Operational Research in Engineering Sciences: Theory and Applications
Vol. 7, Issue 4, 2024, pp. 17-37
ISSN: 2620-1607
eISSN: 2620-1747
DOI: https://doi.org/10.5281/zenodo.15093191

URBAN FORM AND GREEN SPACE ALLOCATION: A PATHWAY TO GREEN SOCIAL EQUITY IN SHRINKING CITIES

Mohanad Mohammed Sufyan Ghaleb[1*], Shaxnoza Abdulhaeva[2]

[1]Department of Management, College of Business, King Faisal University, Al-Ahsa 31982, Saudi Arabia.
[2]Department of Taxation, Tashkent State University of Economics, Uzbekistan.

Received: 24 July 2024
Accepted: 01 December 2024
First Online: 30 December 2024

Research Paper

Abstract: *With the recognized significance of urban green space equity in the promotion of public health and environmental sustainability, Saudi Arabian cities face disparities in green space distribution due to urban form variations. Unequal access to green spaces strangely affects lower-income communities which is ruining social and environmental inequalities. Addressing these disparities, the research examines the impact of urban form dimensions on urban green space (UGS) equity in Saudi Arabian cities. Researchers employed the quantitative research approach, utilizing panel data from 15 Saudi Arabian cities over the period 2014-2024. Fixed-effects and random-effects econometric models were applied to assess the relationship between urban form indicators and UGS equity. The results indicate that urban population growth, per capita income, and unemployment rate, public transport coverage positively significantly increase UGS inequities. While, higher population density, vacant land rate, house affordability index, and green space coverage significantly negatively impact UGS equity which highlights the challenges faced by shrinking cities in maintaining accessible green spaces. The study results highlighted that policymakers should integrate green infrastructure development with urban planning strategies that ensure equitable access to green spaces across income groups. Furthermore, enhancing public transport connectivity to parks, repurposing vacant land for community green spaces, and adopting inclusive planning frameworks can significantly improve UGS equity. This study filled a critical gap in the literature by examining the intersection of urban form and UGS equity in Saudi Arabia. It provides novel insights into the role of urban shrinkage, economic disparities, and spatial planning in shaping sustainable urban green space distribution.*

Keywords: *Urban form, Green space equity, Sustainable Cities, Urban planning, Decision-Making.*

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*Corresponding Author: mghaleb@kfu.edu.sa, (M. M. S. Ghaleb)
sh.abdulkhaeva@tsue.uz, (S. Abdulhaeva)

1. Introduction

Urban green space equity plays a key role in the long-term stability of the cities that helps to develop better ecosystem services (Young, 2010). With an increasing focus, these services represent the urban biological diversity, which is reducing the environmental challenges after reducing urban noise and air pollution (Lin et al., 2015). Given the rapid advancement in UGS equity, it has been recognized as a fundamental component in increasing their positive impact on public health because they are associated with low mortality to improve mental welfare through service as available outdoor places for residents (Jennings et al., 2016; Wolch et al., 2014). Several studies also highlighted the significance of UGS equity where they emphasized that the presence of green areas around residential areas contributes more to welfare and health than large-scale urban green areas (Dadvand et al., 2016; Pietilä et al., 2015). With the ongoing development in the UGS, the importance of this topic cannot be overstated.

Despite the recognized importance of UGS, prior studies indicated that their distribution around residential areas is often uneven, which is affected by urban form (Wolch et al., 2014). A growing interest in enhancing UGS equity has been found in recent years through the distribution and accessibility of green space. The integration of green spaces in multiple locations enhances UGS equity driven by well-planned urban cities (Li et al., 2021). When cities are designed with inclusive planning strategies, green spaces can be evenly distributed, reducing disparities between wealthy and low-income communities (Rigolon et al., 2018). In other words, a thoughtfully designed urban layout enhances accessibility by providing parks within walking distance or ensuring efficient transportation links to green areas, which allows people to get more benefits from environmental advantages (Wolff et al., 2020). Furthermore, uncertain loss of green spaces due to population shifts or urban growth an efficient urban form assists in the sustainable management of green spaces that ensures long-term access to the maintained parks across all communities (Haase et al., 2022). Therefore, urban form plays a critical role in enhancing UGS equity supported by previous studies.

Considering how essential an urban form is, and if the urban form is poorly designed in the urban areas then it could reduce the UGS equity (Zhang et al., 2020). This highlights the significance of urban form in the management of cities because high-density urban areas without proper planning can lead to overcrowding in existing parks which is reducing their usability and quality. Similarly, shrinking cities with declining populations may struggle to maintain green infrastructure, which leads to deteriorating or abandoned parks that no longer serve the community effectively (Riera, 2024). Poor transportation systems limit access to green spaces for marginalized groups can further broaden inequalities (Haque & Sharifi, 2024). In addition, wealthier neighborhoods may have well-funded parks while lower-income areas may face a decline in social, and environmental inequalities due to economic disparities in urban planning (Anwar et al., 2023). These previous studies highlight that investigating how urban forms affect UGS is crucial to addressing these challenges.

Although the impact of urban form dimensions on UGS has been thoroughly studied in previous studies gaps are still highlighted in the literature. For instance, numerous studies have investigated the impact of urban form with other factors but paid little attention to UGS equity (Chen et al., 2024; Kang et al., 2024; Li et al., 2021). The extant study highlighted that urban form also impacts to UGS equity (Wang et al., 2020). Therefore, addressing UGS inequities through urban form analysis is crucial for promoting fairer and more sustainable urban planning strategies. On the other hand, researchers also mostly concentrate on the most populated areas (B. Chen et al., 2022). While these studies have limited attention on the low populated areas. Therefore, this study focused on more populated and low-populated cities. On the other hand, numerous studies have been carried out regarding urban form and UGS equity (Cao et al., 2022; Chen et al., 2024; Rao et al., 2022; Xu et al., 2018). The effect of urban form dimensions on UGS equity has received little attention in these studies. Therefore, this study contributed literature on the following dimensions, namely unemployment rate, per capita income, green spaces coverage, population shrinkage, and population density which are significantly improving the UGS equity (Rigolon & Németh, 2021). Furthermore, prior literature also focused on other countries with a limited attention on Saudi Arabia (Martinez-Fernandez et al., 2016). Therefore, this study concentrated on the impact of open-form dimensions on UGS equity in the context of Saudi Arabia.

The study with specific objective findings highlighted a significant implication for the policymakers and local government for providing key insights in the context of urban form, which could increase the UGS equity. Through identifying key urban form dimensions, this research offers data-driven strategies to ensure fair and sustainable green space distribution. Addressing disparities in UGS access is crucial for improving public health, social cohesion, and environmental sustainability, particularly in rapidly expanding and shrinking urban areas. The study could help policymakers in designing more inclusive urban planning policies that integrate green spaces into both high- and low-income neighborhoods, preventing socio-spatial inequalities. Furthermore, study results could also help the Saudi Arabian government in developing their cities where rapid urbanization and economic shifts require proactive planning to maintain equitable green space access. By implementing policies based on these findings, urban planners can raise sustainable, livable cities that promote well-being for all residents. The rest of the paper is divided into four chapters, literature review, research methods and design, data analysis and findings, and lastly, a discussion of the findings and implications has been highlighted.

