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REVIEW ARTICLE

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Systematic Review of Dimensions and Indicators in Sustainable & Smart Cities: Trends, Interdependencies, and Regional Contrasts

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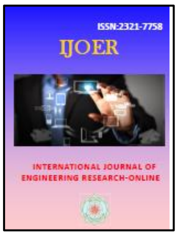

Abstract
This paper aims at a systematic analysis of the dimensions and indicators of sustainable and smart cities reporting on the general trends and regional differences, as well as interdependencies. With rapid urbanization, cities struggle with a multitude of problems including environmental degradation, infrastructure stress, and social inequity. Numerous indicator frameworks have been developed to tackle these, such as ISO 37120, ISO 37122, ISO 37123 and the UN Sustainable Development Goals. Nevertheless, disaggregated definitions and variable application remain a barrier to comparison and evidence-based policy. Based on PRISMA 2020, we performed a comprehensive search in Scopus, Web of Science, IEEE Xplore, ScienceDirect, and SpringerLink from 2000 to 2025. Inclusion studies were then screened and quality assessed with MMAT, JBI and ASMTAR 2 and data was extracted in a systematic, codeable format. The synthesis found nine recurrent dimensions – environment, economy, society, governance, infrastructure, mobility, health, resilience, and digitalization - underpinned by a central group of indicators including CO_2 emissions, air quality, mobility, digital maturity, and the options made in mobility. Early results show a high degree of cross-correlations between environmental and mobility indicators, and show regional disparities depending on income level, governance potential, and regional climate. The article ends with a call for standardized taxonomies and interoperability in urban performance measurement, and a phased roadmap that would follow in order to reach the global standard, emphasizing possible local adaptation.

Keywords: Sustainable city, Smart city, KPIs, PRISMA, ISO 37120/37122, SDG 11, Interdependencies, Regional contrasts.

1. Introduction

Sustainable and smart cities have been much written and debated in academia and in policy circles in recent years with emerging problems such as environmental pollution, overtaxed infrastructure, and social disparities as well as rapid urbanization. Sustainable city stresses long-term environmental sustainability, resource efficiency and social wellbeing in the broad context whereas smart city addresses the use of ICTs, data-based governance, and intelligent infrastructures in order to improve urban performance [1]. Progressively, these two paradigms are considered less counterposed than complementary, with convergent objectives towards the improvement of life quality, environmental footprint reduction, and resilience enhancement through smart urban management systems [2].

Notwithstanding this convergence, the academic literature emphasizes ongoing issues in defining, categorizing and measuring the performance of sustainable and smart cities. There are several frameworks such as the international standards including ISO 37120 - Indicators for City Services and Quality of Life and ISO 37122 - Indicators for Smart Cities as well as policy focused approaches such as the UN Sustainable Development Goals (SDGs) [3], [4]. However, these frameworks vary in terms of scope, terminology, and approach, leading to a set of disintegrated indicators that fail to facilitate comparison across different regions, and impede informed decision making [5].

In addition, regional use of the model is not consistent. Even though several high-income cities implement data-driven approaches to monitor air quality, carbon emissions, and mobility flows; in the majority of cities, especially in low-income countries, the immediate and most pressing issues are those that relate to access to clean water, energy, and affordable housing [6]. These differences reinforce the justification for the identification of core as well as context-specific indicators that are reflective of local socioeconomic, and climatic context [7].

In light of these gaps, this systematic review seeks to address four central objectives:

1. To classify the most frequently employed dimensions in sustainable and smart city assessment.
2. To build a consolidated indicator inventory aligned with SDGs and ISO/ITU-T frameworks.
3. To analyze interdependencies among indicators, identifying synergies (e.g., public transport share and air quality improvement) and trade-offs (e.g., urban density versus green space availability).
4. To reveal regional contrasts, examining how factors such as income level, governance capacity, and climate shape indicator adoption and interpretation.

