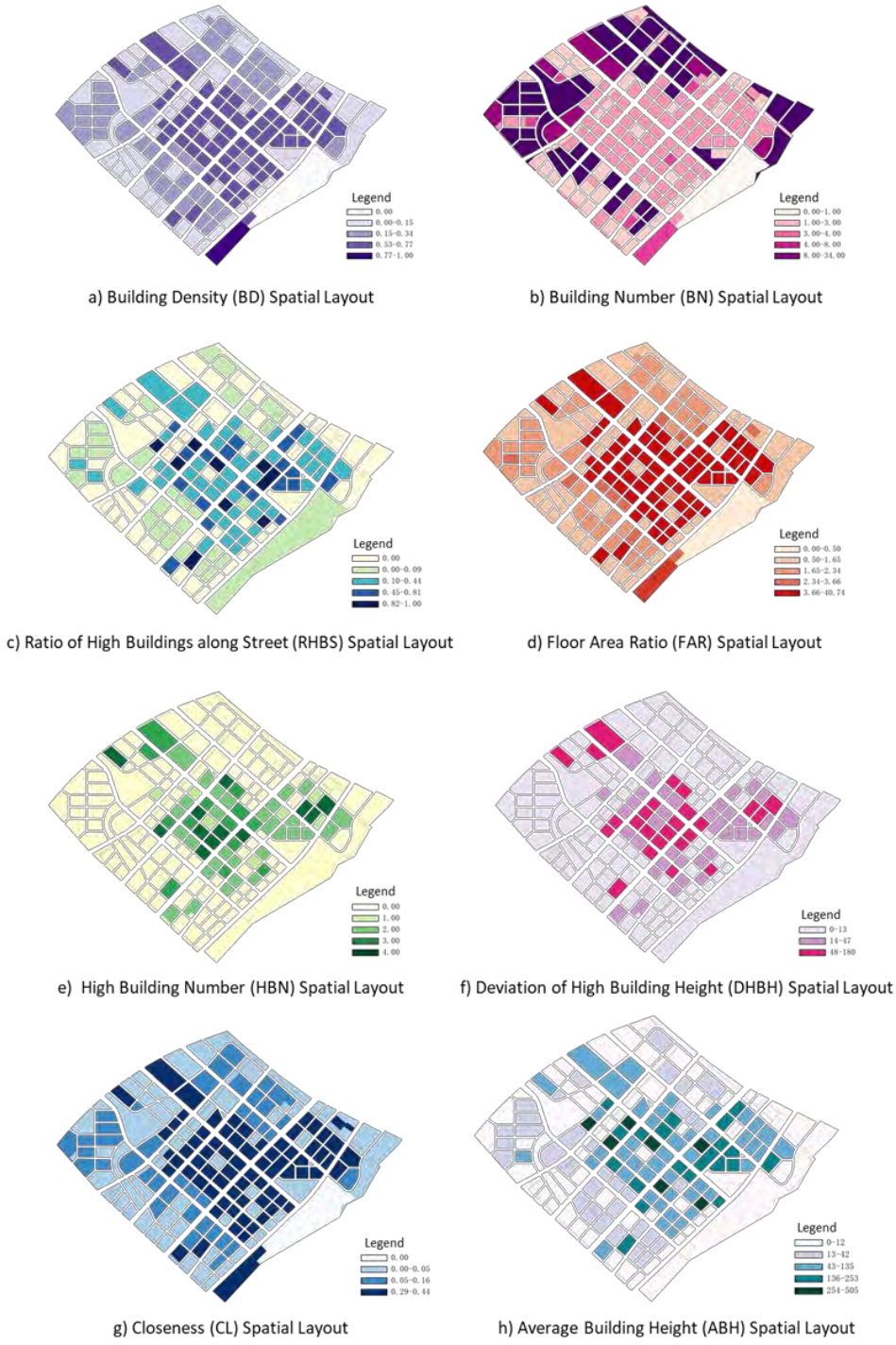

Figure 6. Spatial layout of Jiangbei New District predicted by UBNGUSL. Source: Author.

The results show that UBNGUSL has generated a centrally coherent spatial layout scheme in Jiangbei New District (hereafter referred to as the Scheme). The construction intensity of the scheme is mainly concentrated in the commercial blocks located in the geometric centre of the entire project area. The residential blocks surrounding the centre have a lower construction intensity, and a large number of residential buildings lead to higher BN indicator values (Figure 6b). In addition, Figures 6f and 6g show that UBNGUSL provides detailed design guidance for organising building layouts in both 3D and 2D space. This suggests that UBNGUSL is not just a tool for predicting development intensity based on economic development budgets, nor just a drawing tool for urban planning, but can also provide specific guidance for further detailed urban design.

4. Conclusion

This paper proposes a framework for Using Bayesian Networks to Guide Urban Spatial Layout (UBNGUSL), which includes four layers: Indicator Delineation, Network Building, Model Training and Prediction Generation. This framework can be seen as a conceptual example of machine learning based urban planning and design. The proposal of this framework indirectly proves that the combination of the two is not completely left to the computer to complete the design with powerful computing power, but is guided and corrected by the professional knowledge of planners to help achieve the goals.

This paper uses 436 sets of real block data (80% for training and 20% for testing) to build the Bayesian network model. The DAG of the model shows that spatial layout features are most sensitive to block volume ratio and land use. The accuracy test results of the model are generally higher than 0.7. The visualisation results of the spatial layout predicted by the model show that UBNGUSL not only learns the features of the sample urban spatial layouts, but also provides a reasonable spatial layout solution for Jiangbei New Area. The practical advantages of UBNGUSL are not only that it can provide planning guidance for spatial layout in existing empty blocks, but also that it can automatically arrange suitable blocks based on the three-dimensional construction intention. This means that UBNGUSL can not only help designers explore more detailed possibilities, but also help decision-makers check the rationality of planning schemes.

However, there are inherent limitations in the conceptual framework of machine learning-assisted urban design. Taking the UBNGUSL studied in this paper as an example, the sample library used for model training is the actual urban built environment. The key points of urban construction are not only considered from a single planning perspective. In other words, due to the appeals of multiple stakeholders, the actual construction results of the city may be far from the design plan. In addition, it is unknown whether the problem of the current spatial layout will also be learned by the machine. Therefore, whether the pattern library of UBNGUSL needs to be used for planning and design schemes may be an improvement possibility for future research. Finally, the "creativity" of machine learning or artificial intelligence is essentially a "creative imitation". Whether this conflicts with the concept of "creating cities" in urban design itself will be a key point of discussion in the field in the future.

5. References

Abdulkareem, S.A. et al. (2019) 'Bayesian networks for spatial learning: a workflow on using limited survey data for intelligent learning in spatial agent-based models', GeoInformatica, 23(2), pp. 243–268. Available at: https://doi.org/10.1007/S10707-019-00347-0/FIGURES/8.

Batty, M. (2018) 'Inventing Future Cities', Inventing Future Cities [Preprint]. Available at: https://doi.org/10.7551/MITPRESS/11923.001.0001.

Boeing, G. (2019) 'Urban spatial order: street network orientation, configuration, and entropy', Applied Network Science, 4(1), pp. 1–19. Available at: https://doi.org/10.1007/S41109-019-0189-1/FIGURES/7.

Bouzembrak, Y. and Marvin, H.J.P. (2019) 'Impact of drivers of change, including climatic factors, on the occurrence of chemical food safety hazards in fruits and vegetables: A Bayesian Network approach', Food Control, 97, pp. 67–76. Available at: https://doi.org/10.1016/J.FOODCONT.2018.10.021.

Chickering, D.M., Heckerman, D. and Meek, C. (2012) 'Large-Sample Learning of Bayesian Networks is NP-Hard', Journal of Machine Learning Research, 5, pp. 1287–1330. Available at: https://arxiv.org/abs/1212.2468v1 (Accessed: 16 July 2023).

Cicek, S. and Turhan, G.D. (2022) 'Computational generation of a spatial layout through syntactical evaluation and multi-objective evolutionary optimization', https://doi.org/10.1177/14780771221120576, 20(3), pp. 610–629. Available at: https://doi.org/10.1177/14780771221120576.

Constantinou, A.C. and Fenton, N. (2018) 'Things to know about Bayesian Networks: Decisions under Uncertainty, Part 2', Significance, 15(2), pp. 19–23. Available at: https://doi.org/10.1111/J.1740-9713.2018.01126.X.

Feng, W. et al. (2021) 'Optimization Strategy of Traditional Block Form Based on Field Investigation—A Case Study of Xi'an Baxian'an, China', International Journal of Environmental Research and Public Health, 18(20). Available at: https://doi.org/10.3390/IJERPH182010895.

Jaakkola, T.S. and Jordan, M.I. (2000) 'Bayesian parameter estimation via variational methods', Statistics and Computing, 10(1), pp. 25–37. Available at: https://doi.org/10.1023/A:1008932416310/METRICS.

Jain, R.B. and Wang, R.Y. (2008) 'Limitations of Maximum Likelihood Estimation Procedures When a Majority of the Observations Are Below the Limit of Detection', Analytical Chemistry, 80(12), pp. 4767–4772. Available at: https://doi.org/10.1021/AC8003743.

Kitson, N.K. et al. (2023) 'A survey of Bayesian Network structure learning', Artificial Intelligence Review, 56(8), pp. 8721–8814. Available at: https://doi.org/10.1007/S10462-022-10351-W/FIGURES/20.

Krapu, C., Stewart, R. and Rose, A. (2023) 'A Review of Bayesian Networks for Spatial Data', ACM Transactions on Spatial Algorithms and Systems, 9(1). Available at: https://doi.org/10.1145/3516523.

Law, S. and Stonor, T. (2013) 'URBAN VALUE : Measuring the impact of spatial layout design using space syntax 061'.

Nojavan A., F., Qian, S.S. and Stow, C.A. (2017) 'Comparative analysis of discretization methods in Bayesian networks', Environmental Modelling & Software, 87, pp. 64–71. Available at: https://doi.org/10.1016/J.ENVSOFT.2016.10.007.

Oniśko, A. and Druzdzel, M.J. (2013) 'Impact of precision of Bayesian networks parameters on accuracy of medical diagnostic systems', Artificial intelligence in medicine, 57(3), p. 197. Available at: https://doi.org/10.1016/J.ARTMED.2013.01.004.

Quan, S.J. (2022) 'Urban-GAN: An artificial intelligence-aided computation system for plural urban design', https://doi.org/10.1177/23998083221100550, 49(9), pp. 2500–2515. Available at: https://doi.org/10.1177/23998083221100550.

Schwartz, Y. et al. (2021) 'A decision support tool for building design: An integrated generative design, optimisation and life cycle performance approach', International Journal of Architectural Computing, 19(3), pp. 401–430. Available at: https://doi.org/10.1177/1478077121999802/ASSET/IMAGES/LARGE/10.1177_1478077121999802-FIG15.JPEG.

Troiano, L. and Birtolo, C. (2014) 'Genetic algorithms supporting generative design of user interfaces: Examples', Information Sciences, 259, pp. 433–451. Available at: https://doi.org/10.1016/J.INS.2012.01.006.

Tsagkanos, A. (2008) 'The Bootstrap Maximum Likelihood Estimator: the case of logit', http://dx.doi.org/10.1080/17446540701604309, 4(3), pp. 209–212. Available at: https://doi.org/10.1080/17446540701604309.

Wang, W. et al. (2017) 'Failure probability analysis of the urban buried gas pipelines using Bayesian networks', Process Safety and Environmental Protection, 111, pp. 678–686. Available at: https://doi.org/10.1016/J.PSEP.2017.08.040.

Ye, X., Du, J. and Ye, Y. (2021) 'MasterplanGAN: Facilitating the smart rendering of urban master plans via generative adversarial networks', https://doi.org/10.1177/23998083211023516, 49(3), pp. 794–814. Available at: https://doi.org/10.1177/23998083211023516.

Yue, W. et al. (2019) 'Mismatch of morphological and functional polycentricity in Chinese cities: An evidence from land development and functional linkage', Land Use Policy, 88, p. 104176. Available at: https://doi.org/10.1016/J.LANDUSEPOL.2019.104176.

