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RESEARCH PAPER

Ranking Major Cities of Punjab, Pakistan: A Multi-Dimensional Sustainability Assessment

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ABSTRACT

This study evaluates the sustainability of six major cities in Punjab, Pakistan, through a multi-dimensional assessment spanning from 2003 to 2022. The cities were ranked based on six key dimensions e.g (economy, infrastructure, cultural aspects, resource consumption, environmental factors and social factors) of sustainability by using Principal Component Analysis (PCA), and an overall ranking was calculated by Composite Indices Scores. The findings reveal that Faisalabad and Bahawalpur exhibit relatively higher sustainability in aggregate scores, while Lahore and Rawalpindi perform poorly. Sargodha (-32.54) and Multan (-6.88) appear moderately under-performer. Bahawalpur and Faisalabad's favorable performance is attributed to lower population density, minimal changes in cultivation areas, reduced pollution levels, and lesser pressure on resources compared to Lahore and Rawalpindi. The study concludes and recommends policies i.e formulation of data driven strategies, modernize infrastructure, to reduce disparities among cities and promote overall development of the province.

KEYWORDS CIS, PCA, Ranking of Cities, Sustainability Assessment

Introduction

Cities, home to nearly half the global population and generating over 80% of global GDP, are hubs of socio-economic development and cultural exchange (Sukanya & Tantia, 2023; Samadkulov, 2023). Urban sustainability demands a balance between economic vitality, social equity, and environmental health to address global challenges like climate change, resource depletion, and socio-economic disparities (Goutte & Sanin, 2024). However, rapid urbanization strains resources, infrastructure, and public services, necessitating sustainable urban management as a global priority (Almulhim & Cobbinah, 2023; Arfanuzzaman & Dahiya, 2019).

Global frameworks like the SDGs, particularly Goal 11, emphasize inclusive, resilient, and sustainable cities (United Nations, 2015). Tools like the Global Sustainable Cities Index and the Urban Sustainability Framework guide cities in benchmarking and improving their sustainability through multidimensional indicators, including environmental conservation, economic productivity, social well-being, and governance (Chen, 2024; Arcadis, 2022). Yet, existing assessments, especially in developing nations, face challenges like data gaps, inconsistent metrics, and biases favoring economic and environmental aspects over social and cultural dimensions (Corredor et al., 2020; Ameen, & Mourshed, 2019).

These issues exacerbate in developing countries like Pakistan where researchers have to face limited resources, crippled institutional quality obsolete data (Fang et al., 2021; Zhao, 2023). Cities in Pakistan have to cope with a number of challenges like poor infrastructure, deteriorating environment and social inequalities even though the comprehensive frameworks to ascertain their sustainability remains scare (Farooq et al., 2024; Ghafoor et al., 2021). To address this gap, this study proposes a multidimensional framework for assessing and ranking Pakistani cities across six critical dimensions: economic, infrastructure, cultural aspects, resource consumption, environmental, and social factors. By employing methodologies of Principle Component Analysis and Composite Index Scores, this study aims to provide actionable insights for policymakers and urban planners. There are threefold objectives of this study to visualize the trend of each indicator, to analyze each city's performance across six dimensions and exploring policy implications for fostering sustainable practices. This research aims to drive localized, inclusive urban planning in Pakistan by identifying strengths, weaknesses, and best practices in each city.

This study fills a critical gap in the literature on Pakistani cities as well as also offers a replicable model for other developing nations, contributing to the broader discourse on sustainable, resilient, and inclusive urban futures.

Literature Review

The sustainability ranking of cities has gained significant attention as a pivotal tool for understanding urban performance and guiding sustainable development policies. Multiple techniques have been used to assess and rank cities, focusing on diverse dimensions such as economic growth, environmental health, and social equity. Out of these methodologies, composite indices, such as the Global Sustainable Cities Index and the Urban Sustainability Framework, integrate multidimensional indicators into a single ranking score, offering a comprehensive view of sustainability (Chen, 2024; Bigger & Webber, 2021). Several other studies employed multi-criteria decision analysis (MCDA), principal component analysis (PCA), and data envelopment analysis (DEA) to ascertain the complexity of urban systems and ensure methodological rigor (Bargueño, et al., 2024; Yang, et al, 2016). Despite their contributions, existing methodologies often face challenges such as data availability, indicator weighting, and contextual relevance, particularly in developing countries.

A large chunk of literature has focused on ranking cities based on sustainability metrics like in United States many studies employed the Sustainable Cities Index in which a tripartite of framework encompassing people, planet, and profit is used to evaluate urban sustainability (Arcadis, 2022). In the same way, several studies in Japan have adopted life cycle assessment (LCA) and eco-efficiency metrics to measure sustainability across urban centers (Sharifi et al., 2021; Sharifi & Murayama, 2014). On the other hand, European cities have been measured using a combination of environmental performance indicators, green infrastructure metrics, and economic competitiveness indices (Schmeller & Sümeghy, 2024; Buehler & Pucher, 2021). These studies demonstrate the importance of customized methodologies to specific national contexts while maintaining alignment with global sustainability goals.

On a regional level, studies adopted diverse methodologies to rank the cities. Smart Cities Mission framework has been used mostly for Indian cities, which signifies infrastructure development in respect of climate action, resource efficiency, and citizen engagement (Halder, & Bose, 2024; Hussain et al., 2024; Rajasekar et al., 2018). For

Chinese cities, Urban Sustainability Index integrates economic, environmental, and social indicators to provide a comprehensive ranking of urban performance (Liu, et al, 2024; Zhang & Yang, 2020). Studies on Bangladeshi cities, has used qualitative and quantitative techniques, such as survey-based assessments and environmental impact analyses, to assess urban sustainability (Hasan et al., 2021). The cities of Sri Lanka has been assessed and ranked using multi-criteria analysis which integrates cultural and environmental dimensions into city rankings (Rathnayaka et al., 2024; Perera & Jayasinghe, 2019). These studies emphasize the importance of context-specific approaches that tackle local challenges while remaining aligned with overarching sustainability goals.

There is a lack of extensive research on the sustainability assessment and ranking of cities In Pakistan, Few studies have assessed peculiar dimensions, such as environmental sustainability, with major focus on air quality, water scarcity, and waste disposal while other studies evaluated and ranked Pakistani cities based upon their climatic conditions and tourism potential (Nawaz et al., 2023; Bilal, et al., 2021; Shahzad, et al., 2021). On the other hand, Ghalib et al., (2017) evaluated and ranked major cities in respect of their development progress. What socio-economic impact agglomerated economies have on cities was evaluated in a study of Ghafoor et al., (2021). However, comprehensive frameworks that encompass all six dimensions—economic, infrastructure, cultural, environmental, resource consumption, and social factors are particularly absent. The current body of literature presents scattered insights into urban sustainability which signifies the necessity for holistic and multidimensional methods for ranking cities in Pakistan. So, this study proposes a holistic framework for ranking Pakistani cities.