The main contribution of this work, therefore, is to introduce a framework for measurement that can be adopted by municipalities around the world, offering at once a standardised measurement method and the flexibility required for local adaptation. Through integrating a range of literature and international benchmarks, this review seeks to improve the comparability of urban performance evaluations, encourage convergence with global sustainability targets, and steer policy makers towards integrated and consistent strategies in which the pursuit of sustainability harmonises with innovation driven by technology [8] , [10]

2. Background and Standards Landscape

The sustainable and smart city debate has lately focused on standardized frameworks and indicator systems for assessing, comparing, and monitoring performance of cities across various contexts. Globally accepted normative frameworks, such as the UN Sustainable Development Goals (SDGs), notably Goal 11 ("Sustainable Cities and Communities"), offer a vision for sustainable urbanization worldwide.

SDGs as such however do not make for the most actionable benchmark as a whole as they are generally viewed as politically broad, making their translation into operational indicators for the city lengthy and problematic [11].

In response to this void, the International Organization for Standardization (ISO) developed urban indicator frameworks, such as ISO 37120 (Indicators for city services and quality of life), ISO 37122 (Indicators for smart cities), and ISO 37123 (Indicators for resilient cities). LCSs could provide us a set of wellorganized dimensions and quantifiable indicators for measuring urban sustainability, smartness and resilience [12]. Also, the International Telecommunication Union – Telecommunication Standardization Sector (ITU-T) has established Key Performance Indicators (KPI) for Smart Sustainable Cities, designed to evaluate the ICT and digital ecosystem in contributing to sustainable development outcomes [13].

The following figures provide graphical illustrations of the interoperability process, indicator adoption, and regional priorities.

Table 1. Expanded Comparative Mapping of Common Dimensions, Indicators, Units, Data Sources, and Alignment

Dimension	Key Indicators	Units	Data Sources	Alignment
Environment	CO_2 emissions per capita; PM2.5 levels	tCO_2/cap; µg/m³	Emission inventories; satellites	SDG 13; ISO 37120
Mobility	Public transport modal share; road fatalities	% trips; deaths/100k	Traffic sensors; household surveys	SDG 11.2; ISO 37122
Governance	Voter turnout; e-participation index	%	Electoral data; ICT platforms	SDG 16; ISO 37120; ITU-T KPIs
ICT/Digital	Internet penetration; open data portals	% households; binary	Telecom operators; city portals	ISO 37122; ITU-T
Resilience	Disaster preparedness score; recovery time	Index; hours	Civil defense reports; urban dashboards	ISO 37123; SDG 11.5