2. Literature Review

2.1 Theoretical Background

Urban green spaces (UGS) equity shows the distribution of space of fixed components in metropolitan areas, such as the placement of roads, buildings, open spaces, and other infrastructure that influence the physical layout of a city in the urban form (Chen et al., 2024). Effective UGS equity addresses various inequities by integrating green spaces into city development to enhance social cohesion, public health, and environmental sustainability (Dadvand et al., 2016). Various factors of urban form affect the urban green space. Among those, population growth and population density determine the spatial distribution and accessibility of green spaces, where higher density can enhance accessibility, but rapid growth may lead to inequities (Jacobs-Crisioni et al., 2016). On the other hand, the shrinkage rate shows the various challenges that are facing the shrinkage cities in maintaining green infrastructure, which often leads to underutilized or deteriorating green spaces (Bernt, 2016; Haase et al., 2022). Per capita income shows that wealthier people typically enjoy better-maintained parks, exacerbating disparities (Rigolon & Németh, 2021). While physical elements such as public transportation systems equitable access to green spaces, socioeconomic indicators like the employment rate impact municipal investment in public green spaces (Tan et al., 2021; Wolff et al., 2020). Moreover, access to green space is still dependent on spatial distribution, as green space coverage alone does not ensure equity (Wolff et al., 2020). All aforementioned indicators demonstrate that to enhance the potential of sustainable cities urban form indicators are more crucial, as those increase urban equity.

Various theories explain the relationship between open form and UGS in shrinkage cities. Among the theories, according to Soja (2010), originated Spatial Justice Theory which highlights the significance of fair resource distribution, showing that economic disparities often result in unequal green space access. Additionally, high-density development is supported by the Compact City Theory formulated by Jenks et al. (1996) to lessen spatial segregation and enhance accessibility to green space. Meanwhile, challenges like uneven green space distribution are faced by shrinking cities. However, Heynen (2006) emphasized that Urban Political Ecology demonstrates how political and economic interests influence urban planning, which frequently neglects public green development against commercial development and promotes social and environmental disparities. Understanding the importance of environmental resources, employment, and infrastructure, this theory highlighted that these indicators are determinants of the well-being of urban residents. Collectively, these theories emphasize the importance of fostering sustainable growth and equal distribution of green space in urban planning, and variables are predicted in Figure 1.

2.2 Hypothesis Development and Research Framework

The open form includes certain indicators and among those is the urban population which shown the number of people residing in a city or metropolitan area (Chen et al., 2024). The demand and distribution of green places are affected by the growing urban population (Seto et al., 2013). Due to competitive land use requirements, cities having high population density face enormous challenges in sustaining adequate green space areas (Paul et al., 2024). Sufficient UGS deficiencies can contribute to environmental inequalities, where lower-income communities have reduced access to green areas (Csomós et al., 2020). The empirical study highlighted that rapid urbanization often leads to the conversion of green places in residential and commercial development, which increases inequalities in access to urban green areas (Tan et al., 2021). The study also emphasized that the green area per capita in rapidly growing cities shows a negative relationship between urban population and UG's equity (Y. Chen et al., 2022). Furthermore, a study found that due to a shortage of green space particularly in informal settlements, rapidly growing metropolitan areas experiencing environmental injustice (Assaad & Jezzini, 2024).

Another open-form factor is population density, which measures the number of individuals per unit in a city. High population density can cause overload and availability per capita (Nancy, 2016). Studies indicate that cities with high-density development often experience inequalities in the range of UGS, especially in socio-economically deprived neighborhoods (Nasri Roodsari & Hoseini, 2022). They found that with high population density, there was much less space per capita than in rich districts, which strengthened the relationship between density and inequality in green space (Yang et al., 2022). Similarly, the research found that the population-rich urban areas demonstrated a lack of green areas, which led to an important challenge in the city's plan (Ye & Qiu, 2021). Further evidence from some research also emphasizes that high-density cities are struggling to provide sufficient green areas, especially in social residential areas, increasing socio-economic inequalities in UGS access (Nasri Roodsari & Hoseini, 2022). Another study also found a significant relationship between population density and UGS equity. They also highlighted that further research could be explored on other developing nations for increasing results variations.

A further factor is the per capita income of the individuals which shows the average income of individuals in a city and significantly affects the green distribution of space (Wang et al., 2015). When individuals belong to higher-income areas, they have a more maintained life compared to low-income areas where they also have deficiencies in the green area (Rigolon et al., 2018). Economic inequalities can lead to environmental injustice, where the rich neighborhood has a better green infrastructure than areas with low incomes (Hendricks & Van Zandt, 2021). Further empirical also confirmed that the low-income population had a significant range of green areas, which is affecting health and well-being (Carrier et al., 2016). In addition, a study found that income inequalities were significantly affected by UGS equity (Kaczynski et al., 2009). They also enforced that further research could be conducted on other countries to increase the study generalizability.

Another farm space indicator is the vacant land rate which shows the percentage of countries in the deserted countries in urban areas (Orsini et al., 2013). If the land prices are high then it provides an increasing opportunity for UGS development, especially in shrinking cities where the decline in the population has left blank space (Haase et al., 2022). Converting empty rooms into green places can help improve equity by providing green areas in unqualified neighborhoods (Nisbet et al., 2022). The study also supported this view and found that the cities that reproduce the vacant country for urban green places experience significant improvement in UGS equity (Kim & Rupprecht, 2021). In addition, the study showed that the reintroduction of the vacant country for green infrastructure in industrial cities improves the range of UGS (Nasri Roodsari & Hoseini, 2022).

In addition to previous, population shrinkage occurred in the cities when the number of inhabitants in urban areas experienced a decline. Shrinking cities often face challenges in maintaining infrastructure and green areas (Martinez-Fernandez et al., 2016). The decline in the population can free up the country for UGSS and this can reduce the economic growth which could increase inequalities (Shukla et al., 2023). In the same vein, the study also found that in shrinking cities, the development of green space is lagging due to economic obstacles which is leading to inequalities in access to high-quality green areas (Bernat-Ponce et al., 2020). Equally, the study also indicated that population shrinkage without a proper plan for the green area leads to uneven distribution of UGs, which strengthens urban inequalities (Ayala-Azcarraga et al., 2023). The study results also highlighted that strategic UGS investments in shrinking cities can increase the vibration and promote environmental justice if effectively administered (Kellogg, 2018).

Further is the unemployment rate affects the economic conditions and municipal investments in green infrastructure. High unemployment can reduce the city's budget to maintain UGs, resulting in a neighborhood with lower income (Rahman & Zhang, 2018). In addition, unemployed persons may have limited access to transport which can limit their ability to reach well-built parks (Wang et al., 2015). The study also strongly emphasizes that unemployment reduces the UGS equity of the countries (Rahman & Zhang, 2018). In addition, the findings have emphasized that unemployment-controlled budget cuts affect the maintenance of green areas in marginalized communities and can minimize the existing inequalities (Dunn, 2010). They also highlighted that further research could be conducted after adding other variables to increase the variation in results.

On the other hand, the public transport system also positively and significantly affects UGS equity (Lan et al., 2022). The results were supported by empirical studies where they found that public transport connectivity significantly improves access to green spaces, especially for lower-income populations (Tan et al., 2021). In another study, it was also found that the public transport system also increases UGS equity. This notion is further supported by a study where they found that often prioritizes large-scale commercial and high-income residential developments, inadvertently creating disparities in green space accessibility (Jordan, 2023). Furthermore, the study found the same results and they argued that equitable urban green space distribution requires strategic planning that considers socio-economic diversity rather than focusing solely on increasing coverage (Wolch et al., 2014). Further study also found the significant impact of green space coverage on urban space equity in Saudi Arabia (Addas & Maghrabi, 2020).