Material and Methods

This study creates a comprehensive ranking system to assess the sustainability of six major cities in Punjab, Pakistan. Figure 1.

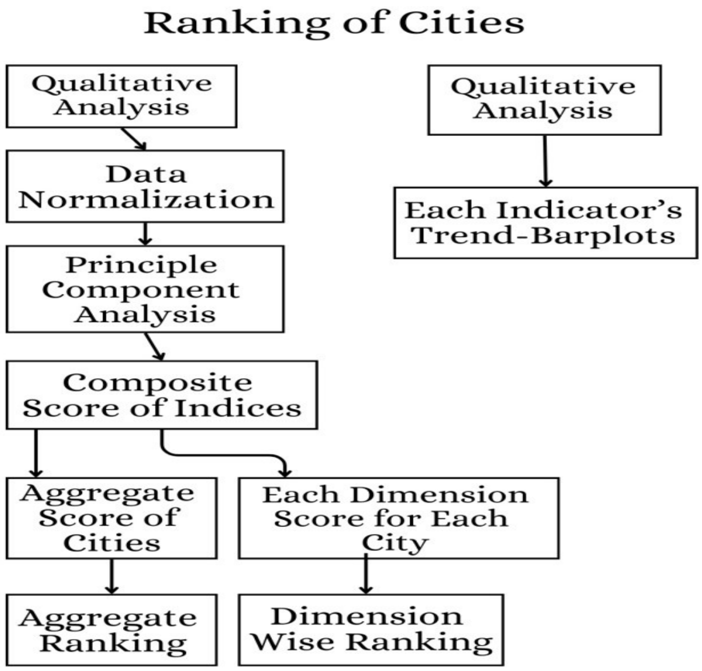

Figure 1: Depicting the steps to be followed in the study.

Data Collection

Twenty-one indicators representing six sustainability dimensions were selected based on their relevance to urban sustainability. Positive indicators signify improved sustainability, whereas negative indicators indicate reduced sustainability. The data were collected for the years 2003–2022 from reliable secondary sources i.e Bureaus of statistics (Punjab development reports), Compendium of Environment Statistics, departments of respective utilities and open datasets.

Indicators Selection

While for indicators' selection following criteria was followed in which more than hundred sustainability indicators were identified, guided by four principles:

- First, indicators were categorized under social, economic, environmental, or cultural dimensions (Ballantyne, & Singleton, 2024).
- Second, they were purpose-specific, following (Phillips, 2024).
- Third, their independence was ensured to avoid redundancy (Guarini et al., 2024)
- Lastly, data availability was prioritized, using open and reliable sources (García-Martín et al., 2024).

The six dimensions of sustainability and their corresponding indicators are as follows:

1. **Economy**: GDP contribution, Employment rates, Number of factories and Population rate
2. **Infrastructure**: Cultivation area, Forest area, Road-length, Total area
3. **Cultural Attraction**: Number of universities, Number of Parks, Number of cinemas
4. **Environment Degradation**: Temperature, Rainfall, Discharge rate of NO_2, O_3,$PM_{2.5}$, PM_{10}
5. **Resource Consumption**: Electricity Consumption rate and Water consumption rate
6. **Social Factors**: Number of Crimes, Number of accidents and Density of population

Data Normalization

To ensure comparability across indicators with different units and scales, data were normalized using min-max normalization, as shown in Equation 1:

$$Zij = \frac{Xij - \min(Xj)}{\max(Xj) - \min(Xj)}$$

Where:

- Zij is the normalized value for indicator j of city i.
- Xij is the original value of the indicator.
- $\min(Xj)$ and $\max(Xj)$ are the minimum and maximum values of indicator j, respectively.

For negative indicators (e.g., environment degradation), the normalization formula was reversed:

$$Z_{ij} = \frac{\max(Xj) - (Xij)}{\max(Xj) - \min(Xj)}$$

Principal Component Analysis (PCA)

Principal Component Analysis (PCA) was used to extract the dimensionality of the data and to extract six principal components corresponding to the six dimensions of sustainability. PCA is a world-wide used statistical technique for such purposes (e.g., Zhao et al., 2023; Fang et al., 2021). The method identifies linear combinations of indicators that explain the maximum variance in the dataset. The factor loadings (weights) for each indicator were derived from the PCA results.

Mathematically, the principal components were calculated as:

$$\boldsymbol{PC_K} = \sum_{J=1} P \quad W_{KJ} \ Z_J$$

Where:

- $\boldsymbol{PC_K}$ is the k-th principal component.
- $\boldsymbol{W_{KJ}}$ is the loading of the j-th indicator on the k-th component.
- $\boldsymbol{Z_J}$ is the normalized value of the j-th indicator.

PCA reduced the dimensions of economy, infrastructure, cultural attraction, environment degradation, resource consumption, and social factors from the data.

Dimension Scores

The factor loadings (weights) derived from PCA were multiplied by the corresponding normalized values of the indicators for each city. The dimension score for each city was then computed as the weighted sum of the normalized indicators within that dimensions.

$$\boldsymbol{D_{ik}} = \sum_{j=1} \boldsymbol{pk} \ \boldsymbol{w_{kj}} \ \boldsymbol{z_{ij}}$$

Where:

- $\boldsymbol{D_{ik}}$ is the score for dimension k of city i.
- $\boldsymbol{pk}$ is the number of indicators within dimension k.
- $\boldsymbol{w_{kj}}$ and $\boldsymbol{z_{ij}}$ are the weights and normalized values, respectively.

Overall Sustainability Scores

The overall sustainability score for each city was calculated as the sum of its scores across all six dimensions:

$$S_i = \sum_{k=1}^{6} D_{ik}$$

Where S_i is the total sustainability score for city i.

City Ranking

Cities were ranked based on their total sustainability scores. For positive indicators (e.g., economy, infrastructure, cultural attraction), a higher score indicates better performance, and cities were ranked from 1 (lowest) to 6 (highest). Conversely, for negative indicators (e.g., environment degradation, resource consumption, social challenges), a higher score indicates worse performance, and cities were ranked from 6 (most unsustainable) to 1 (least unsustainable).

Descriptive Analysis

Descriptive analysis of each indicator was done and found the following results for each dimensions' indicators.

Economy

Figure 2: Depicting the indicators across cities: **A;** GDP, **B;** Population, **C;** No. of employed & **D;** factories

Figure 2 reveals disparities in GDP, employment, population, and industries across Punjab's cities (2003–2022) reveal Lahore's dominance as the provincial capital, driven by its diverse industrial and services sectors (Gu et al., 2022). Faisalabad, reliant on textiles, shows moderate variability in GDP and employment (Ali & Ahmad, 2022; Murdoch, 2018). Rawalpindi and Multan exhibit steady yet less competitive outputs (Eraydın, 2017). Bahawalpur's agriculture-based economy results in lower and more volatile indicators (Henderson et al., 2012), while Sargodha reflects stagnation and minimal urbanization.

