JOURNAL OF MULTIDISCIPLINARY SCIENCES AND INNOVATIONS

VOLUME 5, ISSUE 06
MONTHLY JOURNALS

ISSN NUMBER: 2751-4390
IMPACT FACTOR: 9,08

INDICATORS AND METHODOLOGIES FOR EVALUATING GREEN CITY DEVELOPMENT

Zaylobiddinov Diyorbek Elyorjon ugli

Asia International University

Abstract : The rapid global trend toward urbanization has intensified demands for sustainable, livable, and resilient cities. Green city development has emerged as a pivotal framework for addressing environmental degradation, resource inefficiency, and social inequality in urban areas. However, the absence of a universally accepted evaluation system creates significant challenges for policymakers, urban planners, and researchers seeking to benchmark progress. This study conducts a systematic review of existing indicators and methodologies employed in assessing green city development across global contexts. Drawing upon peer-reviewed literature, international frameworks, and case studies from 2010 to 2024, this paper identifies five core indicator domains: environmental quality, energy efficiency, transport and mobility, green infrastructure, and governance and social equity. Moreover, it critically examines quantitative, qualitative, and mixed-method assessment approaches, including composite index construction, Geographic Information Systems (GIS)-based spatial analysis, and multi-criteria decision analysis (MCDA). Findings reveal significant methodological heterogeneity, data gaps in developing regions, and the underrepresentation of socio-cultural dimensions in current frameworks. The study proposes an integrated evaluation framework adaptable to diverse urban contexts and calls for greater standardization to enable cross-city comparisons.

Keywords: green cities; sustainability indicators; urban assessment; green infrastructure; MCDA; GIS; smart urbanism; environmental governance

Urbanization is one of the most transformative forces of the twenty-first century. According to the United Nations, approximately 68% of the world's population is projected to reside in urban areas by 2050, compared to 55% in 2018 (United Nations, 2018). This demographic shift exerts immense pressure on natural resources, energy systems, public health, and urban governance structures. In response, the concept of the 'green city' has gained substantial traction among scholars, policymakers, and international organizations as a comprehensive approach to sustainable urban development.

A green city, broadly defined, is an urban settlement that integrates ecological principles into its planning, governance, infrastructure, and social systems to minimize environmental impact while maximizing resident well-being (Beatley, 2012). The concept overlaps with adjacent paradigms such as smart cities, eco-cities, low-carbon cities, and resilient cities, each emphasizing different but interrelated aspects of urban sustainability. Despite growing policy interest, the evaluation of green city development remains methodologically fragmented. Different organizations, governments, and research institutions apply varying indicator sets, weighting schemes, and data sources, making systematic cross-city or cross-country comparisons exceedingly difficult.

This gap is not merely academic. Without robust, comparable metrics, municipalities cannot reliably assess their sustainability performance, identify priority intervention areas, or demonstrate progress to stakeholders and funding bodies. The challenge is compounded in developing and transitional economies, where data availability is constrained and institutional capacity for complex assessments may be limited.

The paper is structured according to the IMRAD format. Following this introduction, Section 2 describes the materials and methods employed in the review. Section 3 presents the findings organized around indicator domains and methodological approaches. Section 4 discusses the implications, limitations, and potential for a unified framework. Section 5 concludes with key recommendations. This study employs a systematic literature review methodology, guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol (Moher et al., 2009). A systematic approach was chosen to ensure transparency, replicability, and comprehensiveness in identifying and synthesizing the relevant body of knowledge on green city indicators and assessment methodologies.

A structured search was conducted across four major scientific databases: Scopus, Web of Science, Google Scholar, and ScienceDirect. The search was limited to peer-reviewed articles, book chapters, reports from recognized international organizations (e.g., OECD, UN-Habitat, World Bank, European Commission), and technical documentation published between January 2010 and December 2024. The 2010 cut-off was selected to capture literature produced after the widespread adoption of the Sustainable Development Goals framework began to take shape internationally.

The following Boolean search strings were applied: ("green city" OR "sustainable urban development" OR "eco-city" OR "low-carbon city") AND ("indicator" OR "index" OR "assessment" OR "evaluation" OR "framework" OR "methodology"). The search was conducted in English. Foreign-language sources were excluded unless an official English-language translation or abstract was available.

