Exploring the Interplay of Green Infrastructure and Urban Flows: Economic Disparities and Urban Metabolic Insights from Amman, Jordan

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This research investigates the relationship between economic conditions such as land value, and the health of landscape infrastructure in Amman, Jordan. Focusing on contrasting urban zones with varying wealth distributions, the study delves into spatial relationships among buildings, streetscapes, and green infrastructure. By integrating urban metabolic indicators, this analysis examines building typologies, green elements (public parks, private gardens, and balconies), spatial aspects and maintenance of streetscapes.

Through a mixed-methods approach combining existing databases, spatial analysis, GIS green infrastructure mapping, typological sketches, and surveys, this study evaluates the "triangle" of wealth, green infrastructure health alongside residents' perceptions. Findings aim to uncover discrepancies between perceived and actual urban conditions, challenging assumptions about the correlation between wealth and environmental quality. By addressing these factors, this study seeks to contribute actionable insights to urban resilience and equitable development in cities facing socio-economic divides.

Keywords: Urban metabolism, green infrastructure, socio-economic disparities, streetscape perception

Introduction:

Urban environments serve as the backbone of economic, social, and environmental dynamics, yet they often reflect significant disparities in the quality and distribution of resources. One critical resource being green infrastructure, with a large impact on urban resilience and liveability. Green infrastructure, encompassing public parks, private gardens, tree canopies, and streetscape vegetation, plays a vital role in mitigating urban heat islands, enhancing air quality, and fostering social well-being (Kabisch et al., 2017). However, green infrastructures and their quality are often unevenly distributed, reinforcing socio-economic inequities and creating environmental justice concerns (Wolch et al. 2014).

Amman, Jordan, exemplifies these dynamics as a rapidly urbanizing city facing spatial and socio-economic disparities. Despite being the political and economic centre, Amman struggles with stark contrasts in land use, green infrastructure allocation and water scarcity (Salameh, 2022), and urban metabolic efficiency. As urbanization accelerates, understanding how wealth distribution affects environmental quality has become increasingly urgent especially during a time where green infrastructure research has gained momentum in Western and Asian contexts (Wolch et al., 2014; Wu & Zhang, 2018).

This research explores the “triangle” of land value, green infrastructure health, and residents’ perceptions, focusing on Amman’s Wealthier, Median, and Under-resourced neighborhoods categorized as 1, 2 & 3 through High-value, Mid-value, and Low-value land area pricing. Wealth disparities often shape urban morphology, dictating building typologies, setback regulations, and the allocation of green infrastructure. This might give an insight into the quality and quantity of green infrastructure, as well as the pathway to develop it and even understand its effect, especially in Amman which remains underrepresented leaving critical gaps in the global discourse on urban equity.

Literature Review

Cities worldwide exhibit disparities in green infrastructure quality and availability, which is often linked to economic divides. The relationship between socioeconomic condition and urban environmental health has been a key issue for urban planners. This theme can be seen firstly within urban metabolism studies and later within wealth and green infrastructure statistics. The concept of urban metabolism, first introduced by Abel Wolman (1965), provides a framework for analysing the flows of resources and infrastructure in cities, offering insights into how urban systems manage resources like water, energy, and waste. Studies in the late 20th century, such as Jane Jacobs' (1961) who emphasized the significance of green spaces in fostering community well-being and social cohesion. Recently, Christopher Kennedy (2011) expanded on urban metabolism, incorporating green infrastructure into sustainability discussions and highlighting its role in urban resilience.

A growing body of research highlights the correlation between wealth and access to quality green infrastructure. Wealthier neighbourhoods often boast better-maintained parks, irrigation systems, and tree-lined streets, attributed to higher land values and greater municipal investment (Harnkik, 2010). Conversely, low-income areas frequently face neglect, resulting in fragmented green spaces, exacerbation of urban heat islands, and reduced liveability. For example, the Baltimore Ecosystem Study (BES), a long-term ecological research project initiated in 1997 (Pickett et al., 2015), provides critical insights into how urbanization alters ecological processes. The BES study was conducted in the Gwynn's Falls watershed of Baltimore, Maryland, the process integrated ecological data with social science methodologies, such as demographic analyses and household surveys, to assess disparities in green infrastructure. key finding published in 2015 revealed that wealthier neighbourhoods had significantly higher tree canopy cover and better-maintained green spaces compared to low-income areas. These affluent neighbourhoods benefited from advanced landscaping practices, such as permeable pavements and rain gardens, which slowed urban metabolism and improved environmental quality. In contrast, low-income areas had limited green spaces, poorly maintained streetscapes, and greater exposure to urban heat islands and pollution. The study underscored the role of historical inequities, such as redlining, in shaping these disparities and emphasized the need for equitable urban planning to address them (Pickett et al. 2015).