Zaras, A., Passalis, N. and Tefas, A. (2022) 'Neural networks and backpropagation', Deep Learning for Robot Perception and Cognition, pp. 17–34. Available at: https://doi.org/10.1016/B978-0-32-385787-1.00007-5.

Papers undergoing Peer-review Programme

TRACK 1:
ACKNOWLEDGE community values

Study on the Evolution of Green Space and Ecosystem Service Value in International Metropolis —— Taking Beijing as an Example

DU Jianing, LI Jiayan, LIN Ye, SHAO Ming, TAO Peiyuan, YAO Peng

As the political, cultural and scientific center of China and the forerunner of the transformation of Chinese cities to sustainable development, Beijing has important practical value to explore the evolution characteristics of its urban green space. This study analyzed the spatio-temporal changes of landscape pattern and key indicators of ecosystem service value in Beijing Plain region from 2011 to 2019, and the spatial variation of their correlation coefficients. This paper reveals the correlation between the evolution of green space pattern and ecosystem, especially discusses the influence mechanism of green space in megacities from street scale.

Healthy Urban morphology Construction in Guangzhou, China: a fringe belts perspective

HE Siliang

This study aims to investigate the advantages of fringe belts for biodiversity. Fringe belt is an important concept of the British Conzen School. It is a former urban fringe zone that possesses historical traits. The fringe belts' considerable openness and low housing density give them high ecological and cultural importance. The study focuses on Guangzhou, a supercity in South China, and the fringe belt phenomena there. Drawings of fringe belts over the past century were studied for their ecological and historical properties. It is established that the city's fringe belts are beneficial to its natural resources.

The thermal environmental characteristics and climate-responsive planning of "Rural Communities" in severe cold regions: Evidence from Zhangjiakou, China

CHENG Qi, CHENG Wen, LU Ming, SHA Shiyan

With rapid urbanization, the issues of rural community hollowing and habitat deterioration have emerged. These problems are even more complex in cold regions, where the cold climate hampers sustainable development. This study explores the spatio-temporal characteristics and impact mechanism of thermal environments in typical rural communities in cold regions, aiming to inspire similar planning worldwide. Findings include: (1) The thermal environment is influenced by internal and external factors. (2) Improving thermal environment and comfort in cold areas requires a comprehensive perspective. (3) Resilience of rural communities necessitates integration of industrial systems, functional development, and coordinated spatial deployment.

Characteristics of "Flash Mob" behavior and cultural transmission in public space based on an inclusive perspective: Evidence from Tianjin City, China

CHENG Qi, CHENG Wen, LU Ming, SHA Shiyan

In the Network Society, cultural dissemination is vital for enhancing influence. "Flash mobs" and spontaneous performance art efficiently spread culture and address social needs. These activities are key in cultural dissemination, especially in Tianjin's Haihe River outdoor public spaces. Using surveys, analysis, and data, eight popular "flash mob" spaces were evaluated for accessibility, comfort, convenience, and popularity. Typologies based on characteristics and users were classified, and the relationship between cultural communication and public space types was examined. This study explores how built environments impact "flash mob" occurrences and cultural dissemination, informing urban planning and policy governance for social vitality.

Managing Urban Flood Risk: A Comparative Study of Planning Strategies in Jakarta and Chennai

KAMAT Rajshree, KORI Purnima

Urban floods are a recurring problem worldwide. These floods occur when heavy rainfall exceeds the drainage capacity of urban areas due to climate change and urbanization. The objective of this paper is to study the planning strategies for Jakarta and Chennai and to identify the factors that influences the urban flood risk in these two cities. To mitigate the impact of urban floods, cities are implementing various planning tools such as zoning, flood-proofing, and building flood walls. However, the effectiveness of these measures requires ongoing evaluation to ensure that they are adequately addressing the challenges posed by urban floods.

Role of Government in Facilitating Migration from Coastal Areas: Case of Kerala, India

JENNATH Aysha, PAUL Saikat

Population mobility is expected to be a significant consequence of climate change. The role of governments in facilitating migration is crucial, especially in coastal areas. A comprehensive study was conducted in Kerala, a state in India grappling with severe coastal environment issues to examine the government's role on migration decisions, residents' willingness to migrate in the future, and the permanence of migration among current migrants. Findings revealed that coastal protection effectiveness and post-disaster relief influenced migration decisions. Residents in well-protected areas had lower willingness to migrate, while government-provided housing increased permanent migration likelihood for migrants.

Financing Urban Greening in Jakarta: The Promise and Challenges of Land Value Capture in TOD Areas

FATMA Dyah, SETIAWAN P Julianti, WIBOWO Gito

Jakarta faces challenges in providing green spaces due to limited available land and private ownership. To address this, the city adopted Urban Design Guidelines (UDG) for Transit-Oriented Development (TOD) areas. However, UDG implementation encounters obstacles such as financing, regulation, and stakeholder cooperation. This study aims to bridge these gaps through comprehensive literature and empirical studies, exploring Land Value Capture as a potential option to improve green space provision in TOD areas in Jakarta. By doing so, the research seeks to enhance the integration of green spaces into the city's spatial planning instruments and improve residents' access to natural environments.

Research on low energy consumption design strategies of high-speed railway hub space in cold regions under the guidance of climate adaptation

LIU Wenqian, LIU Yibo, ZHAO Chuanlong

This research starts with the climate characteristics of cold regions,clarifies the key factors that affect the energy consumption level of high-speed railway hubs in cold regions. Then from the three levels of site space, building functional space, and spatial enclosure structure details of high-speed railway hubs, the low energy consumption design strategies for regulating site microclimate, optimizing functional space organization for energy management, and improving the climate adaptation performance of spatial enclosure structure are proposed, aiming to provide ideas and references for effectively reducing the operational energy consumption of high-speed railway hubs in cold regions.

Exploring the Understanding of Community Resilience in Urban China

CHEN Binqing, JIN Tongfei, QU Jiping

The past few decades have seen significant transformation in urban China from various perspectives. These processes have led to significant changes to planning system, shifting from an incremental approach to a 'stock-based' one. Here, co-productive community regeneration has been an approach to pursue community resilience in both policy and practice aspects. However, there is a lack of resilience from the theoretical perspective. By discussing the resilience concept development in social science, resilience thinking in urban planning and urban transformation in China, this paper aims to put forward an initial framework to help to understand and evaluate community resilience.

The Identification of Cultural Scene Characteristics in the Harbin Historic Urban Area from the Perspective of Spatial Perception

DAI Jian, QIU ZhiYong, WANG Yue

In this study, with the help of the cultural value research framework of "scene" and the metaphor extraction technique, we qualitatively analyzed the spatial perception of the crowd in the scene, to excavate the characteristics of the cultural value of the Nangang Historic District.The results show that crowd perception emphasizes "rationality, locality and nationality" in the authenticity dimension, and "charisma of leaders" and "charisma and formality" are more involved in the legitimacy dimension and the drama dimension. The "charisma of the leader" under the legitimacy dimension and "charismatic and formal" under the theatricality dimension are more involved.

Construction of Recreation Opportunity Spectrum of Waterfront Space along Songhua River in Harbin

DAI Jian, LU Zhengran, WANG Xiaoxia

This paper takes the waterfront space of the Binzhou-Dongjiang Bridge Section of Songhua River as the research object. Based on three elements of ROS including recreation environment, activities, and experience, ROS of Songhua River is summarized as recreation opportunity points, activities, and experience routes. By studying the current recreation opportunity points and activities of the waterfront space, we divide recreation experience routes of waterfront space into four types: natural ecotype, leisure vitality , historical style, and abutment viewing to update recreation space and provide a reference for the allocation of resources and spatial renewal of waterfront space along Songhua.

Research on Adaptive Planning Strategy for Urban Recreational Service Units based on Multi-age Demands

ZHOU Jingling

Urban recreational facilities should align with diverse age groups' demands while adhering to organizational principles. This study analyzes Shanghai's downtown area and finds that different recreational formats exhibit distinct interaction forces, resulting in multi core radiation and single core aggregation spatial patterns. Children prioritize physical exercise and shopping, young adults prefer spiritual and historical sightseeing and outdoor recreation, and older adults focus on personal care and physical exercise. Optimization strategies for catering to multi age demands are proposed, including balance, hierarchy, and diversity principles and formed a model of the recreational service unit(RSU).

The Relationship between the Built Environment and Childhood Obesity in London: A Geospatial Interpretation Approach for the Healthy Cities Research

CAI Jiyao, SUN Haocheng

Childhood obesity is one of the prominent problems in the field of Healthy City. At present, the lack of analysis on the mechanism of "obesogenic" caused by the built environment in relevant research leads to the difficulty of effective intervention in healthy urban planning. Based on the open population census and point of interest data, this paper uses spatial autocorrelation and geographically weighted regression methods to construct an analytical framework for the correlation effect between built environment and childhood obesity, and conducts an empirical study in Greater London.

A fuzzy-logic-based decision support system for resilient smart city planning

CHATTOPADHYAY Subrata, DHINGRA Mani, SUR Sourav

The study develops an intelligent decision-support-system to quantify the inherent smartness quotient of a traditional urban system in India. It emphasizes the importance of integrating complex ecosystems of people, their institutions, and heritage and advocates transdisciplinary soft computational techniques for resilient smart city planning. Four levels are identified for the hierarchical evaluation of households' responses within the delineated area of Alwar walled city, further advanced to train and optimize a fuzzy inference system. Application of partial compensatory approach, fuzzy linguistic variables, and non linear optimization enhances the readability, and replicability of the model for making informed decisions.

Explore the community carbon emission characteristics and control strategy through family carbon footprint

WU Yueyue

As the basic cell of the community, the direct or indirect carbon emissions produced by households in their daily life account for 70% of the total global CO2 emissions. Therefore, it is of great significance to promote urban carbon neutrality by studying the characteristics of household carbon emissions. This study starts from the perspective of family daily life behavior, and focuses on the household carbon footprints from two aspects: the analysis of carbon emission characteristics and the implementation strategy of low-carbon optimization. In this study, the concept of household carbon footprint is proposed and resolved into four subsystems: building energy, transportation, waste and vegetation. Then, a community carbon emission measurement method based on multi-source data and GISpro platform is constructed and practiced in Yuejianglou community. This study produced a community map of family carbon footprints and found that the main family carbon footprint come from building power consumption, and the gap between community carbon emissions and carbon absorption is relatively large in terms of total amount. Meanwhile, the carbon emission patterns of different households are quite different in terms of time fluctuations. Therefore, for the types of families with different carbon footprint characteristics, the research proposes spatial carbon reduction policies.

Research on climate adaptive spatial planning strategy and governance mechanism: the case of Hokkaido, Japan

WANG Shuyu, YI Xiaoxiang, ZHANG Haoping

Continued global climate change poses challenges to social development, and the integration of climate change adaptation into spatial planning to improve the adaptive capacity of cities has become one of the important issues in global urban development. Taking Hokkaido, Japan as the research object, we will sort out the spatial strategies and governance paths adopted by Hokkaido in adapting to climate change, propose spatial development strategies for planners, or policymakers to adapt to climate change in spatial planning and management, and help multiple actors to form a collaborative governance mechanism to jointly build sustainable, resilient and inclusive cities.

Adaptation design of park urban community to climate change: a case study of the Jiaotzi Park Community in Chengdu

XIAO Qingnan

In response to carbon peak and carbon neutrality goals, future communities in park cities must adapt to climate change while fostering economic growth. The Jiaozi Park community in Chengdu, serving as the city's financial core, exemplifies this need. Through an environmental characterization approach, it proposes solutions focused on connectivity, water management, ventilation, and shared spaces. By prioritizing these aspects, Jiaozi Park aims to create a sustainable and resilient urban environment that addresses climate challenges and supports economic development. This holistic strategy integrates environmental and socio-economic considerations in park city development.

Spatial assessment of flood susceptibility for three geographic locations in Assam, India: Application of MaxEnt model, a machine learning approach

CHETIA Leena, PAUL Kumar Saikat

The study aims to understand the variation of flood susceptibility in Barpeta district, Assam, India; and achieved with the application of MaxEnt Model, and geographic information system (GIS). For this, a flood inventory of 110 occurrence points and six flood conditioning factors: elevation, slope, distance from river, Topographic Wetness Index (TWI), rainfall, and Land Use Land Cover (LULC) were considered. Occurrence data was divided into 70% and 30% for model building and validation purposes. The model showed an accuracy of 77.6%. It is observed that the central zone of the district from East to West is highly susceptible to flooding.