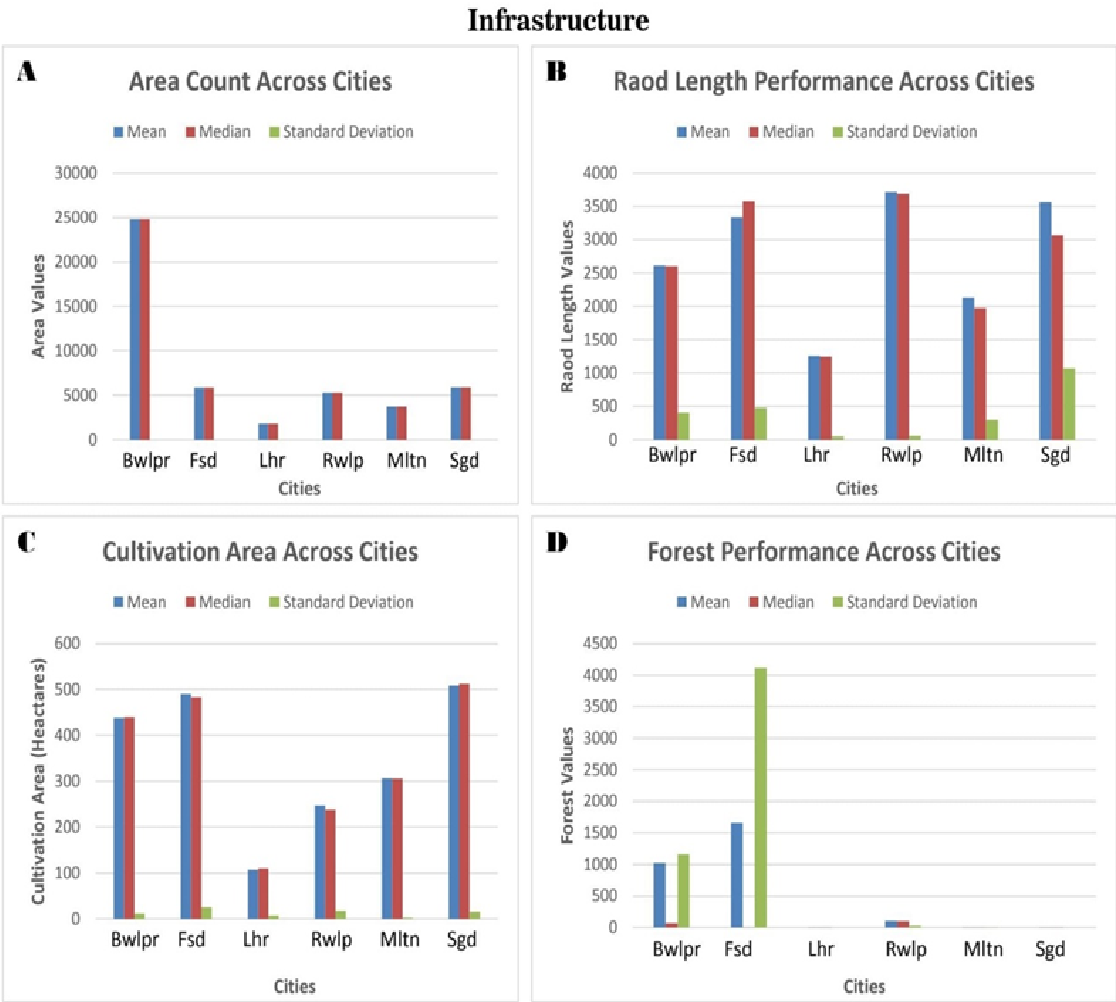

Figure 3: Depicting the indicators across cities: A; total area, B; road length, C; cultivation area & D; forest area

Figure 3 shows disparities in total area, road length, cultivation, and forest cover across Punjab's six cities reveal distinct patterns. Rawalpindi leads in road length due to investments near Islamabad (Ahmad et al., 2020), while Lahore, with the least, emphasizes public transport to reduce congestion. Faisalabad supports industry, and CPEC-driven projects boost Multan (M-5 Motorway) and Bahawalpur's connectivity. Sargodha leads in cultivation, with Faisalabad showing variability from diverse farming (Eraydın, 2017). Urbanization limits cultivation in Lahore and Rawalpindi (Javed, & Riaz, 2020).). Bahawalpur has the largest forests but unevenly distributed (Ahmad et al., 2015); Lahore and Faisalabad face deforestation, while Sargodha and

Multan prioritize agriculture over forests (Tahir, & Khaliq, 2018). Sustainable policies are crucial for balancing urbanization, agriculture, and forests.