Similar findings were observed in Beijing, China. A 2018 study by Wu et al., employed GIS-based spatial analysis and socioeconomic modelling to assess green space with varying income levels. The study revealed stark disparities: high-income gated communities had extensive and well-maintained green spaces, while low-income areas had limited and fragmented greenery policy (Wu & Zhang, 2018). In Mexico City, a 2017 study by Fernández-Álvarez, examined the allocation of green spaces relative to population density and socioeconomic indicators. The research demonstrated that wealthier boroughs had larger and better-maintained green spaces, while lower-income areas were underserved, with fewer recreational opportunities and greater exposure to environmental hazards like heat and air pollution (Fernández-Álvarez, 2017). Finally, A 2020 European study analysed cities such as Berlin, Vienna, and Amsterdam, finding a strong correlation between affluence and urban green coverage, wealthier areas reported higher environmental quality, reduced stress, and improved mental health outcomes. These findings align with global trends, illustrating how socioeconomic disparities impact environmental quality and public health (Kennedy, 2011). Residents' perceptions also play a critical role in shaping green infrastructure and satisfaction. Studies in Mexico City and Beijing highlighted how perceptions of accessibility, and usability influence residents' engagement with green spaces. Interestingly, research revealed discrepancies between perception and reality: affluent residents sometimes reported dissatisfaction with green spaces despite objectively better conditions, this highlights the need to integrate subjective perceptions with objective measures to fully understand green infrastructure dynamics (Pickett et al. 2015, Fernández-Álvarez, 2017).

Methodology

Site Selection & Land valuation

This study aims to explore the relationship between economic conditions, green infrastructure health, and residents' perceptions in Amman, Jordan, by examining contrasting urban zones with varying wealth distributions. The findings seek to provide actionable insights for fostering urban resilience and equitable development in cities facing socio-economic disparities. The selection of neighbourhoods for this study was driven by a comprehensive examination of land prices and property values across Amman and more specifically within the city's main neighbourhoods.

Based on observed patterns, three categories of neighbourhoods were identified: High-value, Mid-value, and Low-value land areas representing economic and income categories. Marked as zones 1, 2 and 3 respectively, zones A were typically categorized within the city building codes as A and B building codes with special conditions, offering larger plots, spacious setbacks, and predominantly private villas or detached housing. Zone 2 primarily fell under C building codes, with occasional B code presence. Zone 3 was largely dominated by D building codes, occasionally including C (Jordanian Engineers Association. 2018). These classifications played a critical role in defining the setbacks, green infrastructure, and density in addition to the land valuation which separated most of these zones utilizing land pricing data sourced from Qoshan and governmental organizations showcasing relation between valuation and codes (Qoshan, 2025; General Corporation for Housing & Urban Development. 2025).

Building codes in Amman, Jordan, are a comprehensive set of regulations established under the Unified Building Law No. 79 of 1966 and the Amman Building and Zoning Regulations of 2018. These codes aim to ensure orderly urban development, safety, and sustainability by controlling land use, building heights, densities, setbacks, and other construction aspects. They are divided into the following: Zone A for high-value, low-density housing (spacious villas) with 5m front setbacks, and 1,000 m² minimum land area; Zone B for medium-density housing (semi-detached homes) with 5-4m setbacks, and 750 m² minimum land; Zone C for medium-density apartments with 4m setbacks and 500 m² minimum land; and Zone D for high-density apartments with 3m/ setbacks, and 300 m² minimum land.

Land by price Category	Land Valuation (JOD, USD, EURO/sqm) [12,13]	Building Code	Areas
Zone 1 - High-value	**500, 640, 710**	**A, B**	**Abdoun, Dabouq, Al-thuheir**
Zone 2 - Mid-value	**250, 315, 350**	**C, occasional B**	**Tla' Al-Ali, Shmeisani**
Zone 3 - Low-value	**100, 130, 140**	**D, occasional C**	**Abu Alanda, tbrbour**

Table 1. Classification zones, building codes and insights into income and wealth through land valuation zoning.