Enlightenment of resilient community building in Japan to China

LU Siyu

In the face of the various risks posed by climate change, the construction and development of cities require resilience. Japan's multi-hazard environment has enabled it to gradually establish an advanced resilient community building system. Taking the post-disaster reconstruction of Kobe Rokkaido Station in Japan as a research object, this paper analyzes its resilient community construction strategies from four aspects: environment, system, individual, and society, and puts forward suggestions in combination with the current situation of China's resilient community construction, intending to provide specific methodological references to China's resilient community construction.

Report on the Evaluation of Shared Bicycle Experience to Reduce Air Pollution and Traffic in Tehran, Iran

ASGARI Atiyeh, DAROUDI Mohammadreza

Tehran, as the capital of Iran, has faced rapid urbanization and a significant increase in traffic volume, leading to unprecedented air pollution. Tehran ranks among the top 10 most polluted cities globally. This report examines the implementation process of the shared bicycle system in Tehran over the past six years, from 2017 to 2022. Over the past decade, Tehran Municipality has emphasized citizens' use of bicycles for sustainable development. However, several obstacles, such as inadequate cycling infrastructure, social barriers, and various threats, have hindered the success of this system. Despite these challenges, the municipality has undertaken numerous measures, documented in plans and programs, to improve the position of bicycles and overcome these obstacles. The report reviews Tehran's experience implementing the shared bicycle system and aims to provide valuable insights into addressing air pollution and traffic issues. This report can serve as a guiding light for other cities worldwide by sharing lessons learned.

Leveraging on Land Value Capture Tools (LVCT) As An Alternative Means of Infrastructure Financing in Ondo State, Nigeria

ALONGE Oloyede Zachariah, AMODU Idowu, MODEBOLA-FADIMINE Tokunbo Funmilayo, OGUNDIPE Samuel, TOFOWOMO Abimbola

The level of city expansion across the globe, particularly in sub-Saharan Africa is not commensurate with the existing infrastructural facilities. One of the many obligations of governments is to ensure the functionality, liveability, and sustainability of cities for the benefit of its citizens through the provision of sustainable infrastructure and the maintenance of existing ones. Land Value Capture Tools (LVCT) has been presented as an alternative source of infrastructural financing in Ondo State however, the LVCT implementation is being influenced negatively by certain factors, among which is the Institutional Structure of the Ministry of Physical Planning and Urban Development.

Examining Sensitivity between Air Pollution and Land uses to Conform Climate Responsive Planning in Lahore

AZIZ Amer, KHAN Ullah Sana M

Remorseless air pollution has threatened the fragile environment of our cities and traditional policies initiatives have failed to combat it. revamping urban planning for the revitalization of urban air quality is the need of the day. The innovative urban planning strategies: the power of mixed land use can contribute significantly to controlling air pollution. Furthermore, it is a great initiative to conform climate response planning in Lahore. Receiver Operating Curve (ROC) analysis has been used to verify an in-depth effect of mixed land uses of air quality indices. The paper suggests policy measures for the adoption of climate response spatial development.

Study on the development of the synergy of a hydraulic community in flood management: the case of Sangyuanwei hydraulic community in the Pearl River Delta, China

YUAN Qifeng, ZENG Yue

To combat flooding, the Pearl River Delta has seen the formation of many hydraulic communities, of which Sangyuanwei is a typical example. From the earliest reliance on community self-organisation; to the gentry as managers, with the state allocating funds to use its interest to maintain the embankment; to the solicitation of donations from large Guangzhou companies because of their silk trade; to the current multi-funding approaches of social capital, bank loans and government funding, this case is a valuable reference not only for areas facing the same risks, but especially in today's general economic slowdown.

Planning and design of ecological protection and restoration of Lengshui Creek small watershed in Lengshui Town, Chongqing supported by ecosystem management concept

YAO Chungui

The planning and design of ecological conservation and restoration of small watersheds is aimed at maintaining the sustainability of ecosystem integrity and species diversity, following four major principles: respecting nature and giving priority to ecology, maintaining ecological integrity and harmonizing development, combining the current situation and adapting to local conditions, and coordinating the future and rationally utilizing the resources. It proposes three ecological protection and restoration strategies: withdrawing from low utility land and increasing the ecological area, optimizing the green space system and building green industries and promoting natural ecology and enhancing the rural landscape.

Winter Assessment of Indoor Air Quality of Middle-Income Households in Kolkata, India

BEDI Kaur Tanya, BHATTACHARYA Pratim Shankha

Indoor air pollution is a growing concern, as it poses health risks and far-reaching economic consequences. The vulnerability and level of impact crucially depend upon the economic status of the society and individuals. The study selectively targets the middle-income group that constitutes the major share of the population in India. Detailed indoor air quality audits were conducted in residential buildings located in different neighbourhoods in Kolkata, the second most polluted mega-city in India after Delhi. The study attempts to study indoor air quality in detail and demonstrate the relationship between indoor pollutant concentration and building-related aspects.

Inclusive Height Control of Historic Urban Areas Based on Multi-dimensional Needs: A Case Study of Suzhou Ancient City

YANG Jianqiang, YANG Zihan, ZHOU Mi

Through the analysis of current problems, realistic development needs and sustainable development background of historic urban areas, this study finds out the realistic problem that the current building height control planning method has shackled the development of historic urban areas. Therefore, from viewpoint and corridor adjustment, height sensitivity analysis, and the effect simulation of building height adjustment on micro wind and thermal environment, the paper proposes to build a rigid-elastic combined building height control system of "landscape corridor control + high sensitivity analysis + microclimate adjustment" based on the perspective of multi-dimensional development needs of historic urban areas.

Sweat equity in green finance to achieve sustainable urban housing

QUINTANA MALUBAY Jacklyn Haydee

In the current “flat world” of divergent economies wallowing in social tensions and geopolitical strife, UN Secretary General Antonio Guterres declared that “the world is on a catastrophic pathway.” The pace of change intensifies. Most global challenges are systemic, to wit: energy at a tipping point, income inequality, one-eighth of the world population lives in unsustainable urban housing largely unfit for human habitation, among many others. Given these, quo vadis? Ultimately, the aim is to create equitable places and communities that support HUMAN FLOURISHING. But how will the world get there? Global recovery is taking place, albeit asynchronously. This is not an ideal setup but it is acceptable as long as “no one will be left behind.” The ideal to work and fight for is financial inclusion. This paper highlights the critical importance of assigning financial value to SWEAT EQUITY. This provides a “tectonic shift” in perspective. This can truly transform the economic landscape. This will push the envelope for GREEN FINANCE, the proverbial “silver” bullet in the novel ESG framework, in essence, a capsule of the SDGs. This research study is born out of professional involvements in UN Habitat in Quito, Ecuador in October 2016, its forerunner Preparatory Committee in Surabaya, Indonesia, in July 2016 and the Urban Thinkers Campus in Geneva, Switzerland in October 2015, and 2018 and 2020 World Urban Forums. This stems from many years of research, in-depth immersion, and advocacy. A constant reminder is to literally (and figuratively) “mind the gap” and for this paper, it is this: that the missing link is the green valuation of sweat equity to truly achieve, not just sustainable urban housing for the world’s masses, but to draw closer to the goal of HUMAN FLOURISHING.

Research on Resilience Assessment Method of Mountain Communities through Environmental Self-Restoration Capacity

WANG Xuanqing

Ecological base condition is an important guarantee for cities to resist climate disasters. Due to its sensitivity to ecological environment, mountainous cities need to pay more attention to the balance between their ecological self-restoration ability and urban development and construction. Existing research mostly focused on macro level framework construction or mechanical evaluation and protection, lacking of consideration for the robustness and redundancy of communities as the basic management unit of the city. Aiming at the above problems, this paper combs through the complex system of mountain communities from the five aspects of Driving, Pressure, State, Impact, and Response (DPSIR), and constructs a mountain community resilience evaluation system by applying the DPSIR theory, so as to quantitatively analyse 76 communities in 11 streets in Yuzhong District, Chongqing. It is found that per capita green space and coverage of public service facilities are important indicators to evaluate the resilience of mountain communities. And as an important factor affecting the self-recovery ability of mountain communities, the height difference occupies a large weight in the resilience evaluation process. The community with large height difference has relatively weak environmental self-recovery ability. Meanwhile, as the main urban area of Chongqing, Yuzhong District's communities have a strong “driving” for development but a weak “pressure”,“impact” and “response” system, and have not formed an effective multi-agent linkage participation model. In the future, the communities should strengthen the construction of local response systems and conduct comprehensive governance according to their own characteristics. The resilience assessment of mountain communities completed by this study contributes to improving the capacity of communities to cope with climate change and other possible future shocks. This research is relevant to citizens, while helping to provide bottom-up support to decision makers in policy development.

The impact of the heat island effect on the development of urban fringe areas

DENG Xueqing

Today, the heat transfer effect in cities is getting worse. This threatens people's health and productive life. This is especially true for the peripheral areas of cities, i.e. underdeveloped areas that do not have certain advantages in terms of economic development per se. These areas are mainly concentrated in the urban fringe and some urban villages in the city centre. At the urban fringes, the heat transfer effect is smaller, and therefore the impact on the economy is relatively small. However, in the city centre, the heat island effect is greater and the impact on the economy is also greater. People in these areas need to spend more time, energy and money to cope with these weather extremes. This project focuses on the relationship between the urban heat island effect and the impact of development in remote urban areas. The economic impact of the urban heat island effect on urban villages will be explored. Firstly, the relationship between urban sprawl and the heat island effect will be explored. Secondly, the economic losses caused by extreme weather on people's production and life will be analysed. Finally, the impact of the heat island effect on people's health will be explored. Health conditions can cause people to spend more money on treatment. This will also affect the local economy. A comparative study of three case studies, Shanghai, China, Washington, D.C., USA and Mumbai, India, shows that as a city expands, so does the area of the heat island effect. The impact of the heat island effect is different for different countries and economic development regions facing the fringe areas. Among them, developed countries, since most of the people live in the middle of the city, the heat island effect has less economic impact on the people in that area. Well, developing countries, since most of the people live in the fringes of the city, this leads to the heat island effect, which has a greater impact on the region.

Activating green hubs in cities to confront climate change in the light of proactive participatory planning (The Case Study: Barada axis in Damascus and Al-Asi in Homs)

ALWAER Husam, DIEB Rida, MTANUS Razan

The executive Strategies for urban development in Syrian cities, lack localization of the environmental, cultural, and participative factors in its most recent update in 2021.Despite Syria's participation in the United Nations Summit, during which it adopted the 2030 Agenda for Sustainable Development, and its regular publication of voluntary national reports on the SDGs; The progress made in Goal 11 (sustainable cities and communities) is hardly noticeable. The weakness of the urban planning in the Syrian cities is linked to the weakness of the executive mechanisms of the Local Administration Law 107 of 2011. The decline of green cover, land capture, energy poverty, pollution, inequality, marginalization and others are all factors directly related to locally social, economic, and environmental values. Planning trends that prioritize building climate-resistant cities start by including adaptation strategies into the planning process or by prioritizing the environment as a component in achieving Goal 11 and climate resistance. In order to improve the green structure in Syrian cities in general and the green structural axis in particular, the research intends to offer a participatory planning paradigm. The relevant case is the Al-Asi River axis.

"Green" shrinkage -- A Preliminary study on the path of high quality urban development in the three provinces of Northeast China

ZHANG Ke, ZHAO Zhiqing

In the context of global warming, reducing carbon emissions has become a key factor in the high-quality development of cities. In September 2020, China officially put forward the goal of "carbon peak and carbon neutrality". At the same time, urban shrinkage has gradually become the main trend of urban development, and cities in the three northeastern provinces of China are at this stage. How to deal with this development law with the concept of low-carbon "green" contraction has become a problem worth considering.