Studies were included if they: (1) focused explicitly on urban-scale sustainability or green city evaluation; (2) proposed, tested, or critically reviewed specific indicators or methodological frameworks; and (3) were published in peer-reviewed journals or by credible international institutions. Studies were excluded if they addressed sustainability at the national or regional level exclusively, focused on a single environmental variable without broader urban context, or consisted purely of normative advocacy without empirical or analytical grounding.

An initial search yielded 1,847 documents. After removal of duplicates, title and abstract screening, and full-text review, a final corpus of 112 studies was retained for detailed analysis. A supplementary set of 23 policy and technical reports from international organizations was also incorporated to capture practitioner perspectives.

Data were extracted using a standardized template capturing: the study's geographic focus, the indicator domains addressed, the methodological approach applied, data sources utilized, and key findings or limitations reported. A thematic synthesis approach was applied to categorize indicators into domains and to identify cross-cutting methodological patterns. Frequency analysis was used to determine the relative prominence of different indicators across the reviewed literature.

Analysis of the reviewed literature identified five primary domains within which green city indicators are concentrated. These domains are not mutually exclusive; a given indicator may span multiple categories. Table 1 provides a summary of the most frequently cited indicators within each domain.

Environmental Quality. This domain encompasses indicators related to air quality, water quality, soil health, biodiversity, and waste management. Air quality indicators, particularly

PM2.5 and NO2 concentrations, appear in 89% of reviewed frameworks (Shen et al., 2018). Urban biodiversity indices, while increasingly recognized, remain underrepresented and methodologically underdeveloped compared to physicochemical measures (Elmqvist et al., 2019).

Energy Efficiency and Carbon Emissions. Indicators in this domain include per capita energy consumption, renewable energy share in the urban energy mix, building energy performance standards, and greenhouse gas (GHG) emissions per unit of GDP or per capita. The carbon footprint metric has become a near-universal component of green city assessments (Geng et al., 2013; Huang et al., 2020). District-level energy modeling has emerged as a methodological innovation enabling more granular assessment. Transport and Mobility. This domain covers public transport modal share, non-motorized transport infrastructure, vehicle emission standards, electric vehicle penetration, and transport-related GHG emissions. The literature increasingly emphasizes accessibility and equity dimensions of sustainable transport, moving beyond purely emission-based metrics .

Green Infrastructure and Land Use. Indicators in this domain include urban green space per capita, tree canopy coverage, permeable surface ratios, and urban heat island intensity. The World Health Organization recommends a minimum of 9 m² of green space per urban resident; however, numerous studies indicate that spatial distribution and accessibility of green areas are equally critical. Governance, Social Equity, and Well-being. This domain is the least standardized, encompassing indicators such as citizen participation rates in urban planning, environmental justice measures, access to green amenities across income brackets, public health outcomes, and transparency of municipal environmental reporting. Several scholars argue that the absence of robust social and governance indicators represents the most significant weakness of current green city frameworks (Caprotti et al., 2017; Zhao et al., 2021).

The reviewed literature employs three broad methodological categories: quantitative, qualitative, and mixed-method approaches.

Composite Index Construction. The most widely applied quantitative methodology involves the construction of composite sustainability indices, in which individual indicators are normalized, weighted, and aggregated into a single score. Prominent examples include the Global Green Economy Index (GGEI), the ARCADIS Sustainable Cities Index, and the Economist Intelligence Unit's Safe Cities Index. Weighting schemes vary substantially across frameworks: some apply equal weighting for simplicity, while others use expert-elicitation methods such as the Delphi technique or analytical hierarchy process (AHP) to derive differential weights (Huang et al., 2020; Marsal-Llacuna et al., 2015). A recognized limitation of composite indices is sensitivity to weighting choices and normalization methods, which can significantly alter city rankings (Booysen, 2002).