Data Collection

This included spatial analysis of building typologies, heights, setbacks and plot utilization rates to evaluate density and available open spaces as seen from figure 1 – figure 6. Utilization of NDVI to analyse green coverage in 3 different zones to analyse the value resulted from each building code as seen in figure 7 and finally, a previously conducted survey of 280 participants which captured residents' perceptions of their neighbourhood [Appendix A]. The survey provided insights into how socio-economic groups perceive urban environmental health:

Aspect	Zone 1	Zone 2	Zone 3
Building code involved	**A, B**	**C**	**D**
Building Heights (m)	**9m (2 floors + roof)**	**16m (4 floors)**	
Setbacks	**5m front/back, 4 M sides**	**4m front/back, 3 M sides**	**3m front/back, 2.5 M sides**
NDVI Value	**0.129**	**0.065**	**0.046**
Survey- Cleanliness	**48 % think it is clean enough**	**65 percent think it is clean enough**	**68 percent think it is clean enough**
Survey- Not enough Green Spaces	**30 % think it is the biggest issue, 45 % are satisfied**	**25 % think it is the biggest issue, 62 % are satisfied**	**23 % think it is the biggest issue, 64 % are satisfied**

Table 2. Data Collected for each zone like heights, setbacks, NDVI and Survey results.

Results

4.1 Zone 1: Representing more probably wealthier areas in Amman, a wide array of private villas and spacious detached housing, are defined by their high environmental quality and exclusivity. These neighbourhoods mandate a 15% green coverage, supported by setbacks of 5 meters in front and back and 4 meters on the sides, which ensure abundant unbuilt space for private gardens and landscaping. Residents, leveraging greater financial means, further enhance greenery through private investments, resulting in more maintained green spaces. This abundance of unbuilt areas allows for better rainwater drainage, reduced urban heat island effects, and ecological resilience. However, particularly in public spaces. 1-meter square planters spaced 5–8 meters apart limit the quality of street-level greenery and pedestrian comfort.

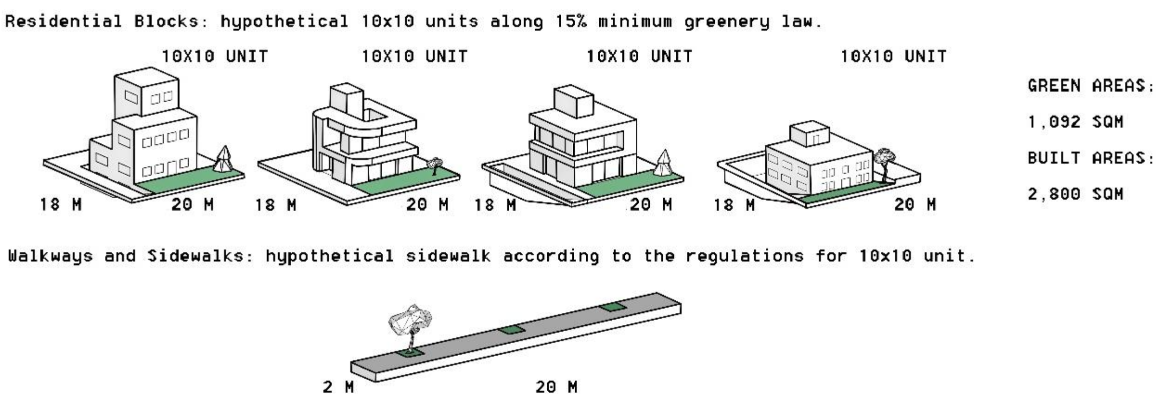

Figure 1. 3d illustration of block typology, setbacks, green areas, walkways and general overview in Zone 1.

The analysis of a 100x100 meter block scenario across zone A provides 28 units with a total built area of 2,800 square meters, leaving 1,500 square meters designated as green space and 5,700 square meters as unbuilt areas. These areas exhibit a low density of 0.0168 residents per square meter, with a total of 168 residents and a Floor Area Ratio (FAR) of 0.28. The green area per person stands at 8.93 square meters, reflecting the spaciousness of high-income zones, which prioritize greenery and ecological resilience.