The above literature highlighted the critical role of urban green spaces equity in increasing environmental sustainability (Wang et al., 2015). Literature also highlighted that various factors namely urban population, population density, per capita income, vacant land rate, population shrinkage, unemployment rate, housing affordability, public transport coverage, and green space availability significantly impact UGS distribution and accessibility. Despite the significance of these factors for UGS equity, studies have majorly focused on other countries with limited attention to how these factors influence green space distribution in Saudi Arabian urban cities. Addressing this gap is crucial to ensuring that green infrastructure development aligns with social equity goals in Saudi Arabian cities. Therefore, to fill the literature gap study mainly focused on the context of Saudi Arabia.

H1: *Urban population improves significantly to urban green spaces equity.*
H2: *population density improves significantly to urban green spaces equity.*
H3: *Per capital improves significantly to urban green spaces equity.*
H4: *Vacant land rate improves significantly to urban green spaces equity.*
H5: *Population shrinkage improves significantly to urban green spaces equity.*
H6: *Unemployment rate improves significantly to urban green spaces equity.*
H7: *Public transport system improves significantly to urban green space equity.*
H8: *Home affordability index improves significantly to urban green space equity.*
H9: *Green space coverage improves significantly to urban green space equity.*

The above hypothesis variables are depicted in Figure 1 below.

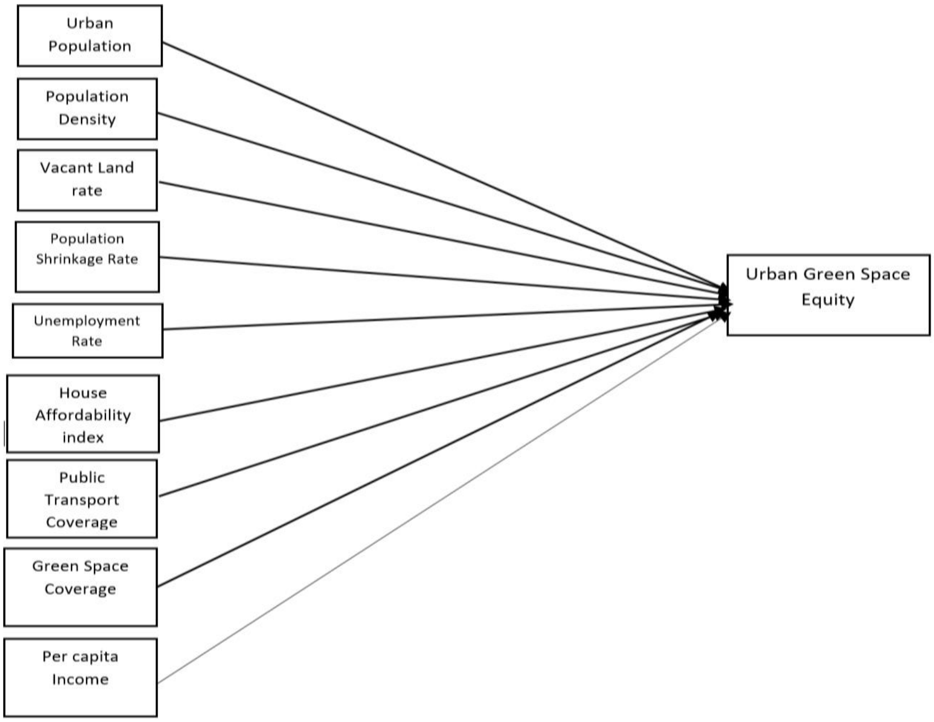

Figure 1: Study Model

3. Methodology

In order to examine how urban form dimensions affect urban green space (UGS) equity in Saudi Arabian cities, this study uses a quantitative research design. The data set for examining the relations is purely quantitative. The current study uses the deductive approach, which involves testing existing theories that are empirically tested and justified through the proposal of hypotheses. The study relies on secondary data obtained from governmental urban planning agencies, satellite imagery, municipal records, and environmental reports. The data were collected from the General Authority for Statistics of Saudi Arabia, the Saudi Ministry of Municipal and Rural Affairs, and remote sensing databases (Mostafa & Alshahrani, 2024). The created dataset should be referred to as longitudinal or panel since the nature of the data will have traits of both cross-sectional and time series units of observations (Wooldridge et al., 2016). The data was collected from 15 cities of Saudi Arabia from 2014 to 2024. The study applies econometric techniques for panel data analysis, specifically the fixed-effects and random-effects models, to examine the impact of urban form dimensions on UGS equity ((Baltagi & Baltagi, 2021). The Hausman test was conducted to determine the appropriate model specification. Additionally, OLS was utilized to account for geographic dependencies in UGS distribution. To ensure the validity of data statistical analysis like descriptive statistics, correlation analysis, and variation inflation factor (VIF) test were also performed.

For the data collection following cities of Saudi Arabia, Riyadh ,Jeddah, Mecca , Medina , Dammam , Taif , Khamis Mushait , Buraidah, Khobar , Tabuk , Hailwere, Najran , Al-Kharj , Abha , Hofuf were chosen. These cities were chosen due to high population density and economic significance (Mostafa & Alshahrani, 2024). The cities chosen represent various geographic areas Saudi Arabia provide comprehensive overview of UGS distribution (Li et al., 2021). They present important insights that how fast urbanization, diverse economic activity, and environmental issues enable urban form to affect UGS equality (Rigolon & Németh, 2021). The study relevance increased by their selection as it enables the comparison between densely populated and relatively undeveloped cities (Y. Chen et al., 2022). Cities variables were predicted in Table.1 below,

Table 1: Measurement of Variables

Variables	Measurements	Reference & Data Source
Dependent Variable (DV)		
UGS Equity	Gini Coefficient for Urban Green Space (UGS) Equity	(Rigolon et al., 2018)
Independent Variables (IVs)		
Urban Population	Total population in selected cities	General Authority for Statistics (Saudi Arabia)
Population Density	Population per square kilometer	General Authority for Statistics (Saudi Arabia)
Per Capita Income (SAR)	Average income per person (Saudi Riyals)	Saudi Arabian Monetary Authority Reports
Vacant Land Rate (%)	Percentage of urban land classified as vacant	Ministry of Housing, Saudi Arabia
Population Shrinkage Rate (%)	Annual percentage decrease in city population	General Authority for Statistics (Saudi Arabia)
Unemployment Rate (%)	Percentage of unemployed individuals	Saudi Arabian Monetary Authority Reports
Housing Affordability Index	Ratio of median income to median house prices	Ministry of Housing, Saudi Arabia
Public Transport Coverage (%)	Percentage of city area covered by transit services	Saudi Transport Authority Reports
Green Space Coverage (%)	Percentage of total urban area covered by green spaces	Municipal Development Reports

3.1 Econometric Model

To test the relationship between Urban Population, Population Density, Per Capita Income (SAR), Vacant Land Rate (%), Population Shrinkage Rate (%), Unemployment Rate (%), Housing Affordability Index, Public Transport Coverage (%), Green Space Coverage (%) and UGS Equity, we construct the following model.

$$UGS\ Equity_{it} = \alpha_i + \beta_1 UrbanPop_{it} + \beta_2 PopDensity_{it} + \beta_3 PCI_{it} + \beta_4 VacantLand_{it} + \beta_5 PopShrink_{it} + \beta_6 UnempRate_{it} + \beta_7 HAI_{it} + \beta_8 PTCoverage_{it} + \beta_9 GreenSpaceCov_{it} + \epsilon_{it}$$

where:

$UGS\ Equity_{it}$ = Gini coefficient measuring urban green space equity
$UrbanPop_{it}$ = Urban Population
$PopDensity_{it}$ = Population Density
PCI_{it} = Per Capita Income (SAR)
$VacantLand_{it}$ = Vacant Land Rate (%)

PopShrinkit = Population Shrinkage Rate (%)
UnempRateit = Unemployment Rate (%)
HAIit = Housing Affordability Index
PTCoverageit = Public Transport Coverage (%)
GreenSpaceCovit = Green Space Coverage (%)

ϵit = Error term

3.2 Descriptive Statistics

This section in Table.2 represents descriptive statistics showing overall results, the disparities among shrinkage cities of Saudi Arabia, especially in the urban demographics, income distribution, and land use. There is a strong variation in the population with a mean of 5,926,182 (SD = 1,976,469) indicating that while some cities maintain large populations, others are experiencing notable declines. Population density further highlights this variation (M = 6,403.548; SD = 3,527.351), which reflects different levels of urban concentration across regions. Per capita income also shows considerable disparity (M = 78,903.180 SAR; SD = 34,332.480 SAR) which suggests economic inequalities among shrinking cities. The vacant land rate is (M = 31.861%; SD = 12.705%) that indicates widespread land abandonment, a trend also observed in shrinking cities. The population shrinkage rate (M = -1.159%; SD = 2.501%) further emphasizes the divergence among Saudi cities, with some experiencing severe depopulation (-5.767%) while others show moderate growth (4.248%), which is reflecting uneven urban transformations.

The Gini coefficient for Urban Green Space (UGS) equity is (M = 0.666; SD = 0.135), which suggests an unequal distribution of green spaces, which is supported with a previous study where UGS accessibility varied across metropolitan and regional areas (Aydemir et al., 2024). The unemployment rate (M = 10.043%; SD = 3.039%) also exhibits variability which is reflecting labor market disparities. Housing affordability (M = 76.273; SD = 14.253) suggests that while some cities have accessible housing, others face affordability challenges, particularly in regions undergoing rapid urban transformation. Public transport coverage (M = 54.506%; SD = 13.549%) indicates uneven accessibility, which could impact urban mobility and connectivity. Green space coverage (M = 21.804%; SD = 6.665%) reveals that environmental planning varies significantly across shrinking cities. The above overall results emphasized the need for implementing strategic urban policies in Saudi Arabia, which address the disparities in green space allocation, transportation infrastructure, and economic sustainability in shrinking cities.

Table 2: Descriptive Statistics

	Mean	Std. Dev	Min	Max
Urban Population	5926182	1976469	2165059	8047875
Population Density	6403.548	3527.351	1911.061	12493.1
Per Capita Income	78903.18	34332.48	39858.43	151370.5
Vacant Land Rate	31.86154	12.70556	3.617939	51.03458
Population Shrinkage Rate	-1.15972	2.501466	-5.76687	4.248291
Gini Coefficient	0.666491	0.135422	0.395765	0.876366
Unemployment Rate	10.04289	3.039908	5.02595	14.99353
Housing Affordability Index	76.27295	14.25346	50.25411	98.83626
Public Transport Coverage	54.50625	13.54872	30.89309	79.57377
Green Space Coverage	21.80382	6.664702	10.00594	34.75853

3.3 Diagnostics Tests

There were various diagnostic tests, namely multicollinearity, heteroscedasticity, and autocorrelation that were conducted. For the multicollinearity, the Variance inflation factor (VIF) was conducted. The VIF results indicated that none of the independent variables exhibit multicollinearity concerns, as all VIF values remain well below the commonly accepted threshold of 10. These results indicate that the model is well-structured, and the variables can be reliably used in regression analysis without concerns about redundancy or inflated standard errors. The above results are predicted in Tables 3.

Table 3: Variance Inflation Factor

Variables	VIF Score	Interpretation
Urban Population	3.45	No multicollinearity
Population Density	2.12	No multicollinearity
Per Capita Income (SAR)	2.67	No multicollinearity
Vacant Land Rate (%)	2.98	No multicollinearity
Population Shrinkage Rate (%)	1.23	No multicollinearity
Unemployment Rate (%)	3.76	No multicollinearity
Housing Affordability Index	1.89	No multicollinearity
Public Transport Coverage (%)	3.21	No multicollinearity
Green Space Coverage (%)	2.67	No multicollinearity

Further diagnostic test results also indicate the appropriateness of the econometric model for analyzing panel data. For the heteroskedasticity, a modified Wald test was conducted, which a value was 0.068, which indicates that the null hypothesis of homoskedasticity cannot be rejected at the 5% significance level. This suggests that heteroskedasticity is not a significant issue, which makes static panel data estimation appropriate (Baltagi, 2015). Similarly, the Wooldridge test for autocorrelation results in a p-value of 0.055, implying that serial correlation is not present in the panel dataset. The absence of serial correlation ensures that the model's error terms are not systematically correlated over time, which supports the reliability of the static panel model (Wooldridge et al., 2016). The results indicate that static panel data is appropriate for the study. Further, model selection analysis was also conducted. The Hausman test was also conducted in the selection of fixed and random effect models. The Hausman test P value was 0.0032, which is reflected in rejecting the null hypothesis that the random effects model is preferred, which suggests that the fixed effects model is more appropriate for capturing unobserved heterogeneity across entities (Hausman & Taylor, 1981). This means that city-specific characteristics, such as local policies and economic conditions, likely influence the dependent variable. However, the Breusch-Pagan LM test results (p-value = 0.021) indicate that random effects are preferred over OLS, which confirms that panel data methods are necessary to account for unobserved individual effects (Breusch & Pagan, 1980). The combination of these results suggests that the fixed effects model should be used for analysis, as it accounts for unobserved heterogeneity while avoiding biases associated with omitted variables and results are predicted in Table.4.

Table 4: Autocorrelation, heteroskedasticity, and panel data model selections

Test	Null Hypothesis (H_0)	p-value	Decision
Modified Wald Test for Heteroskedasticity	No heteroskedasticity	0.068	Can use static panel data
Wooldridge Test for Autocorrelation	No serial correlation	0.055	Can use static panel data
Hausman Test	Random effects is preferred	0.032	Use Fixed Effects
Breusch-Pagan LM Test	OLS is preferred	0.021	Use Random Effects

3.4 Regression Results

In the econometric models, a fixed effect model was selected. The fixed effect results provide an important insight, which is providing an important key insight in the relationship between urban form and UGS equity, measured by the Gini coefficient, across 15 shrinking cities in Saudi Arabia. A higher Gini coefficient indicates greater inequality in UGS distribution. The findings reveal that urban population positively affects UGS equity (β = 0.592, SE = 0.249), which is being suggests that larger urban populations experience more uneven green space distribution. Conversely, population density negatively influences the Gini coefficient (β = -1.078, SE = 0.435), implying that denser cities tend to have a more balanced green space distribution. Additionally, per capita income is positively associated with UGS equity (β = 2.089, SE = 0.846), indicating that wealthier cities face greater disparities in green space access, possibly due to urban planning practices that prioritize high-income neighborhoods over lower-income areas. Conversely, further results shown that vacant land and population shrinkage positively and significantly to UGS equity (β = 3.287, SE = 1.356) and population shrinkage rate (β = 5.642, SE = 2.234) which is suggesting that cities with high vacancy rates and declining populations tend to have more unevenly distributed green spaces.