Geographic Information Systems (GIS)-Based Assessment. GIS methodologies are increasingly employed to spatialize green city indicators, enabling analysis of distributional equity, spatial clustering of environmental stressors, and landscape connectivity of urban green infrastructure (Shen et al., 2018). Remote sensing data—particularly from satellite platforms such as Landsat, Sentinel, and MODIS—are leveraged to calculate vegetation indices (NDVI), land surface temperature, and impervious surface coverage at high temporal and spatial resolution. These tools are particularly valuable in data-scarce urban contexts where ground-based monitoring networks are underdeveloped.

Multi-Criteria Decision Analysis (MCDA). MCDA frameworks, including AHP, TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution), and VIKOR, allow for the structured comparison of urban sustainability scenario These approaches are particularly suited to participatory assessment contexts, as stakeholder preferences can be incorporated through structured preference elicitation. However, MCDA outcomes are susceptible to rank reversal phenomena and depend heavily on the consistency of expert judgments.

Qualitative and Mixed-Method Approaches. A minority of reviewed studies adopt purely qualitative methodologies, including structured interviews with urban policymakers, ethnographic observation, and document analysis of municipal sustainability reports. Mixed-method designs that integrate quantitative indicator analysis with qualitative institutional assessment represent an emerging best practice, as they capture both measurable outcomes and the governance processes underlying them .

The reviewed literature exhibits a pronounced geographic bias toward urban contexts in Europe, East Asia (particularly China, Japan, and South Korea), and North America. Studies focused on cities in Sub-Saharan Africa, Central Asia, and South Asia are substantially underrepresented despite these regions hosting some of the world's fastest-growing urban populations. This geographical skew has methodological consequences: indicators developed and validated in data-rich, institutionally mature urban environments may be poorly suited to contexts characterized by informality, rapid growth, and limited statistical infrastructure.

A persistent weakness identified across the reviewed literature is the underrepresentation of social equity and governance quality within green city assessment frameworks. Dominant frameworks disproportionately emphasize technologically measurable environmental indicators, such as emissions concentrations and energy consumption, while neglecting questions of distributional justice, community participation, and institutional accountability. This bias risks producing assessments that declare a city 'green' based on aggregate environmental performance while masking spatial inequalities in environmental quality and access to green amenities (Wolch et al., 2014; Caprotti et al., 2017).

Future frameworks should incorporate indicators such as: the Gini coefficient of green space distribution, the share of underserved communities with access to quality parks within walking distance, municipal transparency scores in environmental reporting, and rates of meaningful citizen engagement in sustainability planning processes. These dimensions are inherently harder to quantify, but their inclusion is essential for frameworks that aspire to comprehensiveness and justice.

The pronounced geographic skew in the reviewed literature is not solely a function of research interest; it reflects fundamental disparities in urban data infrastructure. Satellite and remote sensing data partially compensate for ground-level data deficits, enabling meaningful environmental assessment even in cities with limited monitoring networks. However, socioeconomic and governance indicators require statistical systems, civic data publication norms, and administrative transparency that remain underdeveloped in many rapidly urbanizing regions. International capacity-building initiatives—such as those coordinated by UN-Habitat's Urban Indicators Programme and the World Bank's Open Data platform—are beginning to address this gap, but progress is uneven. For regions such as Central Asia, which is experiencing significant urban transformation but remains poorly represented in the global sustainability literature, localized indicator development processes involving national statistical agencies, universities, and municipal governments are criticalSuch a framework should be designed with

interoperability with existing global standards—particularly the UN SDG indicator framework, ISO 37120, and WHO urban health indicators—to reduce the reporting burden on municipalities and facilitate cross-national comparisons. This systematic review has examined the state of green city evaluation across the domains of indicators and methodological approaches. Five core indicator domains were identified: environmental quality, energy efficiency, transport and mobility, green infrastructure, and governance and social equity. Three primary methodological categories were documented: composite index construction, GIS-based spatial analysis, and multi-criteria decision analysis.

The analysis reveals substantial methodological heterogeneity that impedes cross-city comparability, a systematic underrepresentation of social and governance dimensions in dominant frameworks, geographic bias toward high-income urban contexts, and emerging but underutilized opportunities from remote sensing and participatory assessment methods.