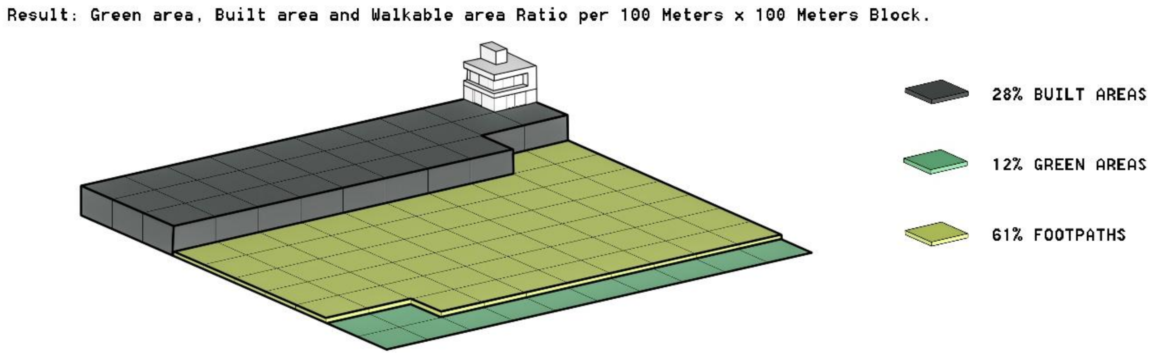

Figure 2. illustration of 100x100m scenario for zone 1, showing built green and non-built areas figuratively.

Zone 2

Representing mid valued land reflect a transitional urban character, balancing moderate density with some greenery. These neighbourhoods were estimated with 7.5% green coverage, though enforcement is inconsistent, leading to fragmented greenery. Setbacks of 4 meters in front and back and 3 meters on the sides create moderate unbuilt spaces (Jordanian Engineers Association. 2018), but these are often underutilized. Older buildings occasionally include green spaces superseding current regulations, Public green infrastructure, such as planters, is sparse, with 1-meter square planters spaced 5-8 meters apart, offering minimal environmental shade and benefit.

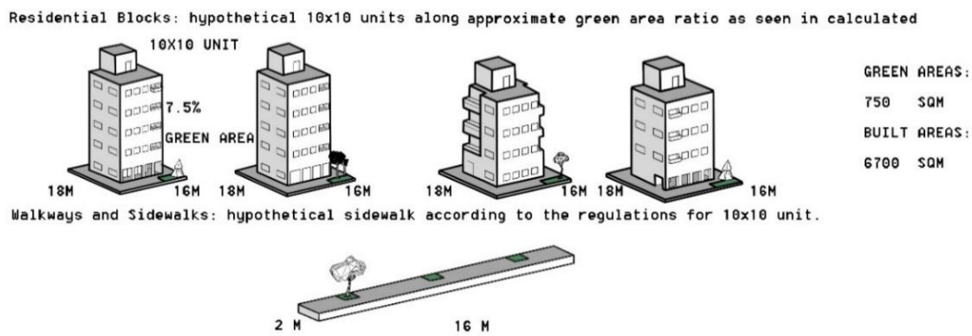

Figure 3. 3d illustration of block typology, setbacks, green areas, walkways and general overview in Zone 2.

Zone 2 in the same scenario would include 67 units, resulting in a built area of 6,700 sqm and 750 sqm of green space. The remaining 2,550 sqm are unbuilt, balancing urban density with moderate greenery. These areas house around 536 residents, a FAR of 0.67 and green area per person is reduced to 1.40 sqm.

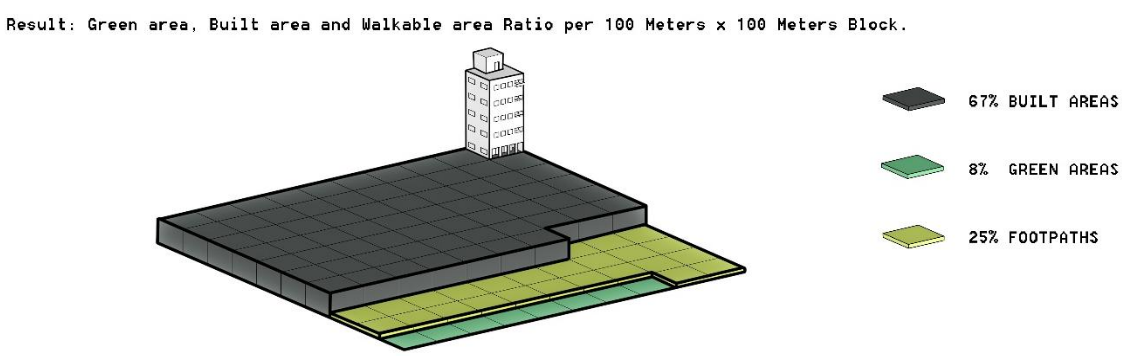

Figure 4. illustration of 100x100m scenario for zone 2, showing built green and non-built areas figuratively.