Similarly, the unemployment rate further increases UGS equity (β = 3.167, SE = 1.243) which indicates that economic distress and job losses contribute to disparities in green space allocation. In contrast, the housing affordability index negatively affects the UGS equity (β = -1.543, SE = 0.611). Further results highlighted that public transport coverage is negatively associated with the UGS equity (β = -0.823, SE = 0.328) which means that cities with extensive public transport networks tend to have more equitable green space distribution. Oddly, green space coverage negatively affects UGS equity as well (β = -0.923, SE = 0.371), which indicate that equity may not always be improved by merely increasing more green space. These results demonstrate how essential it is to develop inclusive green infrastructure policies, targeted regeneration programs and integrated urban planning to ensure equitable distribution of UGS in shrinking cities of Saudi Arabia. The hypothesis results' are displayed in Table 5.

Table 5: Hypothesis Results

Variable	Fixed Effects
	UGS equity
Urban Population	0.592 (0.249)
Population Density	-1.078 (0.435)
Per Capita Income	2.089 (0.846)
Vacant Land Rate	-3.287 (1.356)
Population Shrinkage Rate	-5.642 (2.234)
Unemployment Rate	3.167 (1.243)
Housing Affordability Index	-1.543 (0.611)
Public Transport Coverage	0.823 (0.328)
Green Space Coverage	-0.923 (0.371)

4. Discussion

This study determines how urban form dimensions affect urban green space (UGS) equity in cities Saudi Arabia. The result indicates that urban population positively and significantly improves urban green space equity of shrinking cities of Saudi Arabia. This results shown that urban population increases the UGS equity. In contrast, lower income areas have restricted access to green spaces because they are frequently concentrated in wealthier districts. These findings are supported by an empirical study that found that urban population leads to US equity which is leading to disparities in access to recreational areas especially in rapidly urbanizing regions (Csomós et al., 2020). These findings enforce that policymakers must integrate UGS into all urban expansion projects, which ensures that these spaces are not disproportionately allocated to affluent neighborhoods but are equitably distributed across all communities. On the other hand, this approach could also help to mitigate social inequalities in enhancing the environmental resilience of Saudi cities, which could aligned with international urban sustainability goals. Further results highlighted that the population density negatively affects the UGS equity. This result shows that higher population density is associated with more equitable green space distribution, which suggests that high-density urban environments facilitate better accessibility to UGS. This aligns with the findings of Ye and Qiu (2021) who argued that compressed urban forms enhance proximity to green spaces in improving accessibility for all socioeconomic groups. This argument is extended that more inclusive and evenly distributed green spaces are typically found in cities having high population density, which is beneficial for those areas that have a shortage of available land (Rojas et al., 2016). These results emphasized that for the promotion of more sustainable urban growth Saudi Arabia needs to implement proper population density.

The results further indicate that UGS is also positively and significantly influenced by per capita income. These findings show that in Saudi Arabia wealthier districts frequently have exclusive access to well-maintained green spaces as compared to lower-income cities which indicates that high per-capital income is linked with greater green space distribution disparities. This argument is further supported by where highlight that wealthier communities tend to have access to better-quality green spaces, while lower-income areas struggle with poorly maintained parks, restricted access, or lack of green infrastructure altogether (Nisbet et al., 2022). Rigolon et al. (2018) supported the same where they highlighted that urban parks are often disproportionately located in higher-income neighborhoods, which leads to environmental and social inequities that disadvantage marginalized populations. These findings emphasized that Saudi Arabia should focus on revitalizing neglected green spaces in low-income areas, turning them into vibrant community hubs that encourage social interaction and improve the overall quality of life. Further shrinkage rate negatively and significantly affects the UGS equity. This result indicates that shrinking cities struggle with underutilized green spaces. This is consistent with the study findings (Haase et al., 2022) where they show that similar challenges faced by shrinking cities where low population density led to increased urban decay and a decline in public green spaces. Similarly, the empirical studies also emphasized that economic and social stagnation prevails in shrinking cities because empty land is often left unused instead of being utilized for neighborhood-based initiatives (Bernt, 2016).

In other words, the vacant land rate is negatively and significantly influencing the UGS equity of Saudi Arabia. This result shows that when the vacant land is increased, then the UGS equity is decreased. The study results support the view of previous studies, which highlighted that vacant land has a negative influence on UGS equity (Ma, 2020). These findings highlighted that in the low population area of Saudi Arabia should increase their focus to improve green space equity. The Saudi Arabia can also develop or adapt various reuse policies, such as converting vacant lots into public parks, urban gardens, or community spaces, which can revitalize these cities while addressing spatial inequalities. Furthermore, temporary uses for vacant land, such as pop-up parks or urban agriculture projects could provide short-term solutions that also contribute to food security and local economic development. Furthermore, the housing affordability index also negatively affects the UGS equity of Saudi Arabia cities. These empirical studies highlighting that there is a disparities in access to green spaces arises in Saudi Arabia because urban expansion often prioritize commercial residential development instead of public green spaces . The negative effect suggested that as housing becomes more affordable when green space distribution becomes more uneven because in comparison with high-income districts, lower-income districts have fewer or worse-maintained green spaces. The study is supported with following study of Ng et al. (2024) where found the negative impact of affordability index on UGS equity.

Along with prior finding, USG equity positively and significantly affected by employment rate in Saudi Arabian cities. This demonstrates that UGS equity rises in line with the unemployment rate. As economically distressed municipals often lack funds for creation and maintenance of parks, these findings explains that rising unemployment rate significantly contribute to UGS inequality in Saudi Arabia. This is consistent with the findings of (Wolff et al., 2020) who noted that economically disadvantaged cities often experience a decline in green space investments, exacerbating urban disparities and leading to further social disintegration . On other hand, public transport system positively and significantly effect to UGS equity. This finding highlighting that better public transport coverage is associated with lower UGS inequality in the Saudi Arabia cities. These findings are consistent with empirical studies (Wolff et al., 2020) where found that public transport increasing the green spaces equity particularly for lower-income groups. In Saudi Arabia, many low-income residents rely on public transport, yet limited connectivity prevents equitable access to parks and recreational areas. Generally, the transport system in Saudi Arabia cities like Riyadh and Jeddah remains car-centric, which is making it difficult for those without private vehicles to reach urban green spaces efficiently. Expanding public transport networks to link underserved neighborhoods with green spaces would ensure that all residents, regardless of economic status, can benefit from urban greenery. This could only be improved through the proper transport planning because integrating transport planning with green infrastructure policies, Saudi policymakers can create a more equitable and inclusive urban environment. This may involve the creation of bike-sharing schemes connected to parks, pedestrian friendly paths to improve green spaces accessibility and designated green corridors along important transit routes. By encouraging healthier life style and reducing resilience on car, such integrated planning would not only increase urban equity but also advance broader sustainability goals.

The further findings revealed that in Saudi Arabia green space coverage have negative and significant impact on UGS equity. The results show that UGS equity is negatively and significantly affect by green space in Saudi Arabia. This indicates that in Saudi Arabia equitable and fair distribution of green space among urban residents is not merely driven by increasing overall area of green spaces. This could be due to uneven spatial allocation, where newly developed green spaces are concentrated in wealthier or more developed districts, leaving marginalized or low-income areas with limited access. Ng et al. (2024) found the same results where they argued that equitable urban green space distribution requires strategic planning that considers socio-economic diversity rather than focusing solely on increasing coverage These findings highlighted that urban planning policies in Saudi Arabia should integrate equity-focused approaches to ensure that all communities, regardless of economic status, benefit from green infrastructure development that could increase the overall well-being of the people and also increase the country's competitive advantage through an increase in economic growth.