Sustainable Finance Model for Climate Resilient Cities

KUMAR K Manoj, RAJEEVAN Aparna

When cities and towns are prone to disasters, the sustainability factor is at stake as the selfsufficiency levels of the city goes down. Climate change and disasters can directly affect the livelihood and economic conditions of cities and towns. Hence it is important to develop resilience and economic security of the communities, therefore the cities can withstand the unpredictability. Climate resilient planning of cities by preparing the city for the possible disaster, equipping them with required physical infrastructures and planned use of financial resources contributes significantly to the city's overall sustainability. The study aims at developing a sustainable finance model for the historically significant old port town of Muziris, the present Kodungallur Town of Kerala in India with a population of 412,154 which lies in the flood prone zone of River Periyar, the largest river in Kerala with a basin size of 5,398 Sq.Kms. The model aims at integrating climate considerations into planning process of cities and also create green jobs to be self-sufficient and to retain the economy standards.

A Working Circle: How reuse organisations are making circular cities work for disadvantaged jobseekers

BURKE Lachlan, GRODACH Carl

The circular cities agenda continues to gain momentum worldwide, particularly in post-industrial contexts, as planners seek to reduce waste and improve resource efficiencies in their communities. Whilst important, many "greening" policies have prioritised making space for attracting professionals and improving ecological outcomes, neglecting workplaces providing low- and medium-skill opportunities. Providing diverse job and training opportunities in sustainable economies will be critical to ensuring our circular cities leave no-one behind. As an institutional response to this challenge, reuse organisations work intimately with waste to generate social benefits, including through employing and training seekers facing disadvantage. We explore the case study of Outlook, a 'waste-to-wages enterprise' type of reuse organisation. We draw from a mixed methods approach, involving documents analysis, semi-structured interviews and spatial mapping to explore how the organisation adapts to spatial dynamics of circularity and of disadvantage to support workforce development. Our findings from the case study suggest that waste-to-wages enterprises typically locate in waste transfer stations, building partnerships to facilitate effective circular activities in their communities. These finance employment services, located in disadvantaged areas which connect seekers with a range of other employers. The findings suggest that the reuse organisation model has promise in delivering workforce development outcomes within the circular economy, particularly if supported with social and sustainable procurement policies and inclusive precinctplanning approaches.

Sustainable Urban Finance for Mass Rapid Transit Development

JAISWAL Anuj, LODHI Singh Arjun, SHARMA Nishant Shashikant

Sustainable urban finance is a critical component in developing MRTS in urban areas. This paper presents an overview of sustainable urban finance and its role in supporting mass rapid transit development. It explores the different sources of financing like public and private sector funding, as well as innovative financing mechanisms such as TOD and PPP. The paper also examines the benefits of sustainable urban finance, including improved environmental and social outcomes, increased economic development, and reduced financial risk. Overall, the paper highlights the importance of urban finance as a key tool for achieving sustainable and equitable urban development through MRTS.

Papers undergoing Peer-review Programme

TRACK 2:
DECIDE jointly

Standardization of visual representation of noise and air quality for social consequences in urban planning

KAFULUMA Kefa, MOSCATI Annika

Noise and air quality remain major environmental problems affecting the health and well-being of millions of people in Europe. Therefore, data regarding these phenomena must be clearly represented and communicated to different stakeholders to mitigate their adverse social consequences. A clear and standardized representation of invisible data such as noise and air quality is necessary for the infrastructure industry. This study aims to establish the state of the art of existing representation and visualization of noise and air quality, identify any existing standards in these data visualization processes, and understand if a standardized visualization can impact people's well-being.

Comparison of the spatial and temporal distribution characteristics of the "Informal Economy" in the context of multi-sector collaboration and governance: Evidence from Tianjin, China

CHENG Qi, CHENG Wen, LU Ming, SHA Shiyan

In the post epidemic era, the informal economy has emerged as a vital driver of economic growth. The informal street economy has experienced a rapid resurgence. This study examines three types of typical street spaces to compare the spatio temporal characteristics of the informal economy. Findings reveal that: (1) Informal economic activities thrive in commercially valuable locations with high population density. (2) There is a strong positive correlation between crowd density and informal economic vitality. (3) Collaborative multi sector efforts involving planning, community management, and street design are essential for managing the informal economy in a hierarchical manner.

Spatial Distribution and Usage Characteristics of "Workers' Harbor" from the Perspective of Opening and Sharing: A Case Study from Tianjin, China

CHENG Qi, CHENG Wen, LU Ming, SHA Shiyan

"Opening and Sharing" is vital for regenerating public service facilities in China's urbanization. It aims to provide equal social services to vulnerable groups. Tianjin has opened up resources, like banks, to cater to outdoor workers' needs since 2018. However, the spatial and temporal distribution and design of these facilities often fail to align with workers' demands, hindering their effective use and enjoyment of social benefits. This study analyzes a Workers' Harbor in Nankai District, Tianjin, considering workers' behavior and the spatial distribution and function of the harbor. Recommendations are given to improve sharing quality, planning, and management of workers' harbors.

Advancing a just transition in the built environment: A comparative analysis of Lisbon and Melbourne

GALEA Natalie, LYON Lucy, RIVERA Alejandra, SOEIRO Diana, TIDY Joanna

Lisbon, Portugal and Melbourne, Australia (IHRB project) . Results are presented and contrasted with a focus on the risks and opportunities for the right to housing. The state of the just transition, and the marginality of people, places and values, in both contexts is analysed through the peripheral gaze model. This paper argues that a human (social) rights approach to urban development projects is key to address housing unaffordability, and that the protection and respect for the right to housing is essential for a just transition in the built environment.

The shifts needed towards a just transition in the built environment: A comparative analysis of Lagos and Prague

OJO Joshua Oluwafemi, PIXOVÁ Michaela, RIVERA Alejandra

This is the first paper in a series of four comparative analyses in the project: Just transition in the Built Environment (IHRB). The results of Lagos, Nigeria and Prague, Czechia are presented and contrasted in four key areas: participation, socio spatial inequalities, housing, and workers' rights. The state of the just transition in each context is examined and juxtaposed using X Curve analysis. This paper argues that a human (social) rights approach to climate policy and urban development projects can effectively address both social and environmental issues; and indicates the shifts needed for a just transition in the built environment.

A systematic review of applications of street view imagery in urban communities

NIE Haisong, SONG Jiaqi, XIE Jingxue

Research related to street view imagery has seen a surge in recent years, accompanied by numerous changes and innovations. This study screened 421 recent papers, providing a systematic review of the corresponding studies related to the theme of "health", which is the most substantial among them. The primary findings indicate that current research in this field is generally limited to cross-sectional studies, is geographically homogeneous, and the conclusions lack broad applicability. New research opportunities have also been identified: integration of data from multiple sources, strengthening of longitudinal studies, and enhancing the generalizability of research findings.

Maintain vigilance against the decline of shrinking cities in China: mechanism analysis, type recognition and planning responses

LIU Chenyang

This text constructs a theoretical model to explain the mechanism of urban decline from the perspectives of urban production function and government's financial management capacity. It suggests that urban decline exhibits a nested and mutually reinforcing cycle structure. Subsequently, two indicators are used to further categorize shrinking cities into four types: cities with healthy development, cities facing industrial inefficiency crisis, cities facing service inefficiency crisis, and cities facing dual inefficiency crisis. An empirical analysis is conducted on 136 cities in 9 provinces of China, revealing that cities in different regions are facing varying degrees of decline crisis.

Role of urban cores in the Tourism development of a regional space- Review of Northeast India

BHARULE Pramod Shreyas, BUAM Haziel

This paper tries to observe the role of the cities in Northeast India on the working of the industry throughout the region. It tries to understand the region from the perspective of "Place" which is defined by infrastructure services and destinations and "People" which is characterised by the tribal communities. Studying both these aspects under the purview of the formal and informal institutions leads us to realise the importance of the pivotal role of the nodal city in shaping the journey of the tourist, the perception of the community, and the preservation of the indigenous practices of the region.

Urban spatial governance model driven by "spatial financialization" for urban development in China——a historical review

LIU Chenyang

This article reviews the historical changes in China's financial environment, elaborates on the development context and phased characteristics of China's urban spatial governance model, and points out that under the national Keynesian macroeconomic policies, the combination of local governments' gradually acquired financial mobilization ability and the government's spatial governance strategy of promoting urbanization through space construction has contributed to the current governance characteristics of 'building cities with debt', A superior urban built environment means that local governments bear a heavy debt burden and increasing maintenance expenses. A low financial dependence urban spatial governance reform urgently needs to be explored.

Strategies to improve Shenzhen International Aviation Hub in the Guangdong-Hong Kong-Macao Greater Bay Area

LIN Siyi, ZHAO Miaoxi

Aviation hub is the key infrastructure supporting the modern service industry and logistics industry, playing an important role in urban and regional development. Avoiding homogeneous competition and building a coordinated airport cluster relationship is conducive to the region's overall competitiveness. We analyze the shortcomings of Shenzhen Airports based on the competition and cooperation relationship between airports in the Guangdong-Hong Kong-Macao Greater Bay Area, specifically in terms of airline network, passenger and cargo transportation, airport hinterland and airport capacity. Finally, we put forward Shenzhen's strategies for building a highly internationalized aviation hub from global, regional and local perspectives.

Research on Land and Sea Coupling Coordination Degree Measurement and Spatial Control in Response to Climate Change in Coastal Zone: Taking the Coastal Zone of Xiamen as an Example

LYU Yiping

Under the dual influence of human activities and climate change, the coastal zone is faced with such ecological and environmental problems as sea level change, seawater intrusion, coastal zone erosion, Eutrophication of water bodies, coastal wetland degradation, etc. Firstly, this article focuses on the interactive impact between the development and construction pressure of coastal land areas and the security of marine ecosystems. Based on the perspective of guiding spatial planning, a comprehensive evaluation system for the coupling of development and construction pressure and ecosystem security is established, taking the basic characterization of human activities and climate change as the path.

Cross-border Planning and Governance of Blue-Green Spaces in the Guangdong-Hong Kong-Macao Greater Bay Area in the Context of Climate Adaptation

LIAN Dongxin, WANG Shifu

This paper presents the cross-boundary planning and governance interactions among multiple levels of government in the GBA in the context of extreme climate crises. We noted that in integrating multiple objectives and spatial scales, cross-boundary spatial planning and multi-level governance helped facilitate joint planning collaboration among city governments across city boundaries. In addition, flexible governance tools such as the establishment of joint government meetings, regional cooperation agreements, and the formation of diverse expert consultations can address to some extent the boundary impediments posed by cross-government, cross-sector, cross-level, and cross-discipline.

Innovative financing for nature-based solutions in Flemish cities: an urban living lab approach

COPPENS Tom, CRABBÉ Ann, OP DE BEECK Tara, VAN DAMME Sylvie, VAN ESBROECK Caroline, VAN LIMPT Luc, VANDENDRIESSCHE Joeri

Internationally, the implementation of nature-based solutions into action remains slow due to several barriers, including the large gap between effective investments and needs. This research develops a transdisciplinary understanding of innovative financing of NBS through a process of co-creation with experts, non-academic practitioners and researchers in urban living labs in Flanders (Belgium). It elaborates business cases as tools to facilitate the engagement of public and private stakeholders in setting out the long-term sustainable innovative financing of NBS. The urban living lab approach aims at providing a testing ground for similar NBS projects in other environments.

Study on Spatial Correlation and Carbon Reduction Strategies of Urban Cluster Transportation Carbon Emissions Based on Multi-source Data: A Case Study of the Yangtze River Delta Urban Cluster

JI Xinying

The carbon emissions in urban transportation sector are high and growing rapidly, making it an important area for carbon reduction in cities. Based on the scale of urban clusters, combined with urban statistical yearbooks and multi-source spatial data, this study used the ArcGIS platform and Geoda software to analyze the spatial correlation between 11 selected indicators from three dimensions: urban land use, transportation network, and transportation capacity, and carbon emissions in urban transportation, using a bivariate spatial autocorrelation model. The research findings indicate that spatial factors such as built-up area, urban spatial density, and road network density in the urban built environment are significantly positively correlated with carbon emissions in urban transportation. Conversely, urban road mileage is significantly negatively correlated with carbon emissions in urban transportation, while the spatial correlation between the number of urban taxis and transportation carbon emissions is not significant. Finally, in conjunction with the transportation and construction planning in the Yangtze River Delta region, relevant spatial optimization strategies for low-carbon development in urban clusters' transportation were proposed.