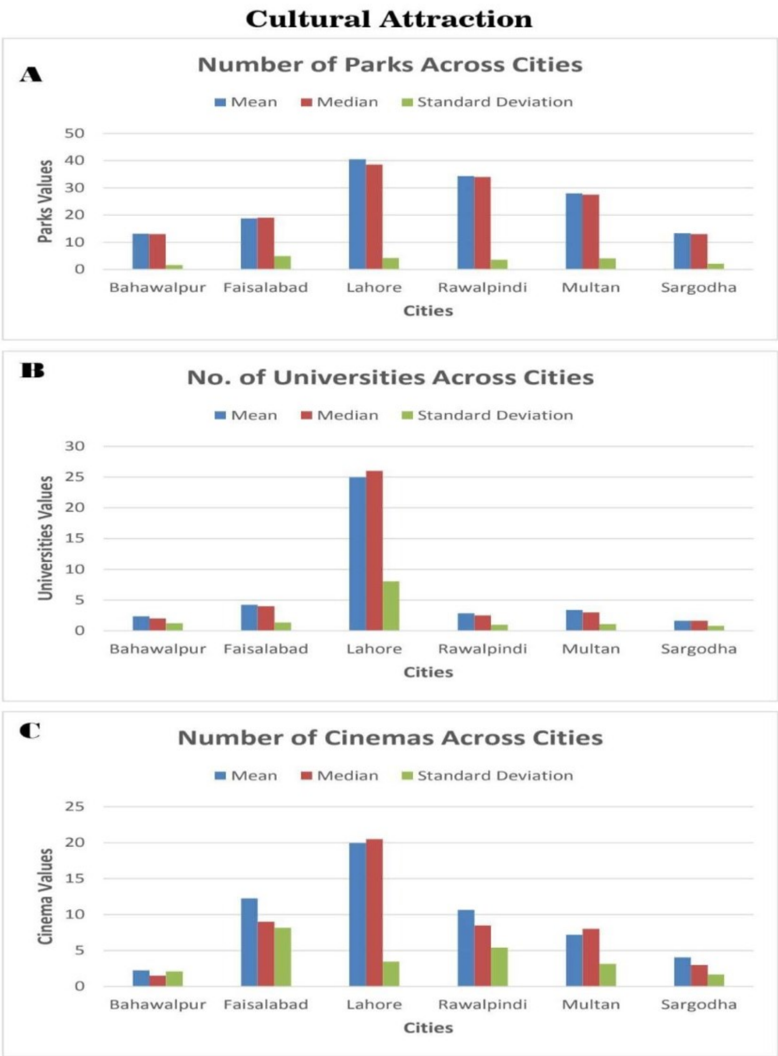

Figure 4: Depicting the indicators of cultural attraction across cities

Figure 4 is showing disparities in parks, cinemas, and universities across Punjab's cities reveal significant trends. Lahore leads in parks and cinemas, reflecting its focus on green spaces and entertainment (Hanif, et al., 2024; Shah, et al., 2023). Rawalpindi stands seconds for having green spaces and it might be due to its proximity to Islamabad (Iqbal et al., 2012). Whereas, Faisalabad and Multan have uneven park distribution and few cinemas, while Bahawalpur and Sargodha have least numbers of both, reflecting lower recreational funding (Ahmad et al., 2015). Lahore also leads in universities, while Faisalabad and Multan show moderate presence. Bahawalpur, Rawalpindi, and Sargodha have fewer, highlighting disparities in educational investments (Khan et al., 2020; Malik et al., 2018). Equitable policies are essential to address these gaps.

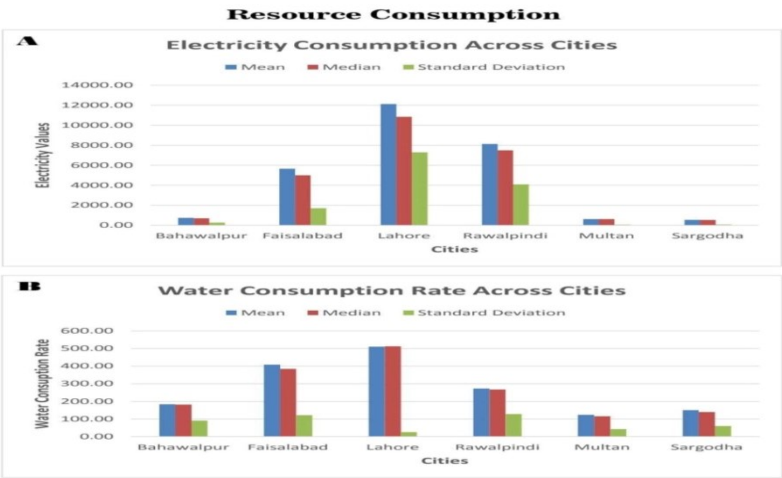

Figure 5: Depicting the various indicators of electricity and water consumption across different cities

Figure 5 is showing inequalities in electricity and water consumption across Punjab's cities depict varying economic and industrial activity. Lahore stands first in consumption of both due to its large population and high economic activity (Malik et al., 2017). Faisalabad's stands second and its demand stems from its textile industry (Ali, & Nawaz, 2013; Khan et al., 2019), while Rawalpindi's huge demand for electricity and water is linked to its proximity to Islamabad and a growing service sector. In contrast, Bahawalpur, Multan, and Sargodha show lower, stable consumption, driven by agricultural economies and limited industrialization. Water consumption follows similar trends, with Lahore and Faisalabad leading due to urban and industrial demands, while smaller cities rely more on localized water sources. These patterns call for policies to balance urban demand with resource efficiency in less industrialized areas.

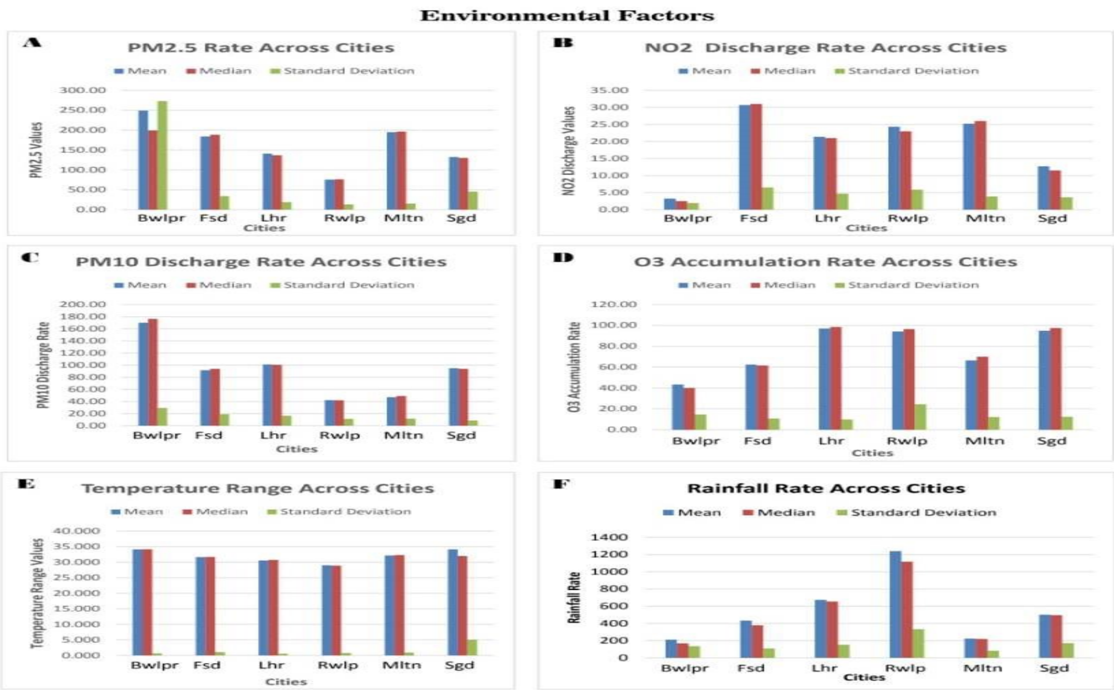

Figure 6: Depicting the indicators across cities: A; $PM_{2.5}$ discharge, B; NO_2 discharge, C; PM_{10} discharge, D; O_3 concentration, E; temperature & F; rainfall.

Figure 6 records disparities in air quality, temperature, and rainfall across Punjab reflect geography and industrialization. Bahawalpur has the highest $PM_{2.5}$ and PM_{10} levels due to desert dust, while Faisalabad and Lahore face pollution from industries and urbanization (Malik et al., 2018; Khan et al., 2019). Rawalpindi shows stable air quality, with Multan and Sargodha experiencing moderate fluctuations linked to agriculture (Ahmad et al., 2015). NO_2 levels are highest in Faisalabad, Lahore, and Rawalpindi due to traffic and industrial emissions, while Bahawalpur has the lowest. Rainfall peaks in Rawalpindi from orographic effects (Syed et al., 2021), while Bahawalpur and Multan have minimal, stable rainfall. Bahawalpur also experiences the highest temperature variability, contrasting with Sargodha's seasonal shifts. These patterns underscore the need for targeted environmental policies.