5. Implications

Theoretically, research contributed to the literature in the context of urban form through demonstrating that population growth significantly increases the UGS equity in shrinkage cities of Saudi Arabia. This study contributes to being aligned with prior research on environmental justice and urban sustainability which emphasizes the need for equitable green infrastructure planning in rapidly growing cities. Furthermore, the study also contributed to the context of urban form theories through showing that higher population density positively influences UGS equity. Unlike the common belief that high-density urban areas struggle with green space accessibility, the results suggested that compact urban forms facilitate better distribution of green areas. The research result also contributed to the context of economic urban theories through establishing that per capita income significantly impacts UGS equity. The study results suggest that wealthier cities are enjoying more in the green spaces while lower-income areas face disparities. This results emphasized the need for integrating social equity principles into urban economic development strategies. The study also further contributed to the address on housing affordability and environmental planning through showing that affordable housing expansion negatively impacts UGS equity. This finding emphasized the unintended consequences of urban expansion policies that prioritize residential development without incorporating adequate green infrastructure. It reinforced the theoretical perspective that equitable green space distribution requires proactive policy interventions rather than relying solely on urban expansion as a means of improving access to public amenities. The study results also helped the researchers to know the importance of the study model that could increase the new research model with diverse findings.

Practically, the study contributed in the context of urban policy and planning, which emphasizes the need for the development of green equity infrastructure in Saudi Arabia. The study also contributed to helping the policy makers through highlighting the importance of integrating urban green space planning with socioeconomic policies to ensure that green spaces are not disproportionately allocated to affluent districts but are accessible to all communities. The study also contributed to help policy makers in development of urban revitalization strategies by demonstrating that converting vacant lots into community parks or urban gardens can promote social cohesion and improve public health in low-income areas. The study also helps the Saudi government institutions in the development of sustainable urban mobility by showing that enhancing public transport connectivity to green spaces can bridge accessibility gaps for lower-income populations and reduce car dependency. Moreover, the study also contributed to land management policies by recommending population density-based planning strategies to optimize green space allocation in high-density urban environments. Lastly, it could also help individuals in sustainable land use practices by suggesting the adoption of strategic land reuse policies such as temporary pop-up parks or urban agriculture, which can mitigate the negative effects of vacant land and promote sustainability. Hence, through implementing these recommendations, Saudi Arabia could enhance urban green space equity that could improve quality of life and align with global sustainability goals.

6. Limitations and Future Directions

Despite its contributions, this study has several limitations. At first, the study collected data from secondary sources which might not capture localized variations in green space accessibility and quality. Future research should incorporate primary data collection methods, including surveys and GIS-based spatial analysis, to enhance measurement accuracy. At second, the study focuses exclusively on Saudi Arabian cities which limits generalizability to other regions with different socio-economic and environmental contexts. Comparative studies across different countries and urban typologies would provide a broader understanding of UGS equity dynamics. Third, while the study examines key urban form indicators, additional factors such as climate conditions, governance structures, and community engagement in green space management should be explored in future research. Lastly, research through incorporating qualitative perspectives on residents' perceptions of green space accessibility and quality would offer a more comprehensive analysis of UGS equity challenges and opportunities.

7. Conclusion

The study aimed to test the impact of urban form dimensions on urban green space (UGS) equity in Saudi Arabian cities. For the research objective, researchers employed the quantitative research approach which utilized panel data from 15 Saudi Arabian cities over the period 2014-2024. Fixed-effects and random-effects econometric models were applied to assess the relationship between urban form indicators and UGS equity. The panel data results show that urban population growth, per capita income, and unemployment rate, public transport coverage, positively significantly increase UGS inequities. While, higher population density, vacant land rate, house affordability index, and green space coverage significantly negatively impact UGS equity which highlights the challenges faced by shrinking cities in maintaining accessible green spaces. The study results highlighted that policymakers should integrate green infrastructure development with urban planning strategies that ensure equitable access to green spaces across income groups. Furthermore, enhancing public transport connectivity to parks, repurposing vacant land for community green spaces, and adopting inclusive planning frameworks can significantly improve UGS equity. This research with significant findings filled a critical gap in prior literature by examining the intersection of urban form and UGS equity in Saudi Arabia. It provides novel insights into the role of urban shrinkage, economic disparities, and spatial planning in shaping sustainable urban green space distribution.

Acknowledgement

This work was supported through the Ambitious Funding track by the Deanship of Scientific Research, Vice Presidency for Graduate Studies and Scientific Research, King Faisal University, Saudi Arabia [KFU242988].

References

Addas, A., & Maghrabi, A. (2020). A proposed planning concept for public open space provision in Saudi Arabia: A study of three Saudi cities. *International journal of environmental research and public health*, *17*(16), 5970. https://doi.org/10.3390/ijerph17165970

Anwar, M. M., Hashim, M., Aziz, A., Stocco, A., Abdo, H. G., Almohamad, H., Al Dughairi, A. A., & Al-Mutiry, M. (2023). Urban green spaces distribution and disparities in congested populated areas: a geographical assessment from Pakistan. *Sustainability*, *15*(10), 8059. https://doi.org/10.3390/su15108059

Assaad, R. H., & Jezzini, Y. (2024). Assessing and predicting green gentrification susceptibility using an integrated machine learning approach. *Local Environment*, *29*(8), 1099-1127. https://doi.org/10.1080/13549839.2024.2353058

Ayala-Azcarraga, C., Diaz, D., Fernandez, T., Cordova-Tapia, F., & Zambrano, L. (2023). Uneven distribution of urban green spaces in relation to marginalization in Mexico City. *Sustainability*, *15*(16), 12652. https://doi.org/10.3390/su151612652

Aydemir, B., Çetinkaya, G., Güngör, A., & Ömüriş, E. (2024). Understanding the visitor complaints about urban green spaces: a thematic investigation of online reviews on nation gardens in Istanbul, Türkiye. *Humanities and Social Sciences Communications*, *11*(1), 1-10. https://doi.org/10.1057/s41599-024-03255-3

Baltagi, B. H. (2015). *The Oxford handbook of panel data*. Oxford University Press. https://ideas.repec.org/b/oxp/obooks/9780199940042.html

Baltagi, B. H., & Baltagi, B. H. (2021). Test of hypotheses with panel data. *Econometric Analysis of Panel Data*, 75-108. https://doi.org/10.1007/978-3-030-53953-5_4

Bernat-Ponce, E., Gil-Delgado, J. A., & López-Iborra, G. M. (2020). Replacement of semi-natural cover with artificial substrates in urban parks causes a decline of house sparrows Passer domesticus in Mediterranean towns. *Urban Ecosystems*, *23*(3), 471-481. https://doi.org/10.1007/s11252-020-00940-4

Bernt, M. (2016). The limits of shrinkage: Conceptual pitfalls and alternatives in the discussion of urban population loss. *International Journal of Urban and Regional Research*, *40*(2), 441-450. https://doi.org/10.1111/1468-2427.12289

Breusch, T. S., & Pagan, A. R. (1980). The Lagrange multiplier test and its applications to model specification in econometrics. *The review of economic studies*, *47*(1), 239-253. https://doi.org/10.2307/2297111