Teaching Climate Change Mitigation and Adaptation in Urban Planning Programs: A Multi-Method Analysis of Urban Planning Curricula

SARKHEYLI Elnaz

The research addresses the crucial role of planners and planning education programs in addressing climate change. While many university programs have attempted to cover sustainable development and climate change issues, there remains a gap between what planners are expected to know about the concepts, potential strategies, and analytical methods and what they learn in their planning programs. As planning students will become critical actors and mediators in future planning projects, they must understand and develop the necessary skills to tackle climate change effectively. The research examines selected urban planning programs at the bachelor's and master's levels in the countries: Japan, Sweden, Iran, and the United States. Preliminary research findings from comparing various programs worldwide indicate the significance of local climate issues and the politics behind the contribution of urban planning schools to prepare planners as agents of change toward more environmentally-friendly developments. The results also emphasize a lack of literature, research, experts, and lecturers specialized in the interdisciplinary fields of climate change and urban planning. Moreover, it highlights critical thinking as a vital skill for planners and the practicality of the knowledge about climate change taught in urban planning.

Building urban climate change resilience in informal settlements: a case of France Colony, Islamabad, Pakistan

ABDUL Latif, TAOFANG Yu

Using the case study method, this paper attempts to explore urban and climate challenges of France colony, Islamabad. In spite of being at the city centre, the colony has failed to grab the attention of city administrators. Presumably, there may not be any intervention from a public or private organisation to make the colony a resilient place for its residents. The study reveals a number of challenges that society confronts on account of haphazard and unregulated growth. Community resilience measurement tools reveal, except social cohesion and inclusiveness, rest of the 7 indicators perform poorly for the colony and its residents.

The spatio-temporal characteristics of urban-rural development imbalance in China's major urban agglomerations and its optimization strategies

CHEN Chen, LIU Fangmei, LV Wenbo, SONG Zuxuan

In the context of globalization, the impact of industrialization has widened the development gap between urban and rural areas, especially in developing countries with a traditional agricultural economy. Based on the connotation of urban-rural balanced development, this paper first constructs an evaluation index system from three dimensions of economic development, population quality and social services, uses scientific research methods such as spatial autocorrelation analysis and multiscale geographically and temporally weighted regression to comprehensively analyze the stages and regional differences of urban agglomeration development, and then proposes optimization strategies for urban-rural imbalance in urban agglomeration planning.

Crossing disciplinary boundaries: Challenges and resolutions for planners to participate in new urban renewal work pattern

HE Liang

Urban renewal in China has shown explosive development. This study summarizes and outlines China's current urban renewal, future trends, planners' challenges, and work patterns through text mining of guiding policies, bibliometric analysis of case study articles, and introduction of an urban renewal consulting project. Findings show that China's urban renewal policies emphasize planning, but also express concern for implementation feasibility and financial security. Planners are now involved in financing, industrial planning, project execution, and management in urban renewal practice. It shows that planners need interdisciplinary knowledge and multi-process participation to meet the new demand for urban renewal services.

Relevance of drought resilience indicators in planning strategies: A principal component approach

BALTA-OZKAN Nazmiye, De MACEDO Batalini Marina, HUO Da, JACOBSON Gregory Michael, KONAK Abdullah, MENDIONDO Mario Eduardo, NARDOCCI Cassia Adelaide, SARMAH Tanaya, SASS Simone Karina, SHRIMPTON Elisabeth

The impacts of urbanisation on climate change, including aggravation of water-related stresses and risks of droughts have been well documented. These studies rely on the assessment of several drought indicators that either contribute to worsening the impacts or help to reduce such impacts when appropriately monitored. However, the current literature on the use of these indicators for modelling drought risk is fragmented and lacks a clear systematic,methodological approach. To fill this knowledge gap, a part of the MADIS project aims to collate and assess the drought indicators from the existing literature to understand their relevance and importance to support the decision-makers in improving relevant policies.

Characteristic identification and cooling design of thermal spaces in high-density cities based on multisource data

BAI Yujing, HUANG Mengshi

The dual effects of urban heat island (UHI) effect and heatwaves has posed a great threaten to the wellness of citizens in high-density cities. To examine the impact of spatial characteristic on thermal environment and to reduce the negative effect of high temperature, this paper identifies the features of thermal spaces in the first. Then we discuss on which design methods or measures should be taken to cope with high temperature problems in high-density cities. Considering the difficult to obtain small scale data, the study uses multisource data including remote sensing images, street view maps, cite survey, and so on. Under the help of geographic information system, the correlation of UHI with spatial characteristics is analysed, and then cooling design scheme for each block are proposed. The results show spatial layout (such as building density, frontal area, orientation) of architectures and configuration (such as green ratio, vegetation type) of green spaces have critical effects on improving thermal environment in high-density cities. It is concluded that decreasing building density of blocks for more open spaces, replacing low albedo surface materials, increasing properly the number of vegetation, and configuring multiple types of green spaces, spatial temperature of high-density cities can be significantly reduced. The results can offer theorical and practical support for adjusting thermal environment in high-density cities and establishing climate adaptive society.

Research on low-carbon renewal strategy of large-scale residential communities from the perspective of “climate positive”: a case study of longzeyuan street in huitian area

LI Chi, WANG Zining

As cities grow, climate change becomes one of the major issues facing the world. As large residential communities are important exploration areas and urban residents gathering places in the healthy climate plan initiated by C40, how to update them with low carbon to cope with climate change and rapid urbanization has become an important issue. From the perspective of "Climate Positive", the research object is based on the area of Huilongguan Street in the Huitian area of Beijing, the largest residential community in Asia, and summarizes community problems based on environmental characteristics, including road system, spatial structure, and public services. Based on this, a low-carbon renewal strategy at the macro, meso and micro levels is proposed, including the construction of a road network system with a complete system and dense density; Improve the public transportation system and build a diversified and multi-level public service facility system; Build a slow travel system that connects multiple living places to reduce carbon emissions. In order to promote carbon emission reduction in urban communities, mitigate climate change, and provide new ideas for improving the environmental quality and quality of life of residents in large residential communities.

Collaborative planning practices of urban gardening in Vienna: achieving sustainable green space governance for urban microclimate enhancement

LI Shuai

Urban gardening ,especially in small and flexible form,not only opens new modes of green space governance to invite different stakeholders but also improve the urban microclimate by creating micro urban wind corridors and urban thermoregulation systems. Based on the case of Vienna,this paper unfolds two levels of discussion.On the one hand,this paper researches how does different stakeholders involved in this collaborative process to promote urban gardening for better urban microclimate.On the other hand,it analyses how government-public negotiations can be allocated to achieve low-cost government spending and sustainable garden operations.

Can the Mundane change the Urban(e)? : Exploring possibilities of integrating urban form-based everyday behavioural practices with Indian planning and design frameworks to create community resilience, Case: Kolkata, India

CHATTERJEE Sambit Shamik

Indian cities are diverse, amorphous, and unimaginably complex systems; rapidly transforming and adapting; yet remaining uniquely rooted in community behaviours and socio-cultural behaviours. In the pursuit of globalised paradigms, the unique patterns of daily urban life that fostered community bonds and kept us connected as 'neighbours' instead of 'strangers', are being sacrificed. Many existing frameworks and tools have attempted to curb this loss of familiarity but have had little success, in part, due to their inability to engage the community adequately. However, Resilience, especially through social or community resilience, due to its' emphasis on adaptation and community, could be an appropriately engaging lens through which to engage design of our cities and enhance the inherent resilience in our communities. Using the case of Kolkata, this paper forms a deeper understanding of how everyday cultural patterns such as 'para' and 'adda', can integrate with urban form elements to form a mutually reinforcing and self-propagating system, capable of enhancing community resilience at the neighbourhood scale. This paper builds on established knowledge frameworks in the fields of social resilience, everyday cultural patterns and urban form and highlights the need of incorporating urban form, elements of social interaction and everyday cultural patterns into a combined socially resilient framework.

Urban planners as agents of change to enact climate change action – An Australian study

BUSH Judy, HURLIMANN Anna, MARCH Alan, MOOSAVI Sareh, WARREN-MYERS Georgia

Climate change is an existential threat. If greenhouse gas (GHG) emissions are not curbed dramatically within the next decade there will be significant consequences for humanity, the environment and cities. Urban planners have a significant role to play in realising built form outcomes of cities, and thus, will be key to facilitating the elimination of GHG emissions in built environments, and adapting to the consequences of climate change. However, there has been limited research conducted to investigate how well-prepared urban planners are to facilitate climate change action, and in particular there is limited information about what sources of information urban planners draw upon when seeking to incorporate climate change action into their work. This paper presents results of in-depth interviews with a diverse group of 23 Australian urban planners about their professional practices for seeking information about climate change. The results indicate four key information sources: academics (for trustworthy research); governments (for policy and key targets); media (for notification of new research/impacts and its public relevance) and industry/professional networks (for industry relevant interpretation of academic research and government policy). The study provides information about how urban planners can use their professional networks to facilitate optimal climate change actions, and to researchers and governments about how best to communicate to urban planners to facilitate uptake of their research and policies.

Papers undergoing Peer-review Programme

TRACK 3:
INVEST wisely

Research on Green Renewal Strategy of Industrial Heritage Under the Guidance of Creative Economy——Taking Harbin Old Shipyard as an Example

DU Lizhu, LIU Minghao, LIU Minghao, SONG Xiaoyun, TAN Qintong

Industrial heritage has witnessed the evolution of urban development and its rise and fall and contains rich cultural values and spiritual connotations. Today, the rise of the creative economy has constantly promoted the transformation of industrial heritage into innovative space based on its Cultural resource management, becoming one of the important means to achieve urban environmental improvement and sustainable development. This paper will take the old shipyard community in Harbin as an example, couple economic development with the demand for improving the living environment and explore a new mode of green empowerment of industrial heritage led by creative economy.

Social infrastructure demand evaluation and planning policies of historical communities from a resilience perspective: Evidence from typical communities in Hebei, China

CHENG Qi, CHENG Wen, LU Ming, SHA Shiyan

In the context of public health event shocks, investing in community social infrastructure ensures community resilience. The COVID-19 Pandemic presents challenges to social infrastructure in historical communities. This study examines the layout and capacity of social infrastructures and their role in addressing residents' needs during public health events. Findings include: (1) Overall, there is an oversupply of social infrastructure in historical communities, yet service urgency persists. (2) Differences in residents' habits, behavior, and age contribute to varying demands for facilities. (3) Social composition significantly influences demand for social infrastructure, highlighting the impact of social structure on community space utilization.

Evaluation of urban community healing space demand and planning strategies from a health equity perspective: Evidence from Tianjin, China

CHENG Qi, CHENG Wen, HAO Wenya, LU Ming, SHA Shiyan

In the face of climate change and urbanization, conflicts between humans and the environment are increasing. Residents face physical, psychological, and social problems. Public health awareness is growing, leading to a rising demand for healing spaces. This study examines and identifies residents' health needs, analyzes dilemmas in existing community, and proposes targeted strategies for community healing space planning. Findings include: (1) Ten types of community healing spaces based on function and openness. (2) Different age groups have varying preferences for healing spaces. (3) Healthy individuals have balanced preferences, while those with sub-health or specific conditions have specific preferences.

Growing Smaller -A reflection on urban rehabilitation, public space, and quality of life in everyday places

DE CAMPOS CUNHA Jeanna, MORGADO Sofia

Can former rural settlements, now engulfed by urban sprawl, be transformed into small towns within a metropolitan area? We believe it is possible. We believe that urban regeneration and public realm interventions are crucial to improving the quality of life for people living in these areas. Small towns are a growing field of research that encompasses many different topics rather than focusing solely on exceptional solutions. The aim is to address essential issues such as urban revitalisation, maintaining and caring for public spaces, and improving everyday concerns related to proximity, available facilities, and increased mobility in smaller urban settlements.