Figure 7: Depicting the indicators of social factors across cities

Accident rates, crime, and population density vary across Punjab's cities. Lahore leads in accidents (640.95) and crime, driven by congestion and urban challenges (Malik et al., 2015; Khan et al., 2020), followed by Rawalpindi and Faisalabad. Multan has the lowest accident rate (106.35) and lower crime, reflecting less congestion. Lahore's high population density stems from rapid urbanization and overcrowded slums (Ahmed et al., 2021; Chaudhry et al., 2020), while Sargodha and Bahawalpur have lower densities, reflecting rural traits.

Empirical Analysis

Table 1 reveals the ranking of six cities—Bahawalpur (BWP), Faisalabad (FSD), Lahore (LHR), Rawalpindi (RWP), Multan (Mul), and Sargodha (Sar)—across three dimensions: economy, infrastructure, and cultural attraction.

Table 1
Dimensional score of the economy, infrastructure & cultural factors

Indices	Indicators	Scores					
		BWP	**FSD**	**LHR**	**RWP**	**Mul**	**Sar**
Economy	GDP	3.46	22.04	81.11	13.67	11.86	2.86
	Population	1.98	26.00	100.52	15.28	12.91	1.31
	Factories	8.74	74.86	109.52	5.67	12.35	11.03
	Employment	4.32	129.05	145.75	18.83	27.95	30.45
Total		**18.50**	**251.95**	**436.89**	**53.46**	**65.09**	**45.65**
Rank		**1**	**5**	**6**	**3**	**4**	**2**
Infrastructure	Area	141.80	25.12	0.00	21.61	11.98	25.16
	Road	53.44	80.31	3.63	94.21	35.97	88.49
	Cultivation	120.09	138.32	4.54	53.50	73.99	144.30
	Forest	7.48	12.16	0.01	0.74	0.02	0.01
Total		**322.80**	**255.90**	**8.18**	**170.05**	**121.97**	**257.97**
Rank		**6**	**4**	**1**	**3**	**2**	**5**
Cultural Factors	Parks	9.16	25.44	88.68	70.80	52.19	9.45
	Cinemas	8.78	47.78	77.81	41.54	28.08	15.80
	Universities	9.23	16.69	98.00	11.19	13.35	6.48
Total		**27.16**	**89.91**	**264.49**	**123.53**	**93.63**	**31.73**
Rank		**1**	**3**	**6**	**5**	**4**	**2**

Economy Rankings

The economic performance of cities is assessed through four indicators: GDP, population, factories, and employment. Lahore (LHR) ranks highest (Rank 6) with a score of 436.89, reflecting its economic dominance in Pakistan, attributed to its large GDP and industrial base. Faisalabad (FSD) follows as a key economic hub, and Sargodha secures Rank 2, representing strong performance in spite of having smaller size. These rankings are in line with previous research findings highlighting industrial development and employment generation as key drivers of urban economic success (Jie et al., 2023; Ahmad et al., 2019). Lahore is also leading due to its diversified economy, including trade, finance, and services.

Infrastructure Rankings

The indicators of total area, road length, cultivation area, and forest cover are a base of infrastructure rankings in this study. Bahawalpur (BWP) stands first (Rank 6), thanks to its large area and cultivated land. Sargodha ranks second, benefiting from large cultivated area and road infrastructure. While, despite its economic strength, Lahore ranks lowest (Rank 1) due to dense urbanization, limited land, and environmental issues. These findings align with studies linking spatial size and land use to infrastructure adequacy (Iqbal et al., 2020). Lahore's issues highlight the complexities of managing infrastructure in the face of rapid urbanization (Rehman et al., 2022).

Cultural Attraction Rankings

Cultural attraction is evaluated through parks, cinemas, and universities. Lahore (LHR) ranks highest (Rank 6), driven by its vibrant cultural scene and educational institutions. Rawalpindi (RWP) and Multan show balanced mix of cultural amenities. Though Bahawalpur enjoys historical importance, still it ranks lowest (Rank 1), indicating underutilized cultural potential. These findings align with the cultural geography framework, which emphasizes the role of cultural and educational hubs in urban appeal (Ali et al., 2021). Lahore’s performance reinforces its reputation as a cultural hub, though disparities across cities highlight differences in resource allocation and urban development priorities.

Figure 8: Depicting the indicators of PM2.5 discharge, NO2 discharge, PM10 discharge, O3 concentration, temperature & rainfall across cities

Table 2 assesses six cities across three dimensions: resource consumption, environmental factors, and social factors. These dimensions consist of indicators that negatively impact the cities. Thus, higher rankings (e.g., Rank 6) denote poorer performance, while lower rankings (e.g., Rank 1) indicate better outcomes.

Resource Consumption Rankings

Resource consumption is measured by electricity and water usage, with higher scores indicating less efficiency. Lahore (LHR) ranks lowest (Rank 6) due to high resource use, driven by its population and industry. Faisalabad stands second last with high consumption of both these resources due to heavy industrial use, while Multan ranks best (Rank 1), suggesting more efficient resource utilization. These results align with studies highlighting how larger cities with industrial economies consume more resources (Malik et al., 2021). Lahore and Faisalabad's inefficiencies may result from urbanization pressures (Qureshi & Rehman, 2022), while lower scores in smaller cities reflect less economic activity, not higher efficiency.

Table 2
Assesses cities across three dimensions: resource consumption, environmental & social factors

Indices	Indicators	Scores					
		BWP	FSD	LHR	RWP	Mul	Sar
Resource Consumption	Electricity	2.08	31.79	70.94	46.76	1.34	0.89
	Water	46.45	116.46	148.09	74.23	27.92	36.17
Total		**48.53**	**148.26**	**219.04**	**120.98**	**29.25**	**37.06**
Rank		**3**	**5**	**6**	**4**	**1**	**2**
Environmental Factors	PM2.5	13.76	9.37	6.48	2.06	10.11	5.88
	NO2	8.63	113.93	78.06	89.57	93.02	44.88
	PM10	132.13	62.20	70.68	18.13	22.50	65.06
	O3	29.16	54.14	99.22	95.57	59.17	96.42
	Rainfall	13.67	31.46	50.67	95.93	14.63	36.92
	Temperature	44.05	27.29	19.94	9.31	30.76	43.82
Total		**241.40**	**298.38**	**325.05**	**310.56**	**230.19**	**292.97**
Rank		**2**	**4**	**6**	**5**	**1**	**3**
Social Factors	Accidents	11.68	22.49	104.86	55.11	5.28	26.02
	Crimes	5.53	23.80	141.92	16.85	12.01	9.74
	Density	0.19	11.89	137.99	8.52	10.84	2.11
Total		**17.39**	**58.18**	**384.77**	**80.48**	**28.13**	**37.87**
Rank		**1**	**5**	**6**	**4**	**2**	**3**

Environmental Factors Rankings

Environmental factors, including air quality ($PM_{2.5}$, NO_2, PM_{10}, O_3), rainfall, and temperature, reveal Lahore (Rank 6) as the poorest performer due to high pollution levels and elevated temperatures linked to industrialization and urbanization. Multan (Rank 1) performs best, reflecting relatively better conditions. Industrial hubs like Lahore and Faisalabad face significant environmental challenges, while cities with less industrial activity, such as Multan and Sargodha, show better performance, though geographical factors also influence rankings.