The study contributes to the growing body of scholarship calling for integrated, standardized, and equity-sensitive evaluation frameworks for green urban development. Given the accelerating pace of urbanization—particularly in the Global South and transitional economies such as those of Central Asia—the development of robust, adaptable, and inclusive green city metrics is not merely an academic exercise, but an urgent practical imperative for sustainable urban futures.

Future research should prioritize: longitudinal evaluation studies to assess the validity of current indicators over time; co-production of contextually appropriate indicators with communities in underrepresented regions; and the integration of emerging data streams, including citizen science platforms, real-time IoT sensor networks, and big data analytics, into next-generation green city assessment frameworks.

REFERENCES

1. Beatley, T. (2012). Green Cities of Europe: Global Lessons on Green Urbanism. Island Press.
2. Booysen, F. (2002). An overview and evaluation of composite indices of development. Social Indicators Research, 59(2), 115–151. https://doi.org/10.1023/A:1016275505152
3. Caprotti, F., Cowley, R., Flynn, A., Joss, S., & Yu, L. (2017). Smart-eco cities in the UK: Trends and city profiles 2016. University of Exeter.
4. Elmqvist, T., Andersson, E., Frantzeskaki, N., McPhearson, T., Olsson, P., Gaffney, O., Takeuchi, K., & Folke, C. (2019). Sustainability and resilience for transformation in the urban century. Nature Sustainability, 2(4), 267–273. https://doi.org/10.1038/s41893-019-0250-1
5. Geng, Y., Fu, J., Sarkis, J., & Xue, B. (2013). Towards a national circular economy indicator system in China: An evaluation and critical analysis. Journal of Cleaner Production, 23(1), 216–224. https://doi.org/10.1016/j.jclepro.2011.07.005
6. Huang, L., Wu, J., & Yan, L. (2020). Defining and measuring urban sustainability: A review of indicators. Landscape Ecology, 30(7), 1175–1193. https://doi.org/10.1007/s10980-015-0208-2
7. ISO (International Organization for Standardization). (2018). ISO 37120:2018 — Sustainable cities and communities: Indicators for city services and quality of life. ISO.
8. Kucukvar, M., Egilmez, G., & Tatari, O. (2016). Evaluating environmental impacts of alternative construction waste management approaches using supply-chain-linked life-cycle analysis. Waste Management & Research, 34(2), 153–164. https://doi.org/10.1177/0734242X15622828

9. Litman, T. (2022). Sustainable transportation indicators, strategies, and performance evaluation. Victoria Transport Policy Institute.
10. Marsal-Llacuna, M. L., Colomer-Llinàs, J., & Meléndez-Frigola, J. (2015). Lessons in urban monitoring taken from sustainable and livable cities to better address the Smart Cities initiative. Technological Forecasting and Social Change, 90, 611–622. https://doi.org/10.1016/j.techfore.2014.01.012
11. Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & PRISMA Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. PLOS Medicine, 6(7), e1000097. https://doi.org/10.1371/journal.pmed.1000097
12. Shen, L., Kyllo, J. M., & Guo, X. (2018). An integrated model based on a hierarchical indices system for monitoring and evaluating urban sustainability. Sustainability, 5(2), 524–559. https://doi.org/10.3390/su5020524
13. United Nations. (2018). 2018 Revision of World Urbanization Prospects. United Nations Department of Economic and Social Affairs. https://population.un.org/wup/
14. WHO (World Health Organization). (2016). Urban green spaces and health: A review of evidence. WHO Regional Office for Europe.
15. 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
16. Yigitcanlar, T., Kamruzzaman, M., Foth, M., Sabatini-Marques, J., Da Costa, E., & Ioppolo, G. (2020). Can cities become smart without being sustainable? A systematic review of the literature. Sustainable Cities and Society, 45, 348–365. https://doi.org/10.1016/j.scs.2018.11.033
17. Zhao, M. Y., Cheng, C. T., Chau, K. W., & Li, G. (2021). Multiple criteria data envelopment analysis for full ranking units associated to environment impact assessment. International Journal of Environment and Pollution, 28(3–4), 448–464. https://doi.org/10.1504/IJEP.2006.011222