Equity-oriented research on the characteristics of socio-spatial differentiation and governance strategies in shrinking cities

CHENG Qi, CHENG Wen, LU Ming, SHA Shiyan

Globalization and de-industrialization cause local shrinkage, altering social and physical structures in cities. Fragmented social networks and reduced resilience impact government and market funding, accelerating aging and decline in physical space. Analyzing shrinkage is vital from a social-spatial perspective. China's shrinkage differs from the West, with urbanization and growth alongside shrinkage, resulting in socio-spatial differentiation. Field research focuses on Hegang's old town to study differentiation between social and physical spaces in shrinking cities. It uncovers causes of decaying public spaces and declining resilience, proposing regeneration policies for social aging and physical decay.

Implementation of Mid-Rise Housing in Housing Provision in Yogyakarta, Indonesia

ANANDHIN Nawang, PUSPASARI Asmita, ZULHIJJIANI Rizkika

Yogyakarta as a city with high interest as a comfortable place to live is experiencing and experiencing housing provision problems. The term ‘Missing Middle House (MMH)’ refers to mid-rise housing that highlights innovative housing solutions balancing the demand for landed houses with sustainable urban growth and community-oriented living in mid-rise housing. The research depicts several potential middle houses compositions derived from analysis on urban growth patterns, demographic conditions, economic situation, existing familiar housing typologies, and culture in Yogyakarta. Afterwards, best composition(s) will be synthesized through PPP financial schemes simulation to show implementation feasibility.

Mapping Spatial Justice of Top Hospitals’ Accessibility in China: an open-data solution

AN Huiyan, FENG Zhuolei, JIAO Ke, SU Wanqing, ZOU Zhichong

China's large population faces serious health challenges due to environmental decline, pollution, unsafe food, and high work pressure. Although progress has been made in medical care, technology, and science, there are uneven and insufficient medical resources. "Difficulty accessing quality healthcare" remains a significant issue for most Chinese. Urban planners need to understand the disparities in medical resource distribution when designing hospitals. This study examines access to top quality healthcare in different regions of China, highlighting challenges faced by citizens. The data reveals variations in reachable time and informs planners and policymakers about access difficulties.

A grounded theory study on the impact mechanism of innovation ecosystem planning around universities

SONG Guohui, SU Wanqing, WU Qianhong, ZOU Zhichong

Forming an efficient innovation ecosystem around universities is crucial for improving overall innovation efficiency. The study selected 20 interviewees for in-depth interviews.It takes the grounded theory method to study the impact mechanisms of three stages of enterprise development: student innovation teams, startups, and mature enterprises. The study proposed a planning support theoretical model for the university innovation ecosystem.The study found that innovative enterprises at different stages have different functional requirements and behaviour activities, including travel distance, service facility, policy support, etc. It provides theoretical support for improving the planning of the innovation ecosystem around universities.

Research on the Asset Evaluation System of the Old Industrial Community In Harbin City from the Perspective of this Theory

DAI Jian, QIU ZhiYong, YANG Ling, ZHANG XinJian

Under the background of urban renewal, the old industrial communities in Northeast China are facing new development opportunities. In view of the fact that the asset based theory is rarely studied and practiced in northern China, this study takes the community of Harbin Steam Turbine Works as an example to sort out community assets, build an asset evaluation system, use Analytic hierarchy process and fuzzy evaluation methods to determine the weight of assets, clarify community needs, and explore new models of community development, Provide a basis for future community governance actions in Harbin and provide solutions for urban grassroots governance.

Protection and renewal of public space in historical and cultural districts from the perspective of residents' activities

CHEN Xiaoqian, GUO Rong, WU Xiaochen

The article takes the West Liulichang South Area in the Xicheng District of Beijing as an example and explores the activity characteristics and practical needs of residents in the public space of the neighborhood through field surveys, resident interviews, and questionnaires, finds and summarizes the problems of point, linear and surface spaces in the neighborhood, and proposes micro-renewal strategies for the public space of residential historical and cultural neighborhoods from the design level, to propose micro-renewal strategies for residential historical and cultural neighborhoods with similar problems.

Study on the impact of public space on emotional perceptions and evidence-based design strategies on cold university campuses

LIU Yibo, MENG Zichao, PENG Junjie, YANG Mingyao

This study starts from emotion perception, an important indicator of mental health, and uses the least partial squares model to construct a system of emotion perception in cold university campus public spaces, taking Harbin Institute of Technology, a typical cold city university, as an example. This study selects eight university campus public spaces covering three types of parks, squares, and stadiums to carry out an evidence-based design based on quantitative measures of emotion in cold and non-cold seasons using Likert scales.

What incentive or incentive mix would facilitate increase in uptake of electric vehicles in Sydney?

GOMEZ Virginia, PIRACHA Awais

Electric vehicles are a sustainable means of transport that is in urgent need of global adoption. The purpose of this research is to identify what incentive or incentive mix would facilitate increase in uptake of electric vehicles in Sydney. The aims of this research are to discover the types of incentives that are available and being tested, explore successful incentives, and analyse if there is a feasible combination of these incentives that work well together. This research is to identify the type of incentives that will be most successful in Sydney. Theories supporting this research include consumer behaviour theory, public policy theory and urban sustainability theory. The methodology used include transport expert interviews and a case study on the leading electric vehicle city Oslo. Transport experts were interviewed from the state government and from the Electric Vehicle Council. Data collected found two main challenges in the consumer market, the first being a lack of benefit awareness, cost savings and features of electric vehicles. The second challenge is the absence of incentives that could motivate consumer purchase decisions. National policy on electric vehicles would increase government funding and motivate state and local governments to create regional and local policy responses.

Impact of Climate Action on Health of Residents in Ondo State, Nigeria: Strategies for Promoting Equitable Adaptation

OLUFAYO Olushola

Climate change affects human health. This paper examines the impact of climate action on health of residents in Ondo State, Nigeria. Multi stage sampling technique was employed for the study: these include stratification of Ondo State into the three senatorial districts; selection of one (1) LGA from each of the senatorial district and stratification of settlements as urban or rural. 1.5% sample size used. Findings revealed high usage of firewood for cooking; hand dug wells are not kept clean; malaria is the common illness. Reduction in burning of biomass fuels; improve water and sanitation services; improve public awareness are recommended.

Optimization Strategies of Residential Street Morphology based on Thermal Comfort Improvement: An Exploration by Using Microclimate Thermal Comfort Zoning Method

CHEN Xi, MA Yanhong, WANG Yiran

In order to provide recommendations for the planning and investment of street morphology optimization with thermal comfort improvement, the study determines the main climatic factors and morphological factors which bring big difference to microclimate thermal environment of urban residential streets in winter city. With real-time measured data testing the accuracy of simulation data as the premise, as well as applying microclimate thermal comfort zoning method, the research conducts an analysis for relevance between microclimate thermal comfort and morphology of residential streets in winter city, and on this basis proposes the corresponding optimization strategies of residential street morphology of winter city.

Investment in Tourism Sector Planning and its Impact on Disaster Resilience

DEY Priyanka, MANDAL Kasturi

The study focuses on the disaster prone Eastern Coast of India, where frequent cyclones cause disruption within the tourism dependent host communities by impacting the dynamics of their socio economic structure. The magnitude of these impacts grows with the growth in tourism and allied activities as more stakeholders come into play. Existing literature suggests that famous tourist destinations returned to normalcy faster than their lesser known counterparts, post cyclonic occurrences. Therefore, the study aims to identify and investigate the attributes of the tourism sector and integrate the same while edging proactive and reactive strategies for effective disaster management and resilience.

Blue-green space reconstruction under the background of urban waterlogging: A case study of ecological reconstruction of Pearl River in Nanjing

DAI Yunlai

The article introduces a case study of the ecological reconstruction of the Pearl River in Nanjing, a vital water system for the city. The project aims to improve the river basin's water quality, flood control, and social activities by relocating shanty residents, diverting sewage, and creating a barrier-free system. Taking into account social, environmental, and economic factors, governments must make intelligent decisions. Through examples, this article demonstrates the importance of wise measures to improve the community landscape and promote urban prosperity. Findings inform decision-makers in other cities, promoting sustainable urban development. Considering factors creates resilient, livable spaces benefiting communities and the environment. The ecological transformation of the Pearl River and subsequent government measures are positive examples of regeneration with profound impacts on communities, the environment, and urban resilience.

Evaluation of coupled coordination between urban resilient development and land use efficiency in the Guanzhong Plain region of China

LU Yan, ZHANG Yuzheng

Guanzhong Plain region is facing the problem of prominent contradiction between ecological and economy. Based on the entropy value method, the coupled coordination degree model and the relative development degree model, the study launched the related research on the coupled coordination relationship between urban toughness and urban land use efficiency in Guanzhong Plain urban agglomeration. The results show that: the urban resilience of Guanzhong Plain region shows an upward trend, and the urban land use efficiency shows a fluctuating trend. Both of them show a spatial distribution pattern of "high in the center and low in the edges."

Scenario-based urban prediction of island cities by modeling urban layout's influence on population dynamics: A Case study of Zhoushan Island

ZHANG Xun

As ecologically fragile areas that are simultaneously affected by the interaction between the ocean and the mainland, Island cities are facing practical challenges and great uncertainties.The multi-scenario planning approach has been proposed for exploring multiple possible solutions in certain strategic urban planning decisions, in order to cope with the uncertainties and complexities of urban futures. Previous studies on multi-scenario planning of island cities have focused on coastal use, ecological layout, and other physical space. However, the urban layout's influence on island population mobility, human activity patterns is not yet well understood. There is also a lack of clear understanding regarding the application and guiding significance of dynamic population distribution predictions for multi-scenario planning in island cities. To bridge the gap, revealing and predicting the influence of urban layout on dynamic population distribution, this study constructed a prediction model for the steady-state distribution of the population in island cities and incorporated it into the framework of multi-scenario planning, which includes "scenario presetting-population flow prediction-evaluation feedback," enabling the deep application of the predictive model in various planning scenarios. The results indicate that factors such as floor area ratio, building density, land use mix, transportation accessibility, and landscape diversity are closely related to the density and clustering patterns of population distribution, forming the key variables of the urban population steady-state prediction model. In the context of multiple-scenario predictions, due to the limitations of existing coastal space, the population distribution predictions from the point-based update scheme better support the differentiated development and utilization of various coastal areas in the Shenjiamen region. This study expands a new insight for multi-scenario planning and offers practical recommendations for rational urban planning in other island cities.

Analysis of the Visual Environment of Chinese Residential Historic Districts in the Process of Urban Renewal —— A Case Study of Xiaoxihu District in Nanjing, China

XU Yipin

This paper explains the significance of urban renewal work for ecology, economy, and social justice. Taking the historical residential blocks that are commonly concerned in China's urban renewal work as the main object, it focuses on discussing the justice of the visual resource in urban environment. It extracts the basic attributes that are most concerned about the visual environment in Chinese cities, and discusses the methods and strategies for shaping and optimizing the just visual environment in urban renewal work through the renewal practice of the Xiaoxihu Block in Nanjing.

Evaluation of the Influence of University Campus Environment on Students' Emotional Health in Severe Cold Regions and Evidence-based Optimization Design

HU Yuxing, HU Yuxing, JIANG Cunyan, LIU Jinpei, LIU Wangyin, OUYANG Lijia, YU Hanling, YUAN Qing, ZHENG Kexuan

Negative emotions of college students frequently occur, and healthy campus environment is extremely important to relieve students' pressure and negative emotions. However, long-cold winter in the severe cold regions has an important impact on the emotion relief of the campus environment. This paper takes a typical university located in severe cold regions as the research objective, and evidence-based design and neurological-physical techniques were used in assessing the impact of different campus environment on students' emotion and diagnosing potential factors that stimulate high stress. Based on the results, design suggestions for improving the campus environment would be proposed.

A Research on the Current Status and the Effects of the Digital Transformation on Japanese Neighborhood Associations in the Post COVID-19

HWAJIN Lim, KONDO Sae, OGAWA Naoya, OIDA Norihito, ONO Haruka

We examined the progression of ICT adoption in Japanese neighborhood associations during and after the COVID 19 period. Our findings indicate that ICT has been implemented in neighborhood associations during the pandemic through diverse approaches, including grassroots initiatives by the associations and proactive involvement from local governments. These endeavors aim to address long standing challenges, such as the aging of board members, and declining participation in association activities. Moreover, another contributing factor is the increasing familiarity of ICT in society during the COVID 19 period, which has lowered the barriers to the adoption of ICT in neighborhood associations and indirectly.