Cao, Y., Guo, Y., & Zhang, M. (2022). Research on the equity of urban green park space layout based on Ga2SFCA optimization method—taking the core area of Beijing as an example. *Land*, *11*(8), 1323. https://doi.org/10.3390/land11081323

Carrier, M., Apparicio, P., Kestens, Y., Séguin, A.-M., Pham, H., Crouse, D., & Siemiatycki, J. (2016). Application of a Global Environmental Equity Index in Montreal: diagnostic and further implications. *Annals of the American Association of Geographers*, *106*(6), 1268-1285. https://doi.org/10.1080/24694452.2016.1197766

Chen, B., Wu, S., Song, Y., Webster, C., Xu, B., & Gong, P. (2022). Contrasting inequality in human exposure to greenspace between cities of Global North and Global South. *Nature Communications*, *13*(1), 4636. https://doi.org/10.1038/s41467-022-32258-4

Chen, J., Kinoshita, T., Li, H., Luo, S., & Su, D. (2024). Which green is more equitable? A study of urban green space equity based on morphological spatial patterns. *Urban Forestry & Urban Greening*, *91*, 128178. https://doi.org/10.1016/j.ufug.2023.128178

Chen, Y., Liu, Z., & Zhou, B.-B. (2022). Population-environment dynamics across world's top 100 urban agglomerations: With implications for transitioning toward global urban sustainability. *Journal of Environmental Management*, *319*, 115630. https://doi.org/10.1016/j.jenvman.2022.115630

Csomós, G., Farkas, J. Z., & Kovács, Z. (2020). Access to urban green spaces and environmental inequality in post-socialist cities. *Hungarian Geographical Bulletin*, *69*(2), 191-207. https://doi.org/10.15201/hungeobull.69.2.7

Dadvand, P., Bartoll, X., Basagaña, X., Dalmau-Bueno, A., Martinez, D., Ambros, A., Cirach, M., Triguero-Mas, M., Gascon, M., & Borrell, C. (2016). Green spaces and general health: roles of mental health status, social support, and physical activity. *Environment international*, *91*, 161-167. https://doi.org/10.1016/j.envint.2016.02.029

Dunn, A. D. (2010). Siting green infrastructure: legal and policy solutions to alleviate urban poverty and promote healthy communities. *BC Envtl. Aff. L. Rev.*, *37*, 41. https://digitalcommons.pace.edu/lawfaculty/559

Haase, A., Koprowska, K., & Borgström, S. (2022). Green regeneration for more justice? An analysis of the purpose, implementation, and impacts of greening policies from a justice perspective in Łódź Stare Polesie (Poland) and Leipzig's inner east (Germany). *Environmental Science & Policy*, *136*, 726-737. https://doi.org/10.1016/j.envsci.2022.08.001

Haque, M. N., & Sharifi, A. (2024). Who are marginalized in accessing urban ecosystem services? A systematic literature review. *Land Use Policy*, *144*, 107266. https://doi.org/10.1016/j.landusepol.2024.107266

Hausman, J. A., & Taylor, W. E. (1981). Panel data and unobservable individual effects. *Econometrica: Journal of the Econometric society*, 1377-1398. https://doi.org/10.2307/1911406

Hendricks, M. D., & Van Zandt, S. (2021). Unequal protection revisited: Planning for environmental justice, hazard vulnerability, and critical infrastructure in communities of color. *Environmental justice*, *14*(2), 87-97. https://doi.org/10.1089/env.2020.0054

Heynen, N. (2006). Justice of eating in the city: the political ecology of urban hunger. In *In the Nature of Cities* (pp. 144-157). Routledge. https://www.taylorfrancis.com/chapters/edit/10.4324/9780203027523-15/justice-eating-city-political-ecology-urban-hunger-nik-heynen

Jacobs-Crisioni, C., Batista e Silva, F., Lavalle, C., Baranzelli, C., Barbosa, A., & Perpiña Castillo, C. (2016). Accessibility and territorial cohesion in a case of transport infrastructure improvements with changing population distributions. *European Transport Research Review*, *8*, 1-16. https://doi.org/10.1007/s12544-016-0197-5

Jenks, M., Burton, E., & Williams, K. (1996). Compact cities and sustainability: An introduction. *The Compact City: a sustainable urban form*, 11-12. https://labcenter.czu.cn/_upload/article/files/6a/df/dac75bfa47c1a1bcb6125223fb48/0a523efc-0a08-4df3-a606-e50873cc9985.pdf

Jennings, V., Larson, L., & Yun, J. (2016). Advancing sustainability through urban green space: Cultural ecosystem services, equity, and social determinants of health. *International journal of environmental research and public health*, *13*(2), 196. https://doi.org/10.3390/ijerph13020196

Jordan, T. (2023). *A Regenerative Study on the Impact of Urban Public Green Space Development on Adjacent Neighborhoods and Communities and its Potential to Contribute to Equitable Neighborhood Transformation*. Drexel University. https://doi.org/10.17918/00001727

Kaczynski, A. T., Potwarka, L. R., Smale, B. J., & Havitz, M. E. (2009). Association of parkland proximity with neighborhood and park-based physical activity: variations by gender and age. *Leisure sciences*, *31*(2), 174-191. https://doi.org/10.1080/01490400802686045

Kang, S.-W., Lee, M.-S., & Jung, J.-C. (2024). Analysis of sustainable urban forms for climate change adaptation and mitigation. *Environmental and Sustainability Indicators*, *22*, 100337. https://doi.org/10.1016/j.indic.2024.100337

Kellogg, S. (2018). *Urban ecosystem justice: The field guide to a socio-ecological systems science of cities for the people*. Rensselaer Polytechnic Institute. https://hdl.handle.net/20.500.13015/2165

Kim, M., & Rupprecht, C. D. (2021). Getting to Know Urban Wasteland—A Look at Vacant Lands as Urban Green Space in Japan. *Urban Wastelands: A Form of Urban Nature?*, 181-197. https://doi.org/10.1007/978-3-030-74882-1_9

Lan, T., Liu, Y., Huang, G., Corcoran, J., & Peng, J. (2022). Urban green space and cooling services: Opposing changes of integrated accessibility and social equity along with urbanization. *Sustainable Cities and Society*, *84*, 104005. https://doi.org/10.1016/j.scs.2022.104005

Li, X., Ma, X., Hu, Z., & Li, S. (2021). Investigation of urban green space equity at the city level and relevant strategies for improving the provisioning in China. *Land Use Policy*, *101*, 105144. https://doi.org/10.1016/j.landusepol.2020.105144

Lin, B. B., Philpott, S. M., & Jha, S. (2015). The future of urban agriculture and biodiversity-ecosystem services: Challenges and next steps. *Basic and applied ecology*, *16*(3), 189-201. https://doi.org/10.1016/j.baae.2015.01.005

Ma, F. (2020). Spatial equity analysis of urban green space based on spatial design network analysis (sDNA): A case study of central Jinan, China. *Sustainable Cities and Society*, *60*, 102256. https://doi.org/10.1016/j.scs.2020.102256

Martinez-Fernandez, C., Weyman, T., Fol, S., Audirac, I., Cunningham-Sabot, E., Wiechmann, T., & Yahagi, H. (2016). Shrinking cities in Australia, Japan, Europe and the USA: From a global process to local policy responses. *Progress in planning*, *105*, 1-48. https://doi.org/10.1016/j.progress.2014.10.001