Zone 3

Here significant challenges in environmental quality and green infrastructure arise in less economically valued areas. These neighbourhoods mandate only 5% green coverage according to estimations, Setbacks of 3 meters in front and back and 2.5 meters on the sides result in compact developments, leaving little room for greenery. While some older buildings feature legacy green spaces exceeding current standards, these are unevenly distributed and poorly maintained.

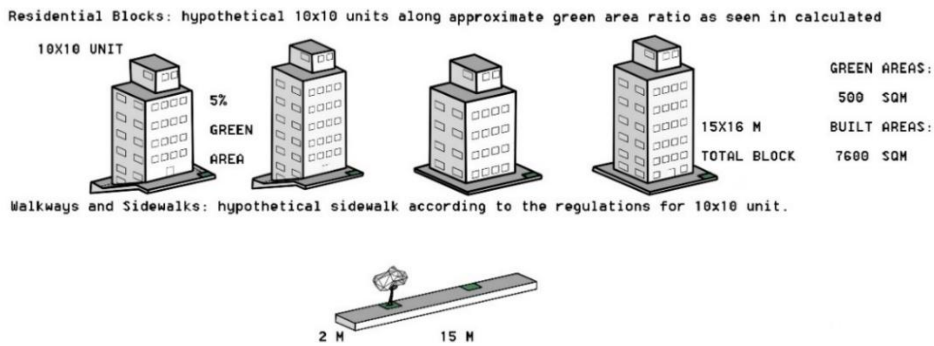

Figure 5. 3d illustration of block typology, setbacks, green areas, walkways and general overview in Zone 3.

Presented in a 100x100 m scenario, it inhibits the most densely populated zone with 76 units, covering 7,600 sqm of built area and leaving 500 sqm as green space. Unbuilt areas account for 1,900 sqm, with 608 residents contributing to a density of 0.0608 residents per sqm. The FAR of 0.76 reflects the high utilization of land, while the green area per person is the lowest at 0.82 square meters.

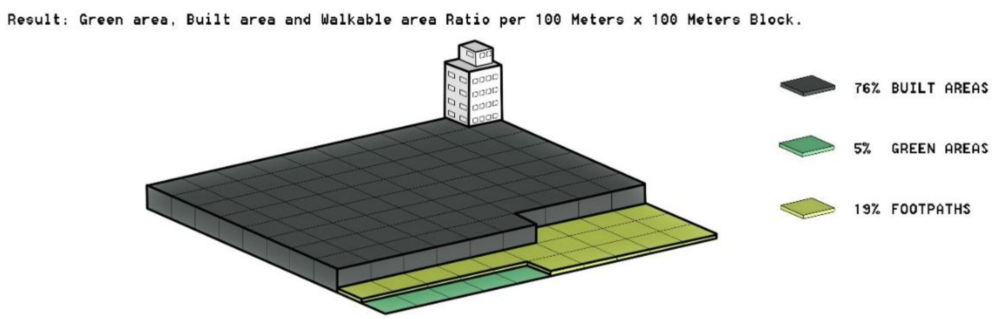

Figure 6. illustration of 100x100m scenario for zone 3, showing built green and non-built areas figuratively.

These results highlight the disparities in land use, green infrastructure, and liveability across income categories. Zone 1 excels in providing expansive private greenery and ecological advantages, while zone 2 attempt to balance density with moderate green infrastructure. Zone 3, however, face significant challenges due to high land utilization, limited greenery, and overcrowding. These findings underscore the importance of tailored urban planning strategies to address the unique needs of each income category, fostering sustainability, equity, and improved quality of life.