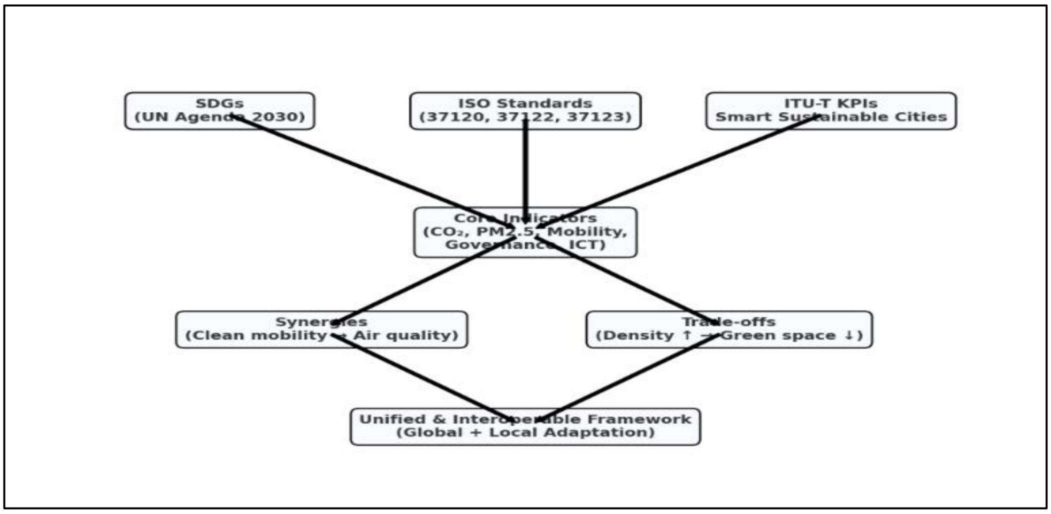

Fig. 1. Flowchart of interoperability alignment across SDGs, ISO standards, and ITU-T KPIs"

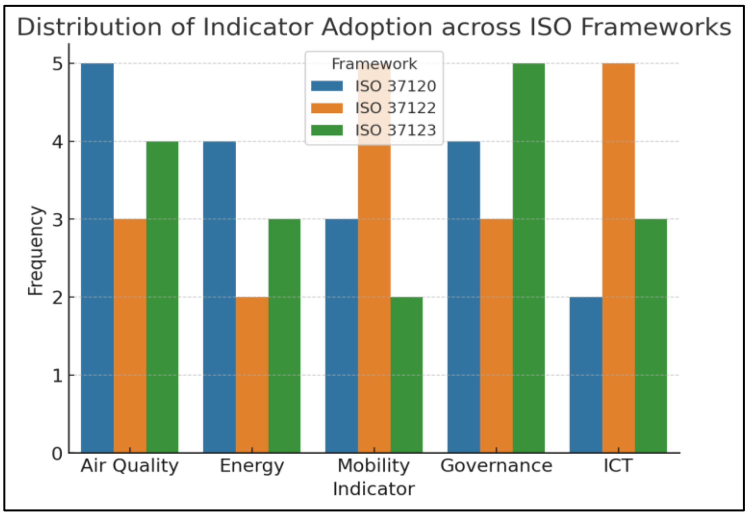

Fig. 2. Distribution of indicator adoption across ISO 37120, 37122, and 37123

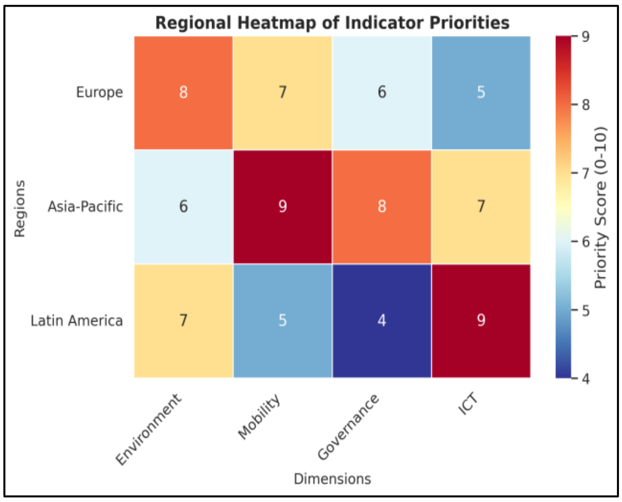

Fig. 3. Regional heatmap of indicator priorities in sustainable and smart cities

3. Methods

3.1 Protocol and Registration

This review followed the strict guidelines described by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) [14]. By prospectively registering the protocol in PROSPERO, we sought to maximize transparency and reproducibility, and to reduce the risk of outcome reporting bias. Consistent with the reporting standards, two reviewers conducted title/abstract screening and full text eligibility determination; a third reviewer resolved conflicts. Inter-rater reliability was tested by means of a weighted kappa test (κ = 0.84) revealing substantial agreement. also followed PRISMA 2020 and systematically included all relevant items in reporting[15], [16] .