Mostafa, A. M., & Alshahrani, A. (2024). Humanizing sustainable development through green spaces: a case study of Saudi cities. *Frontiers in Sustainable Cities*, *6*, 1416983. https://doi.org/10.3389/frsc.2024.1416983

Nancy, S. J. (2016). Densification of residential areas in Dhaka an enquiry of causes and consequences to address approaches towards sustainability. http://lib.buet.ac.bd:8080/xmlui/handle/123456789/4776

Nasri Roodsari, E., & Hoseini, P. (2022). An assessment of the correlation between urban green space supply and socio-economic disparities of Tehran districts—Iran. *Environment, development and sustainability*, *24*(11), 12867-12882. https://doi.org/10.1007/s10668-021-01970-4

Ng, M., Dai, X., Cogen, R. M., Abdelmasseh, M., Abdollahi, A., Abdullahi, A., Aboagye, R. G., Abukhadijah, H. J., Adeyeoluwa, T. E., & Afolabi, A. A. (2024). National-level and state-level prevalence of overweight and obesity among children, adolescents, and adults in the USA, 1990–2021, and forecasts up to 2050. *The lancet*, *404*(10469), 2278-2298. https://doi.org/10.1016/S0140-6736(24)01548-4

Nisbet, C., Lestrat, K. E., & Vatanparast, H. (2022). Food security interventions among refugees around the globe: a scoping review. *Nutrients*, *14*(3), 522. https://doi.org/10.3390/nu14030522

Orsini, F., Kahane, R., Nono-Womdim, R., & Gianquinto, G. (2013). Urban agriculture in the developing world: a review. *Agronomy for sustainable development*, *33*, 695-720. https://doi.org/10.1007/s13593-013-0143-z

Paul, A., Dey, S., Ram, D. K., & Das, A. P. (2024). Hexavalent chromium pollution and its sustainable management through bioremediation. *Geomicrobiology Journal*, *41*(4), 324-334. https://doi.org/10.1080/01490451.2023.2218377

Pietilä, M., Neuvonen, M., Borodulin, K., Korpela, K., Sievänen, T., & Tyrväinen, L. (2015). Relationships between exposure to urban green spaces, physical activity and self-rated health. *Journal of outdoor recreation and tourism*, *10*, 44-54. https://doi.org/10.1016/j.jort.2015.06.006

Rahman, K. A., & Zhang, D. (2018). Analyzing the level of accessibility of public urban green spaces to different socially vulnerable groups of people. *Sustainability*, *10*(11), 3917. https://doi.org/10.3390/su10113917

Rao, Y., Zhong, Y., He, Q., & Dai, J. (2022). Assessing the equity of accessibility to urban green space: a study of 254 cities in China. *International journal of environmental research and public health*, *19*(8), 4855. https://doi.org/10.3390/ijerph19084855

Riera, A. (2024). The interplay of rightsizing and growth strategies in legacy urban communities. https://mavmatrix.uta.edu/planning_dissertations/62

Rigolon, A., Browning, M. H., Lee, K., & Shin, S. (2018). Access to urban green space in cities of the Global South: A systematic literature review. *Urban science*, *2*(3), 67. https://doi.org/10.3390/urbansci2030067

Rigolon, A., & Németh, J. (2021). What shapes uneven access to urban amenities? Thick injustice and the legacy of racial discrimination in Denver's parks. *Journal of Planning Education and Research*, *41*(3), 312-325.

https://doi.org/10.1177/0739456X18789251

Rojas, C., Páez, A., Barbosa, O., & Carrasco, J. (2016). Accessibility to urban green spaces in Chilean cities using adaptive thresholds. *Journal of Transport Geography*, *57*, 227-240. https://doi.org/10.1016/j.jtrangeo.2016.10.012

Seto, K. C., Parnell, S., & Elmqvist, T. (2013). A global outlook on urbanization. *Urbanization, biodiversity and ecosystem services: challenges and opportunities: a global assessment*, 1-12. https://doi.org/10.1007/978-94-007-7088-1

Shukla, J., Shalini Dhyani, Ã., Chakraborty, S., Purkayastha, S. D., Janipella, R., Pujari, P., & Kapley, A. (2023). Shrinking increasing conundrum urban vulnerability: of the green demand-supply spaces, solving the gap in an urbanizing city. *Earth Observation in Urban Monitoring: Techniques and Challenges*, 359. https://doi.org/10.1016/B978-0-323-99164-3.00009-4

Soja, E. (2010). Spatializing the urban, Part I. *City*, *14*(6), 629-635. https://doi.org/10.1080/13604813.2010.539371

Tan, H., Li, J., He, M., Li, J., Zhi, D., Qin, F., & Zhang, C. (2021). Global evolution of research on green energy and environmental technologies: A bibliometric study. *Journal of Environmental Management*, *297*, 113382. https://doi.org/10.1016/j.jenvman.2021.113382

Wang, A., Wang, H., & Chan, E. H. (2020). The incompatibility in urban green space provision: An agent-based comparative study. *Journal of Cleaner Production*, *253*, 120007. https://doi.org/10.1016/j.jclepro.2020.120007

Wang, D., Brown, G., & Liu, Y. (2015). The physical and non-physical factors that influence perceived access to urban parks. *Landscape and urban planning*, *133*, 53-66. https://doi.org/10.1016/j.landurbplan.2014.09.007

Wolch, J. R., Byrne, J., & Newell, J. P. (2014). Urban green space, public health, and environmental justice: The challenge of making cities 'just green enough'. *Landscape and urban planning*, *125*, 234-244. https://doi.org/10.1016/j.landurbplan.2014.01.017

Wolff, M., Scheuer, S., & Haase, D. (2020). Looking beyond boundaries: Revisiting the rural-urban interface of Green Space Accessibility in Europe. *Ecological Indicators*, *113*, 106245. https://doi.org/10.1016/j.ecolind.2020.106245

Wooldridge, J. M., Wadud, M., & Lye, J. (2016). *Introductory econometrics: Asia pacific edition with online study tools 12 months*. Cengage AU. https://search.worldcat.org/title/1007411928

Xu, C., Haase, D., Pribadi, D. O., & Pauleit, S. (2018). Spatial variation of green space equity and its relation with urban dynamics: A case study in the region of Munich. *Ecological Indicators*, *93*, 512-523. https://doi.org/10.1016/j.ecolind.2018.05.024

Yang, W., Yang, R., & Zhou, S. (2022). The spatial heterogeneity of urban green space inequity from a perspective of the vulnerable: A case study of Guangzhou, China. *Cities*, *130*, 103855. https://doi.org/10.1016/j.cities.2022.103855

Ye, Y., & Qiu, H. (2021). Exploring affecting factors of park use based on multisource big data: Case study in Wuhan, China. *Journal of Urban Planning and Development*, *147*(1), 05020037. https://doi.org/10.1061/(ASCE)UP.1943-5444.0000656

Young, R. F. (2010). Managing municipal green space for ecosystem services. *Urban Forestry & Urban Greening*, *9*(4), 313-321. https://doi.org/10.1016/j.ufug.2010.06.007

Zhang, J., Yu, Z., Cheng, Y., Chen, C., Wan, Y., Zhao, B., & Vejre, H. (2020). Evaluating the disparities in urban green space provision in communities with diverse built environments: The case of a rapidly urbanizing Chinese city. *Building and Environment*, *183*, 107170. https://doi.org/10.1016/j.buildenv.2020.107170