NDVI Analysis

Conducted using data from the Sentinel Hub platform to assess the green cover of the three different categories. The average NDVI values from Sentinel satellite imagery indicate the extent and density of vegetation in each neighborhood, providing a quantitative measure of green cover for comparing urban greenery across different areas in my study. This provided a reliable average NDVI value of 0.129 for Zone 1, reflecting the abundance of private gardens, landscaped areas, and greeneries. For both zone 2 and 3 the

NDVI was 0.065, 0.046 respectively. Using these results the approximation for the total green area per residence in both categories was estimated to be 7.5% green area regulation for medium-income areas and the 5% regulation for low-income areas, The NDVI analysis emphasizes the importance of integrating green infrastructure into urban planning as a means of fostering equity and sustainability.

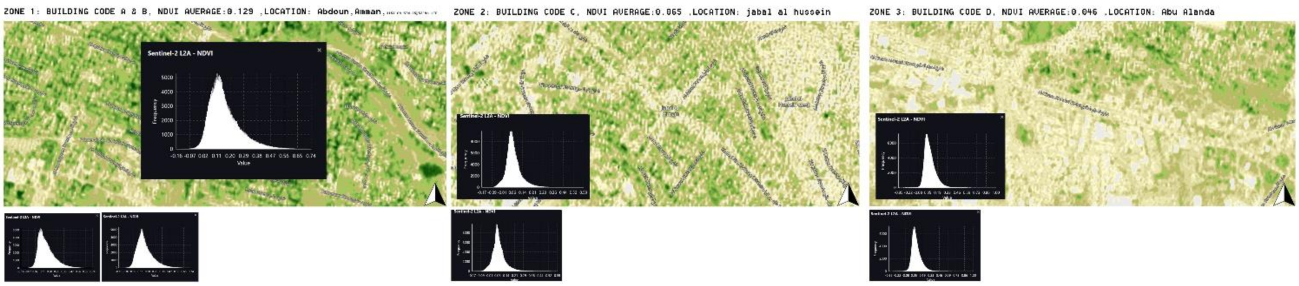

Figure 7: Zone 1,2 and 3 NDVI values and distribution to assess the green cover of the building codes.

Implications & Discussions:

Inclusive Policies for Low-Income Areas

The study reveals significant challenges in Zone 3, where limited green coverage, high density, and narrow setbacks result in poor environmental quality. To address this, urban greening grants should be allocated to develop community parks, vertical gardens, and small-scale urban forests using fast-growing native species. These initiatives can quickly enhance green coverage, improve air quality, and provide accessible recreational spaces for residents. Additionally, shared green spaces, such as shaded public plazas or mini parks, should be strategically integrated into dense neighbourhoods to ensure equitable access to greenery.

Community-Driven Green Infrastructure Initiatives

Empowering local communities to take ownership of urban greening efforts is an inclusive and cost-effective solution for development. Community gardens can be established by allocating vacant public spaces or underutilized land in zones 2 & 3.

Incentivizing Private Green Investments in High-Income Areas (Zone 1)

While Zone 1 benefits from extensive private greenery, the study highlights residents' dissatisfaction with public green infrastructure, particularly streetscape planters. To address this, tax incentives could be introduced for residents who invest in maintaining or enhancing public green spaces, such as streetscape planters or tree-lined sidewalks.

Pavement Design Optimization

Zone 2, with its moderate density and fragmented green infrastructure, would benefit from pavement design optimization. Replacing standard pavements with permeable materials can improve water infiltration and reduce surface runoff, addressing water management issues. Increasing the size and frequency of planters (e.g., 1.5 meters in size, spaced 3–5 meters apart) would enhance shading, cooling, and aesthetic appeal, aligning with residents' needs for improved streetscape quality.

Conclusion

Socio-Economic Disparities and Regulations

Zone 1 demonstrates the most significant green infrastructure advantages. These neighbourhoods benefit from strict urban regulations, such as mandatory 15% green coverage, spacious setbacks, and low built-to-land ratios. The ability to allocate significant portions of land to unbuilt and green spaces is further amplified by the economic capacity of residents to invest in private landscaping and gardens. These regulations create an environment where 0.129 NDVI values are achieved, reflecting a healthier urban ecosystem compared to the 0.065 and 0.046 NDVI values of medium- and low-income areas, respectively. In contrast, Zone 3 face significant challenges due to less stringent regulations, high-density developments, narrow setbacks, and smaller plot sizes contribute to a compact urban form that leaves little room for greenery. Mid value land zones occupy a transitional space, balancing moderate density with some adherence to green space regulations, these neighbourhoods maintain a somewhat better green infrastructure.