Renewal Strategy of Public Space in Government Office Area Based on the Improvement of Civil Servants

LENG Hong, YUAN Qing, ZHAO Tianshu

The primary factors contributing to health issues among Chinese civil servants are their demanding work schedules and sedentary lifestyles. This study aims to investigate the physical fitness of civil servants in Harbin, evaluate the quality of nearby public spaces, and provide recommendations for improvement.The findings highlight the subpar cardiovascular function, balance ability, and hand strength exhibited by civil servants in the Harbin municipal government, emphasizing the inadequacy of balance training facilities within open spaces. While expanding indoor open spaces may pose challenges, increasing the number of facilities represents a viable approach.

Improving social resilience in shrinking cities through social infrastructure regeneration: A investigation from Hegang, China

CHENG Qi, CHENG Wen, LU Ming, SHA Shiyan

Globalization and new economic systems have broken spatial limitations, concentrating resources in "Global Cities". Northeast China's "Rust Belt" region faces shrinkage, resulting in physical space decline and social-level crises. Social infrastructure and capital serve as coping strategies, enhancing social resilience in shrinking cities. Hegang, a typical shrinking city in Northeast China, deals with deteriorating social infrastructure and the risk of social capital loss. This study reviews social infrastructure theory and resilience production paths to explore their role in addressing shrinkage. It identifies regular patterns in social infrastructure supply and demand and proposes regeneration strategies to enhance social resilience.

Comparative Analysis of the Role of Motorized Vehicular Emissions Impacting Climate Change in Urban Areas across Developing and Developed Nations

MANDAL Kasturi, TIWARI Sapan

The pressing concern over greenhouse gas emissions from motorized vehicles and their impact on global temperature variation and climate change motivates this research paper. It conducts a comparative analysis of the contribution of motorized vehicles to climate change in urban contexts across developing and developed nations, focusing specifically on the transportation planning strategies and interventions implemented in Mumbai and Sydney. The study adopts a mixed-methods approach, employing the Delphi method and a comprehensive literature review to gather expert perspectives and analyse data. The findings highlight the effectiveness of transportation planning initiatives, such as public transit investment, promotion of active transportation, and policy incentives, in reducing emissions. Mumbai's higher population, population density, and reliance on older, less efficient vehicles contribute to higher emissions, while Sydney's implementation of stricter emission standards and developed public transit system result in relatively lower transport emissions. The study emphasizes the importance of tailoring solutions to specific contexts and provides practical insights for policymakers, urban planners, and researchers to inform sustainable transportation planning and address the challenges posed by climate change.

A Financial Support Framework For Equitable Recovery From Urban Floods: Case of Chennai, India

GHOSH Solanki, JAYASHANKER Sri Poojaa, VARDHAN Prasanth

The frequency of extreme disasters, particularly urban floods, has been increasing due to climate change and unregulated urban development. This study focuses on Chennai, India, and aims to optimise financial management to enhance community resilience. The research assesses the economic damages caused by urban floods, considering both tangible and intangible losses. Tangible losses are calculated by estimating per capita damages using a household survey and developing depth-damage curve equations for each zone. Intangible losses are quantified by establishing a relationship between social indicators and total damages. The study also examines the financial capacity of the city government to fund recovery efforts. Results show significant variability in financial allocation, with existing budgets falling short of proposed limits. To bridge the funding gap, the study proposes a community risk financing mechanism through disaster risk insurance. This research contributes to the limited knowledge on the financial resilience of Indian local governments during disasters and provides a budget allocation framework for planned response, recovery, and reconstruction. It also discusses potential methods to mobilise funds, such as a spatial vulnerability-informed insurance framework, and emphasises the need for regular review and adaptation to changing urban structures and financial demands.

Neighborhoods' Heat Vulnerability Assessment and Resilience Improvement Strategies in High-Density Cities: A Case Study of Zhengzhou, Henan Province, China

CHEN Xiaojian, FENG Jia, ZHENG Xili

This study developed Chinese neighborhood Heat Vulnerability Assessment tools Tool consists of 3 dimensions and 15 observations.Secondly, the entropy weight method is used to determine the weights, and a neighborhood heat vulnerability evaluation model based on TOPSIS method is established. Taking Zhengzhou City as an example, the heat vulnerability index of 6 neighborhood is evaluated and ranked. The results indicate that the tool is feasible in practical application.We also find that there is an inequality of thermal vulnerability among different grades of units, and the thermal vulnerability of units and workers should be identified and intervened in space.

Intelligent data solution for prioritising public fund allocation to reduce flood disaster risks and build preparedness: Case of Assam, India

ARORA Kabeer, DAMMALAPATI Krishna Sai, GEORGE Jeeno, SHARDA Mohak, SURAMPUDI Datta Phani

Climate change impacts are widespread and never restricted to the limits of cities. Despite increasing efforts to combat the resulting ramifications, public finance mechanisms rarely inform planning tools. Public funds finance all goods, works, and services for the public. Yet, data on public procurement rarely report strategies for disaster risk reduction due to the lack of readily available procurement data that is geocoded and mapped to different disasters and tools which integrate the data. For this work, we identify and use Assam's flood-related procurement data from 2018 to 2022. Using a set of identified flood disaster data, we use Confirmatory Factor Analysis of Structural Equation Modelling to derive six factors, flood hazard, demographic exposure, access to infrastructure, government response, losses, and damages, and need for preparedness. The 'need for preparedness' is hypothesized to depend on the first four factors and compared against the losses and damages. The results provide insights into how to finance the region further in its vision to build resilience against flood-related disasters. The use case presents how decision-makers at different levels can integrate different datasets to gain actionable insights.

Mapping Spatial Justice of Top Hospitals' Accessibility in China: an open-data solution

AN Huiyan, FENG Zhuolei, JIAO Ke, SU Wanqing, ZOU Zhichong

China's large population faces serious health challenges due to environmental decline, pollution, unsafe food, and high work pressure. Although progress has been made in medical care, technology, and science, there are uneven and insufficient medical resources. "Difficulty accessing quality healthcare" remains a significant issue for most Chinese. Urban planners need to understand the disparities in medical resource distribution when designing hospitals. This study examines access to top quality healthcare in different regions of China, highlighting challenges faced by citizens. The data reveals variations in reachable time and informs planners and policymakers about access difficulties.

Socioeconomic group inequity in urban park microclimate comfort

CHEN Xiaojian, HENG Yanyan

Traditional research has mostly focused on the study of the relationship between the physical environment and human comfort, neglecting to explore the equity of residents' experience of park microclimate comfort. This study analyzes whether there is inequity in the summer park microclimate comfort experiences of residents with different socioeconomic status based on the composition of visitors to parks with different microclimate comfort levels. The results indicate that residents with very low and very high socioeconomic status experience inequity in the better microclimate comfort parks. Residents of low and high socioeconomic status have similar experiences in parks with various microclimate comfort.

Spatio-temporal evolution of food self-sufficiency in metropolitan area: A case study in the Pearl River Delta

ZHANG Yuyang, ZHAO Miaoxi

Nowadays, various factors such as climate change, natural disasters and fluctuations in international politics have posed great challenges to food security. To this end, taking the Yangtze River Delta metropolitan area in China as an example, we structure the Metropolitan Foodshed and Self-Sufficiency Scenario (MFSS) model. We find that The YRD is relatively rich in land resources .However, the arable land of some cities cannot meet self-sufficiency. And we found that the food consumption in the core region relies heavily on food supply from outside the region. Based on the results this study makes relevant recommendations.

The Transformation of Local Cities in China: Land Finance and Urban Development Experience in Late-Development Country

OU Zhenyu, ZHAO Zhiqing

After four decades of rapid growth, China's cities have widespread local government fiscal deficits and high debt, and have hit the boundaries of growth. Therefore, how to change the mode of financing and economic growth become a new challenge.This paper reviews the development process of land finance and urban planning, and analyzes the dilemma of unsustainable land finance and the lack of connection between urban finance and planning. And puts forward countermeasures from four aspects: coordination of financial budget and planning, establishment of urban asset management system, improvement of tax system,and shifting from "land finance" to "non-land finance".

Neighborhoods' Heat Vulnerability Assessment and Resilience Improvement Strategies in High-Density Cities : A Case Study of Zhengzhou, Henan Province, China

CHEN Xiaojian, FENG Jia, ZHENG Xili

This study developed Chinese neighborhood Heat Vulnerability Assessment tools Tool consists of 3 dimensions and 15 observations.Secondly, the entropy weight method is used to determine the weights, and a neighborhood heat vulnerability evaluation model based on TOPSIS method is established. Taking Zhengzhou City as an example, the heat vulnerability index of 6 neighborhood is evaluated and ranked. The results indicate that the tool is feasible in practical application.We also find that there is an inequality of thermal vulnerability among different grades of units, and the thermal vulnerability of units and workers should be identified and intervened in space.

Papers undergoing Peer-review Programme

TRACK 4:
INTERACT with tech

Energy Efficient Cities: Spatial determinants and energy consumption in Tehran Metropolitan Area

LAK Azadeh, NASIRIFAR Maryam, NEDAE Tousi Sahar

As the urban population grows, environmental challenges are exacerbated, with the primary cause being increased energy consumption. The suboptimal energy efficiency has resulted in a rise in energy utilization per capita that exceeds global norms in Iran. Tehran city is found to significantly deviate from an Energy Efficient City. This study aims to examine the causal relationship between energy consumption and the spatial determinants of urban development through analysis of the status of 22 regions in Tehran. the research focus on exploring spatial determinants by which this undesirable phenomenon can be mitigated through the urban planning tools.

Spatial variations in heat consumption and space use per person in Germany-A comparative analysis

HUBER Manuel, MANN Deepika, SCHMITT Michael, SOMMER Felicitas

Residential housing in Germany emitted 75.2 million tons GHG in 2020. 72.2% of the emissions are caused by heating of living space. Living space per person has increased in Germany from 35qm2 in 1991 to 47qm2 in 2022. The interconnection of climate change and land use is well established, but the association between (heat) energy consumption and space use per person is seldom investigated or considered in EU sustainable finance or climate targets.This paper aims at spatial investigation of the connection between settlement types, high space use and energy use per person in Bavaria.

Analysing and assessing the vulnerable areas of Bhopal for urban flooding

CHATURVEDI Satyam, KAMAT Rajshree

Around the globe, there's a surge in city flooding instances. Accompanied with the aid of using fast temperature and rainfall sample fluctuations that are the characteristic of weather alternate. Bhopal, being one of the fastest developing town India is going through the identical trouble for decades.Furthermore, the town’s undulating topography acts as both, boon and bane to the town’s populace. The paper tries to locate the insights for city flooding with the assist of GIS strategies to construct an inclusive city flood vulnerability map and duly prescribe a few coverage interventions on numerous tiers to include improvement and resilience.

Calculation and Modeling of Historical Block Vitality Based on Trajectory Data--Taking Harbin's China Baroque Historical Block as an Example

HOU Xiaoyu, WU Cuiling, ZHAO Zixuan, ZHU Haixuan

Cities are the physical and spatial carriers of human activities. Now ICT technology, especially social media technology, has promoted the emergence of new trends in human spatial cognition and spatial production. Taking a typical historical space as an example, the paper constructs a physical space structure based on spatial background data, and constructs a cognitive space structure based on behavior trajectory data. Through the three dimensions of overall structure, significant points, and spatial flow, the paper compares the similarities and differences between the two, and discusses the ICT era. , the new laws of human spatial cognition and spatial production.

Exploring the Potential of Digital Tools and Modular Design for Energy-Efficient Refurbishment

TILLNER Silja, WILLINGER Alfred

Unique opportunities lie in refurbishment in terms of rethinking, redesigning and modernizing existing buildings into more energy efficient and less material intensive ones. This is particularly true for less advantaged neighbourhoods with low income residents in older social housing blocks with a lack of funding for the refurbishment. The building sector can best follow the 10 principles of circular economy by prioritizing the refurbishment of existing buildings, especially social housing over further soil sealing and CO2 emissions resulting from new construction. The challenges are high – especially for the transformation to renewable energy sources in the built city.