Social Factors Rankings

The social dimension evaluates urban safety and density, considering accidents, crimes, and population density. Lahore (LHR) ranks lowest (Rank 6) due to high accidents, crime rates, and density, while Bahawalpur (BWP) performs best (Rank 1), with lower population pressure and better safety. These findings align with urban sociology research linking high density and rapid expansion to social challenges like crime and accidents (Ali et al., 2022). Lahore's density exacerbates these issues, while Bahawalpur's smaller population helps manage them. Further analysis could explore qualitative aspects of safety, such as community trust and governance.

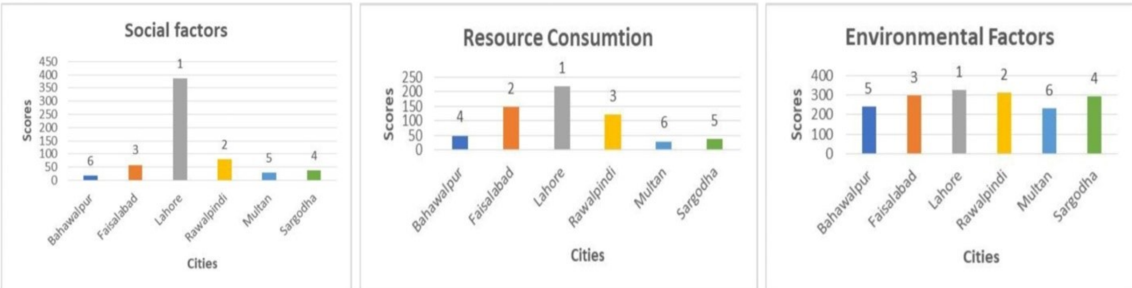

Figure 9: Depicting the indicators of social factors, resource consumption & environmental factors

Aggregate Sustainability

The aggregate performance analysis of six cities shows striking differences in cities' sustainability emphasizing the need for focused interventions. Faisalabad leads the highest with an remarkable score of 92.94, driven by strong economic and infrastructural performance, showcasing its industrial vitality. Bahawalpur also delivers well, scoring 61.14, implying efficient resource and social management despite environmental challenges. These results are in line with studies emphasizing the role of governance and regional economic growth in fostering sustainability (Ahmed et al., 2022; Samadkulov, 2023). Conversely, RWP and LHR confront significant sustainability deficits, with scores of -219.30 and -164.98, respectively. The root cause of poor performance of Lahore is severe air pollution, high population density, and social pressures, echoing findings on environmental challenges in large cities (Bibri & Krogstie, 2017). The major challenges of RWP are economic and infrastructural domains, consistent with challenges identified in mid-tier cities (Zhao, 2023). At the same time, Multan (-6.88) and Sargodha (-32.55) performed mediocre which shows that their challenges are manageable and have potential for growth with focused interventions, supporting Cohen's (2006) findings on smaller urban centers.

Table 3
Depicting the aggregate sustainability

City	Total Negative	Total Positive	Aggregate Value
BWP	-307.32	368.46	61.14
FSD	-504.82	597.76	92.94
LHR	-928.86	709.56	-219.3
RWP	-512.02	347.04	-164.98
Mul	-287.57	280.69	-6.88
Sar	-367.9	335.35	-32.55

Discussion

The analysis of aggregate performance of six major cities of Pakistan shows significant differences in cities' sustainability. Faisalabad scored the highest (92.94), it emphasize the role of robust economic activity and infrastructure in urban resilience, aligning with Ahmed et al. (2022), on the importance of industrial hubs. Bahwalpur stands second which shows how effective resource management can promote sustainability, reinforcing Samadkulov (2023) on governance.

Conversely, LHR (-219.30) and RWP (-164.98) deals with infrastructural and environmental challenges, endorsing findings by Bibri and Krogstie (2017) and Khan et al. (2020) on the environmental strain of urbanization. These issues stress the need for equitable resource distribution and improved governance.

Sargodha (-32.55) and Multan (-6.88) demonstrate mediocre performance, indicating their potential for growth if targeted interventions are implemented, as noted by Cohen (2006) for smaller cities. Dimension-specific rankings manifest that big cities like Lahore experiences economic strength but face resultant environment toll, while, Bahwalpur's infrastructure performance imply the significance of spatial planning (Iqbal et al., 2020). These results underscore the need for customized urban planning strategies to address each city's unique context, with an emphasis on sustainability, as outlined in SDG 11.

Conclusion

The study concludes that the analysis of cities' sustainability across six Pakistani cities—Bahawalpur, Faisalabad, Lahore, Rawalpindi, Multan, and Sargodha—manifest inequalities driven by contrasting economic, infrastructural, environmental, and social factors. Bahawalpur and Faisalabad exhibit successful balancing of economic growth and sustainability through strong governance, while, Lahore and Rawalpindi signify the dire need for interventions to address environmental and infrastructural challenges. The average performances of Multan and Sargodha reveal that smaller cities can achieve sustainable growth with strategic planning.

These results stress the need for a localized, comprehensive and multidimensional approach to urban planning, focusing on balanced resource distribution, environmental conservation, and socio-economic development. High-performing cities can act as examples for sustainable urbanization, whereas underperforming cities need customized solutions to address their challenges.

Policy Recommendations

The following policies are recommended based on the findings of this study to improve urban sustainability.

- Balanced Regional Development: Promote industrial base and establish economic zones in smaller cities like Bahawalpur and Sargodha to reduce disparities with larger cities like Lahore.

- Infrastructure Modernization: Improve transport facilities, make land use efficient, and increase public services in cities like Lahore to improve livability.

- Environmental Management: Implement strict emission controls and urban greening in Lahore and Faisalabad to enhance air quality.

- Resource Efficiency: Promote energy and water conservation, and renewable energy in high-consumption cities.

- Social Safety and Governance: Strengthen community policing, law enforcement, and equitable service access in cities like Lahore to reduce crime and accidents.

- Cultural and Educational Investments: Develop cultural and educational infrastructure in smaller cities to diversify their social and economic landscapes.

- Data-Driven Policies: Use data, including public satisfaction and governance metrics, to guide urban development strategies.