The Triangle of Perception, Green Infrastructure, and Wealth

One of the most striking findings of this study is the disparity in perception versus reality. Zone 1 despite having the most greenery and lowest density, often perceive their neighbourhoods as unclean and lacking sufficient greenery. This perception starkly contrasts with that of lower income residents, who frequently view their neighbourhoods as clean and green despite their lower NDVI values and minimal green coverage. This divergence highlights the psychological and cultural dimensions of urban liveability.

This triangular relationship between wealth, green infrastructure health, and perception reveals that wealthier neighbourhoods not only benefit from better regulations and infrastructure but also face higher expectations of environmental quality. The superior perception could be arising from wealthier residents that often have greater exposure to global standards of urban design and greenery, either through travel, media, or education. This exposure raises their expectations of what constitutes a “clean” and “green” environment. Conversely, in zones 2 & 3, residents adapt their perceptions to their circumstances, often emphasizing other priorities, such as traffic or accessibility, over greenery, finding satisfaction in modest improvements or the mere presence of greenery, regardless of quantity. This divergence suggests that perception is a critical factor in shaping urban satisfaction, irrespective of the objective of greenery.

Reinforcement of Broader Urban Theories

The findings align with global research on socio-economic disparities in green infrastructure such as, studies from Baltimore and Mexico City (Pickett et al. 2015, Fernández-Álvarez, 2017) highlight how wealthier neighbourhoods consistently enjoy better-maintained parks and tree canopies due to municipal investments and private funding reinforcing the need for systemic reforms.

Social dynamics

Emphasizes the social dynamics of space usage, where cultural preferences in Amman lead to an emphasis on private green spaces over public ones in high-income areas. In contrast, studies from Europe often highlight the importance of shared public green spaces in promoting mental health and social cohesion. This divergence underscores the cultural specificity of urban green infrastructure in Amman. This can also be linked to the low water availability, where Amman’s arid climate further contributes to this dynamic. Public green spaces require significant water resources, while in higher value land residents, with access to private irrigation systems, can better sustain greenery within their private properties.

Study Limitations and Applicability in Other Regions

This study has limitations that warrant consideration. First, reliance on NDVI for green coverage analysis, while useful, does not fully capture the quality, functionality, or accessibility of green spaces. Integrating metrics like the Green View Index (GVI), which uses street-level imagery, could provide a more nuanced understanding of green infrastructure health.

Second, Amman's unique cultural, climatic, and urban characteristics may limit direct applicability to other regions. Its arid climate and water scarcity create distinct challenges for green infrastructure, unlike cities in temperate or water-abundant regions. Additionally, Amman's cultural preference for private green spaces over public ones reflects local dynamics that may not apply elsewhere. For example, in Rabat, Morocco, public green spaces are more central to urban planning, while in Riyadh, Saudi Arabia, greater financial resources enable large-scale green projects.

Despite these limitations, the study's methodological framework can be adapted to other cities in the MENA region, such as Beirut, Cairo, Damascus, Tunis, and many other cities within the MENA region, where similar socio-economic and environmental challenges exist. Future research could enhance this framework by incorporating AI-driven spatial analysis to improve precision in green infrastructure mapping or by examining the role of regulatory reforms in promoting equitable green space distribution.

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Appendix A: This survey aimed to assess residents' perceptions of their neighbourhood's in Amman, focusing on green infrastructure. The survey included questions on demographics, the place of their residence location, and critical urban issues. Below are the most relevant survey elements used in the study:

1.Neighborhood Cleanliness: Residents were asked if they felt their neighbours were aware of street cleanliness and disposed of trash correctly: *Yes, the majority do, some people do, No.*

2.Satisfaction with Green Infrastructure: Residents were asked if they were satisfied with the quantity and quality of green spaces: *Yes, the majority are satisfied, some people are satisfied, No.*

3. Major Neighborhood Issues: Participants identified the most pressing problems in their neighborhoods:

Lack of green areas or vegetation, Climate control and extreme weather, Lack of interaction zones or proper social spaces, Waste management and cleanliness, Water flooding, management, and shortages, Increased traffic, Street vendors, High energy costs and lack of sustainable energy.