Hierarchical clustering to reveal hierarchical spatial structure: Take Jinan for example

WU Zhiqiang, XU Haowen, ZHAO Gang

This paper adopts a bottom-up hierarchical clustering algorithm on the origin-destination matrix built from taxi flow data to reveal Jinan's hierarchical urban spatial structure. Using all the trajectory data, we found that Licheng District, Zhangqiu District, and Jiyang District formed a spatial continuous cluster, while Huaiyin District, Shizhong District, and the west half of Tianqiao District made an equivalent one; by further exploring the substructures of these clusters, the subclusters of the Licheng-Zhangqiu-Jiyang cluster appeared to break the administrative boundaries while the Huaiyin-Shizhong-Tianqiao cluster still kept this administerial impact.

Machine-thinking urban public realm

LI Junqiao

In today's urban life, due to the subjective evaluation methods of public space and the lack of unified standards, the evaluation of urban public areas has always been unfair due to subjective factors. Due to the development of Internet of Things technology and smart algorithms, the public realm is no longer a constant physical space and concept, but with the mobility and rewritability of social life in the physical space, strong connection is generated with relevant urban data. This paper provides a new idea to solve this unfair phenomenon through the combined application of big data and artificial intelligence algorithms.

Research on Water Ecological Safety Evaluation Research in the Background of Climate Adaptability in the City

FANG Qiumei, LIU Zhijing

Climate change is a global challenge, which poses a great threat to the security of water resources and the sustainability of ecosystems. Many cities are exploring the concept of climate adaptive cities to enhance their adaptability to the impact of climate change. Xining City is located in the Qinghai Tibet Plateau, where climate change has a particularly prominent impact. Urban water resources are easily affected by changes in precipitation pattern, temperature and evaporation rate, thus affecting urban water ecological security.

Study on Habitat suitability Evaluation and ecological corridor construction of rare waterfowl habitat in Plateau Wetland

PAN Di

The Dashanbao Nature Reserve is one of the critical habitats for winter bird migration. Wetland degradation and fragmentation due to human activity threaten the survival of valuable water birds. We used the MaxEnt model to assess the habitat fitness of the black-necked crane population based on its distribution location and environmental data. In this study, we finally constructed a comprehensive ecological protection network, which consists of 27 main corridors and 12 secondary corridors. The study helps optimize suitable habitats.

The Role of AI and Big Data in Climate-Responsive Policymaking, Planning, and Financing

LIU Xi

This paper explores the role of AI and big data in climate responsive policymaking, planning, and financing. Firstly, it discusses how AI and big data can be used to analyze the impacts of climate change, including trends, extreme weather events, and natural disasters. Secondly, it examines how these data can be used to develop climate responsive strategies, such as improving energy efficiency, reducing greenhouse gas emissions, and promoting sustainable transportation. Additionally, it investigates how AI and big data can be used to support climate responsive planning, such as urban and land use planning.

Research on the Influence Mechanism of Urban Heat Island Effect on Population Residential Distribution under the Background of Climate Adaptive City

LIU Zhijing, WEN Xiaoyi

Climate change affects all aspects of human society, and cities around the world are exploring ways to be more resilient and adapt to climate change. As one of the major challenges faced by cities under climate change, the urban heat island effect has become a hot topic in domestic and foreign research in recent years. This study aims to explore the impact mechanism of the urban heat island effect on the distribution of urban population in the context of climate adaptive cities.

Carbon sequestration in urban ecosystems in the background of big data assistance

LI Peiying, SHI Tiemao, TANG Yu

Cities are the main geographical space for carbon emission generation, the continuous development of remote sensing data and spatial big data integration provides the possibility of quantifying urban ecosystems. On the basis of systematically sorting out the accounting methods of carbon sequestration (vegetation, soil, water system and buildings) in various types of cities, the total carbon sequestered by urban carbon sequestration is estimated to be 3.85 million tons, which can offset 6.89% compared with the carbon emissions from energy consumption in the same year, taking the third ring road of Shenyang as the accounting boundary.

Identification and planning response of unequal key areas of urban public green space based on accessibility

LU Yan, ZHANG Yuzheng

Identifying the unfair key areas of urban public green space and making planning response plays an important role in creating fair urban public space and realizing accurate urban space governance. Taking Kunming, China as an example, this paper constructs the evaluation index system and research framework of urban public green space equity, evaluates the social equity and economic performance equity of public green space in Kunming, and identifies and divides the types of planning response.

Carbon is Money, and this is how we count money in Urban Shanghai——A low-carbon city research based on RS, drone, street view and AI technologies

WEI Wei

This study uses remote sensing images to explore the local carbon sinks in Shanghai's urban areas, uses big data and GIS spatial analysis technology to explore the carbon emissions of buildings and the carbon reduction potential of the urban fifth facade in Shanghai's certain districts, and uses UAV oblique photography and AI algorithms to explore the vegetation carbon sink at block scale, etc. The research may bring some inspiration to the quantitative research of low-carbon cities and the development of carbon market in the future.

Big data based evaluation model for the justice spatial distribution of public service facilities in 15-min community: a case study of Shanghai

LI Shuai

The justice spatial distribution of urban public service facilities is of utmost importance, as good and adequate public service facilities can directly meet people's work and living needs.This paper demonstrates the use of python to obtain public service facility POI big data from electronic maps, and build computable community geographic units with the help of GIS platform to achieve an accurate measurement of all communities in Shanghai city. The study effectively identifies the current uneven service levels of community public service facilities in Shanghai, and can provide government administrators with accurate information on left-behind communities.

Study on ecological restoration of Chongqing's Liangjiang New Area based on the evaluation of landscape ecological security patterns

YAO Chungui

Firstly, based on the theory of landscape ecological safety pattern, the hydrological system safety pattern, geological hazard safety pattern, biological protection safety pattern and vernacular culture safety pattern are analyzed in Liangjiang New Area of Chongqing Municipality. Secondly, the comprehensive ecological infrastructure pattern was constructed, and three ecological safety zones with different safety levels of low, medium and high were identified. Finally, four ecological restoration strategies are proposed for the identified ecological restoration space in the Liangjiang New Area: 1. Maintaining biodiversity; 2. Strengthening shoreline control; 3. Optimizing green space structure; and 4. Mitigating geological disasters.

Inferring urban thermal environment patterns from street view data——a machine learning method based on grid correlation: a case study of Xi'an in China

CHEN Xiaojian, FENG Jia, ZHENG Xili

The heterogeneity of urban spatial characteristics constitutes a significant source of spatial variations in urban thermal environment patterns. This study aims to explore the relationship between land surface temperature and three-dimensional spatial indicators using a stepwise regression analysis approach. The results reveal a positive correlation between building density(BD) and land surface temperature, while greenery visual ratio(GVR) and sky openness(SO) exhibit a negative correlation with land surface temperature. The thermal island classification obtained through the inversion of environmental elements indicates that GVR, BD, and SO all have an impact on land surface temperature. Areas with higher BD tend to have higher temperatures, possibly due to hindered airflow leading to heat accumulation. Regions with higher GVR experience lower temperatures as vegetation absorbs solar radiation and reduces surface heat. Moreover, areas with higher SO experience lower temperatures, facilitating the dissipation of surface heat. Furthermore, the method of environmental element inversion accurately reflects the zonation of urban thermal islands. In conclusion, the findings of this study provide essential insights for urban planning, highlighting that optimizing greenery and building layout can effectively mitigate the urban heat island effect.

Planning support IT tool for prioritising fund allocation: Linking public funding to socially vulnerable areas using latent variable modelling

DAMMALAPATI Krishna Sai, GEORGE Jeeno, SHARDA Mohak

Efficient disaster management needs data for creating tools. However, data is distributed across multiple actors. The work aims to use the identified data on flood disaster and management to test the hypothesis that a relationship exists between observed variables and their underlying latent constructs to predict the factors, flood hazard, demographic exposure, access to infrastructure, flood impact, and government response. Further, Structural Equation Modelling tests the relationship of government response to the other four factors. The government response is significantly related to flood impact and demographic exposure, while the presence of infrastructure and flood hazard factors do not exhibit significant influence. The results highlight the need to relook at the distribution of critical infrastructure in Assam as we identify the presence of infrastructure as a coping mechanism for disaster risk reduction. We notice an insignificant relation of flood hazard to the government response, and it points out the need to conserve the high flood-prone areas from dense human habitation to safeguard their ecological benefits. The method provides a scope to evaluate new proposals in infrastructure networks and funding patterns. Therefore, it highlights the present system's gaps and recommends implementable solutions.

Economic space demand forecasting and the planning goal of net zero land take

ZAMAN Jan

The aim of our research is to develop a method for forecasting economic space demand in urban and peri-urban areas, within the context of net zero land take. Our study shows that a model based on subdivision in types of ‘small areas’ (e.g. statistical sectors in Belgium) is best fit for purpose. We tested the typology of areas with economic use, developed by the Flemish planning bureau. The number of employees in a type of small area can explain up to 90% of the variance in space used for economic activities. On a building block level, the regression analysis explains up to 60% of the variance. Both methods based on types of areas have a much higher coefficient of determination than the results we find in other economic space forecasting methods. We ran a test for the province of Western Flanders, based on the economic forecast for Belgium (Hermes model, Federal Planning Bureau). To meet the zero net land take ambitions, part of the projected economic growth was shifted away from green field areas. This results in a planning brief both on a regional level (economic space demand for each type of small area) and on a local level (economic space demand in a specific area). This research was funded by the Belgian province West-Vlaanderen.

Construction of an Ecological Security Pattern Based on Ecosystem Service Value for Megacities: A case study of Tianjin

BAI Yujing, HUANG Mengshi

With the rapid urbanization, high-intensity human activities and socio-economic development have led to drastic changes in land use. The expansion of construction land in megacities has severely squeezed ecological space, leading to frequent ecological risk problems and serious degradation of ecosystem service capabilities. These problems have threatened regional ecological security and sustainable development. In order to cope with the increasingly severe ecological security problems, the megacities continue to strengthen the construction strategy of ecological security development and protection pattern. It is of great significance to accurately grasp the ecosystem service value of blue-green space and efficiently build a blue-green space network to alleviate the outstanding contradiction between ecological protection and land space development.

Characteristics and OptimisationStrategies of Community Green Space Carbon Sinks for MegaCities

LOU Ying, ZHENG Haoyu

Community carbon sinks play an important role in climate regulation in densely populated megacities with scarce land use. In China's new urbanization phase, improving the carbon sink of community green spaces is the key to reducing carbon in cities and promoting sustainable urban development. Therefore, this paper studies the spatial distribution characteristics of community green space carbon sinks in Shanghai, a megacity, and uses them as dependent variables to explore the formation mechanism of community green space carbon sink distribution under the influence of different facilities. The results show that the six types of facilities have significant negative effects on the central urban area of Shanghai, and the construction process of megacities is affected by economic agglomeration, land allocation and facility performance in different periods, which makes the green space carbon sink of communities in different construction periods show significant spatial differences. In addition, this paper proposes targeted strategies to promote the construction of community green space carbon sink from the three perspectives of carbon aggregate control, carbon sink quality control and carbon sink construction guidance, and the research results can provide strategic suggestions such as design and management for the optimization of community green space carbon sink.

Climate Suitability Planning: Research on carbon sink measurement of block blue-green infrastructure based on multi-source data

ZHANG Zhihan

Currently, cities are facing the great challenge of global climate change, and blue and greeninfrastructure, as an important space for carbon sink enhancement in cities, plays animportant role in reducing urban carbon emissions and enhancing urban climate resilience. This study takes neighborhood blue-green infrastructure as the research object to discuss the overall carbon sink capacity under the coupling of blue and green spaces. It is found that there are spatial differences in the distribution of carbon sinks in blue and green spaces inthe case neighborhoods, and that the spatial aggregation of blue and green elements andthe area of green space are the main factors affecting the carbon sink capacity. Further analysis shows that trees are the main factor in enhancing carbon sink capacity. By optimizing the plant communities of urban blue-green infrastructure and widening the area of waterfront green space, we aim to enhance the carbon sink capacity, enrich the perspective of urban landscape planning, and provide a reference path for cities to cope with global climate issues.


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