References

Ahmed, S., Huifang, W., Akhtar, S., Imran, S., Hassan, G., & Wang, C. (2021). An analysis of urban sprawl in Pakistan: consequences, challenges, and the way forward. *International Journal of Agricultural Extension*, *8*(3), 257-278.

Ahmad, M., Akram, W., Ikram, M., Shah, A. A., Rehman, A., Chandio, A. A., & Jabeen, G. (2021). Estimating dynamic interactive linkages among urban agglomeration, economic performance, carbon emissions, and health expenditures across developmental disparities. *Sustainable Production and Consumption*, *26*, 239-255.

Ali, H., & Nawaz, M. (2013). Energy crisis and productive inefficiency: micro-evidence from textile sector of Faisalabad. *The Pakistan Development Review*, 447-464.

Ali, S., & Ahmad, T. (2022). Regional Economic Disparities in Pakistan: An Empirical Analysis. *Economic Development Review, 34*(1), 45-67.

Almulhim, A. I., & Cobbinah, P. B. (2023). Urbanization-environment conundrum: an invitation to sustainable development in Saudi Arabian cities. *International Journal of Sustainable Development & World Ecology*, *30*(4), 359-373.

Alsaid, L. A. Z. A., & Ambilichu, C. A. (2024). Performance measurement in urban development: unfolding a case of sustainability KPIs reporting. *Journal of Accounting in Emerging Economies*, *14*(1), 48-74.

Ameen, R. F. M., & Mourshed, M. (2019). Urban sustainability assessment framework development: The ranking and weighting of sustainability indicators using analytic hierarchy process. *Sustainable Cities and Society*, *44*, 356-366.

Anwar, A., Sinha, A., Sharif, A., Siddique, M., Irshad, S., Anwar, W., & Malik, S. (2022). The nexus between urbanization, renewable energy consumption, financial development, and CO 2 emissions: Evidence from selected Asian countries. *Environment, Development and Sustainability*, 1-21.

Arfanuzzaman, M., & Dahiya, B. (2019). Sustainable urbanization in Southeast Asia and beyond: Challenges of population growth, land use change, and environmental health. *Growth and Change*, *50*(2), 725-744.

Atanda, J. O. (2019). Developing a social sustainability assessment framework. *Sustainable cities and society*, *44*, 237-252.

Arcadis (2022). *Sustainable Cities Index 2022: Prosperity Beyond Profit*. Arcadis.

Bargueño, D. R., Marins, F. A. S., Balestieri, J. A. P., Belmar, P. I. P., Dias, R. A., & Salomon, V. A. P. (2024). Multi-Criteria Decision-Making Methods Applied to the Sustainability of Urban Transport: A Systematic Literature Review. *Concepts in Smart Societies*, 27-42.

Bibri, S. E., & Krogstie, J. (2017). Smart sustainable cities of the future: An extensive interdisciplinary literature review. *Sustainable cities and society*, *31*, 183-212.

Bilal, M., Mhawish, A., Nichol, J. E., Qiu, Z., Nazeer, M., Ali, M. A., ... & Ke, S. (2021). Air pollution scenario over Pakistan: Characterization and ranking of extremely polluted cities using long-term concentrations of aerosols and trace gases. *Remote Sensing of Environment*, *264*, 112617.

Ballantyne, P., & Singleton, A. (2024). Using composite indicators and city dashboards to promote place-based policy interventions. *Cities*, *154*, 105329.

Bigger, P., & Webber, S. (2021). Green structural adjustment in the World Bank's resilient city. *Annals of the American Association of Geographers*, *111*(1), 36-51.

Chaudhry, A. G., Masoumi, H., Dienel, H. L., Aslam, A. B., Ahmad, M., & Shahnaz, M. (2024). Mobility attitudes and urban form: shaping public transport and shared mobility choices in Dubai and Lahore. *Urban, Planning and Transport Research, 12(1), 2420735*.

Cohen, B. (2006). Urbanization in developing countries: Current trends, future projections, and key challenges for sustainability. *Technology in society*, *28*(1-2), 63-80.

Corredor-Ochoa, Á., Antuña-Rozado, C., Fariña-Tojo, J., & Rajaniemi, J. (2020). Challenges in assessing urban sustainability. In *Urban Ecology* (pp. 355-374). Elsevier.

Chen, G., Zhou, Y., Voogt, J. A., & Stokes, E. C. (2024). Remote sensing of diverse urban environments: From the single city to multiple cities. *Remote Sensing of Environment*, *305*, 114108.

Duxbury, N., Cullen, C., & Pascual, J. (2012). Cities, culture and sustainable development. *H. Anheier, y YA Isar, Cultural Policy and Governance in a New Metropolitan Age*, 73-86.

Eraydın, A. (2017). Governing Urban Diversity: Creating Social Cohesion, Social Mobility and Economic Performance in Today's Hyper-diversified Cities *(DIVERCITIES).*

Farooq, M. S., Feroze, N., Cheng, T., & Feroze, F. (2024). Pakistan's Green Urbanization in the Perspective of Ecological Civilization. *Chinese Journal of Urban and Environmental Studies*, *12*(03), 2450017.

Fang, X., Shi, X., Phillips, T. K., Du, P., & Gao, W. (2021). The coupling coordinated development of urban environment towards sustainable urbanization: An empirical study of Shandong Peninsula, China. *Ecological indicators*, *129*, 107864.

García-Martín, M. A., Bernedo, I. M., Salas, M. D., & González-Pasarín, L. (2024). Indicators of contact visit quality in non-kinship foster care: An observational checklist. *Children & Society*, *38*(2), 524-546.

Ghalib, A., Qadir, A., & Ahmad, S. R. (2017). Evaluation of developmental progress in some cities of Punjab, Pakistan, using urban sustainability indicators. *Sustainability*, *9*(8), 1473.

Ghafoor, N., Fayyaz, S., Nisa, M. U., & Akbar, M. R. (2021). An empirical investigation of socio-economic impacts of agglomeration economies in major cities of Punjab, Pakistan. *Cogent Economics & Finance*, *9*(1), 1975915.

Goutte, S., & Sanin, M. E. (2024). Main challenges regarding development and sustainability in economics and finance. *Development and Sustainability in Economics and Finance*, 100002.

Guarini, M. R., Sica, F., Tajani, F., Sabatelli, E., & Anelli, D. (2024). A Strategic Multidirectional Approach for Picking Indicator Systems of Sustainability in Urban Areas. *Urban Science*, *8*(3), 107.

Gu, X., Sheng, L., & Lei, C. (2022). Specialization or diversification: A theoretical analysis for tourist cities. *Cities*, *122*, 103517

Hakovirta, M. (2024). Socioeconomic aspects of climate change in cities and municipalities. In *Carbon Neutrality: Follow the Money* (pp. 143-156). Cham: Springer Nature Switzerland.

Halder, S., & Bose, S. (2024). Ecological quality assessment of five smart cities in India: a remote sensing index-based analysis. *International Journal of Environmental Science and Technology*, *21*(4), 4101-4118.

Hanif, A., Jabbar, M., & Mohd Yusoff, M. (2024). Exploring key indicators for quality of life in urban parks of Lahore, Pakistan: toward the enhancement of sustainable urban planning. *International Journal of Sustainable Development & World Ecology*, 1-18.

Hussain, S., Hussain, E., Saxena, P., Sharma, A., Thathola, P., & Sonwani, S. (2024). Navigating the impact of climate change in India: a perspective on climate action (SDG13) and sustainable cities and communities (SDG11). *Frontiers in Sustainable Cities*, *5*, 1308684.

Imperiale, A. J., & Vanclay, F. (2021). Conceptualizing community resilience and the social dimensions of risk to overcome barriers to disaster risk reduction and sustainable development. *Sustainable Development*, *29*(5), 891-905.

Iqbal, S., Wasim, M., Tufail, M., Arif, M., & Chaudhry, M. M. (2012). Elemental contamination in urban parks of Rawalpindi/Islamabad—a source identification and pollution level assessment study. *Environmental monitoring and assessment*, *184*, 5497-5510.

Javed, N., & Riaz, S. (2020). Issues in urban planning and policy: The case study of Lahore, Pakistan. *New Urban Agenda in Asia-Pacific: Governance for sustainable and inclusive cities*, 117-162.

Jie, H., Khan, I., Alharthi, M., Zafar, M. W., & Saeed, A. (2023). Sustainable energy policy, socio-economic development, and ecological footprint: The economic significance of natural resources, population growth, and industrial development. *Utilities Policy*, *81*, 101490.

Khan, A., Arif, S., & Mushtaq, M. (2013). Electricity consumption for energy conservation in office buildings in lahore-pakistan. *Pakistan Journal of Science*, *65*(2), 243.

Malik, M. U., Rehman, Z. U., Sharif, A., & Anwar, A. (2024). Impact of transportation infrastructure and urbanization on environmental pollution: evidence from novel wavelet quantile correlation approach. *Environmental Science and Pollution Research*, *31*(2), 3014-3030.

Michalina, D., Mederly, P., Diefenbacher, H., & Held, B. (2021). Sustainable urban development: A review of urban sustainability indicator frameworks. *Sustainability*, *13*(16), 9348.

Nawaz, R., Ashraf, A., Nasim, I., Irshad, M. A., Zaman, Q. U., & Latif, M. (2023). Assessing the Status of Air Pollution in the selected Cities of Pakistan. *Pollution*, *9*(1), 381-391.

Patil, G. R., & Sharma, G. (2022). Urban Quality of Life: An assessment and ranking for Indian cities. *Transport Policy*, *124*, 183-191.

Perera, U. S., Siriwardana, C., & Pitigala Liyana Arachchi, I. S. (2024). Development of critical infrastructure resilience index for cities in Sri Lanka. *International journal of disaster resilience in the built environment*, *15*(2), 193-211.

Phillips, R. (2024). Urban sustainability indicators. In *Encyclopedia of quality of life and well-being research* (pp. 7447-7449). Cham: Springer International Publishing.

Rajasekar, U., Chakraborty, S., & Bhat, G. (2018). Climate resilient smart cities: opportunities for innovative solutions in India. *Climate Change in Cities: Innovations in Multi-Level Governance*, 203-227.

Rathnayaka, B., Robert, D., Adikariwattage, V., Siriwardana, C., Meegahapola, L., Setunge, S., & Amaratunga, D. (2024). A Unified Framework for Evaluating the Resilience of Critical Infrastructure: Delphi Survey Approach. *International Journal of Disaster Risk Reduction*, 104598.

Rehman, A., Radulescu, M., Ma, H., Dagar, V., Hussain, I., & Khan, M. K. (2021). The impact of globalization, energy use, and trade on ecological footprint in Pakistan: does environmental sustainability exist?. *Energies*, *14*(17), 5234.

Samadkulov, M. (2023). The Economics Of Urbanization: Challenges And Strategies For Sustainable Development. *SPAST Abstracts*, *2*(02).

Schmeller, D., & Sümeghy, D. (2024). Is the rival city always greener? An analysis of the indicators for European Green Capital Award shortlisted and applicant cities, 2010–2024. *Regional Statistics*, *14*(2), 197-228.

Shah, M., Malik, S., & Iqbal, F. (2023). Investigating the interaction effect of urbanization and natural resources on environmental sustainability in Pakistan.

Shahzad, L., Tahir, A., Dogar, M., & Saeed, S. (2021). A metric-based assessment of climate and tourism in major cities of Pakistan. *Environment, Development and Sustainability*, 1-21.

Shmelev, S. E., & Shmeleva, I. A. (2018). Global urban sustainability assessment: A multidimensional approach. *Sustainable Development*, *26*(6), 904-920.

Sharifi, A., Dawodu, A., & Cheshmehzangi, A. (2021). Neighborhood sustainability assessment tools: a review of success factors. *Journal of Cleaner Production*, *293*, 125912.

Sukanya, R., & Tantia, V. (2023). Urbanization and the impact on economic development. In *New Perspectives and Possibilities in Strategic Management in the 21st Century: Between Tradition and Modernity* (pp. 369-408). IGI Global.

Sun, X., Mi, Z., Sudmant, A., Coffman, D. M., Yang, P., & Wood, R. (2022). Using crowdsourced data to estimate the carbon footprints of global cities. *Advances in Applied Energy*, *8*, 100111.

Syed, A., Liu, X., Moniruzzaman, M., Rousta, I., Syed, W., Zhang, J., & Olafsson, H. (2021). Assessment of climate variability among seasonal trends using in situ measurements: A case study of Punjab, Pakistan. *Atmosphere*, *12*(8), 939.

Tahir, M., & Khaliq, T. (2018). Land Use in Pakistan. In *Developing Sustainable Agriculture in Pakistan* (pp. 33-57). CRC Press.

United Nations (2015). *Transforming Our World: The 2030 Agenda for Sustainable Development*. United Nations General Assembly.

Yang, W. C., Lee, Y. M., & Hu, J. L. (2016). Urban sustainability assessment of Taiwan based on data envelopment analysis. *Renewable and Sustainable Energy Reviews*, *61*, 341-353.

Zhao, R., De Jong, M., & Edelenbos, J. (2023). Will the true inclusive city rise? Mapping the strengths and weaknesses of the city ranking systems. *Cities*, *143*, 104617.

Zhao, J., Abdul Aziz, F., Cheng, Z., Ujang, N., Zhang, H., Xu, J., ... & Shi, L. (2024). Post-Occupancy Evaluation of the Improved Old Residential Neighborhood Satisfaction Using Principal Component Analysis: The Case of Wuxi, China. *ISPRS International Journal of Geo-Information*, *13*(9), 318.