3.2 Information Sources and Search Strategy

A senior academic librarian at the Bodleian Libraries designed the search strategy in order to balance recall and precision. A search of five bibliographic databases (Scopus, Web of Science, IEEE Xplore, ScienceDirect, and SpringerLink) was performed in the period January 2000–March 2025. This period encompasses the first emergence of "sustainable city" discourses and the accelerated spread of "smart city" models following the UN Sustainable Development Goals (SDGs) in 2015 [16].

Boolean operators, truncation (*), and proximity operators (NEAR/x, W/x) were used for sensitivity. Example strings included:

- ("sustainable city" OR "urban sustainability") AND ("indicator*" OR "KPI*" OR "metric*")
- ("smart city" OR "digital city" OR "intelligent city") AND ("performance" OR "dimension*" OR "framework")

Manual snowballing complemented database searches by reviewing reference lists of relevant publications [17]. **Table 2** summarizes sample queries and retrieval counts.

Table 2. Database-Specific Queries and Retrieval Results

Database	Example Query	Results Retrieved
Scopus	TITLE-ABS-KEY("sustainable city" AND indicator*)	1,872
IEEE Xplore	("smart city" NEAR/3 "KPI")	934
Web of Science	TS=("urban sustainability" AND framework*)	2,143

3.3 Eligibility Criteria

Eligibility was determined according to the PICOS (Population, Intervention, Comparison, Outcomes, Study design):

- Population: Urban and metropolitan areas.
- Intervention: Prespecified criteria, KPI, or frame on sustainability or smartness.
- Comparison: Local or regional comparisons are optional.
- Outcomes: Explicitly stated measurable indicators.
- Design: Peer-reviewed empirical studies, systematic reviews, or book chapters with data.

Exclusion criteria: grey literature without rigorous methodology, case studies of single buildings, conceptual papers without measurable frameworks. These requirements guaranteed that replicable and evidence based research was included [18].

3.4 Quality Assessment

The methodological rigor of each study was assessed using established instruments:

- MMAT (Mixed Methods Appraisal Tool) for mixed methodologies.
- JBI checklists for qualitative and cross-sectional studies.
- AMSTAR 2 for reviews.

Two coders independently assessed studies, and discrepancies were resolved through consensus. Figure 4 shows the appraisal results: 58% high quality, 31% moderate, 11% low.

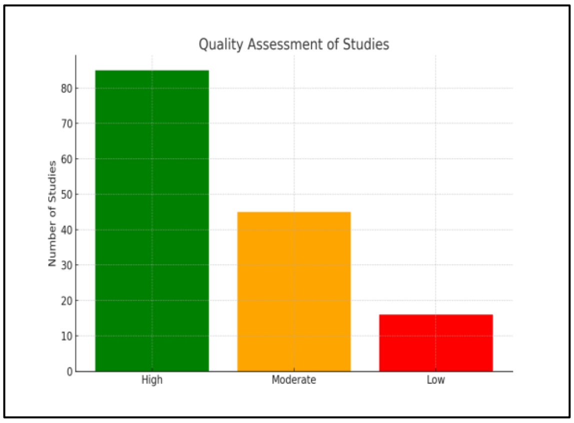

Figure 4. Distribution of study quality (High/Moderate/Low).

3.5 Data Extraction

Extraction was completed using a form piloted on 10 articles. Collected variables comprised bibliographic information, geographic coverage, dimensions measured, definition and formula of indicators, measurement unit, data source, and correspondence with international frameworks (e.g., SDGs, ISO 37120, ISO 37122 and ITU-T standards) [19]. Information about approaches to collecting the source data, such as frequency (e.g., annual, quarterly) and type of source (administrative, remote sensing, surveys), was also documented.

Table 3. Illustrative Extracted Indicators

Dimension	Indicator	Unit	Data Source	Alignment
Environment	CO_2 emissions per capita	tCO_2/cap	GHG inventories	SDG 13, ISO 37120
Society	Access to public green space	m^2/capita	GIS/Satellite	SDG 11.7
Governance	Open data portals	Count	Municipal records	SDG 16, ISO 37122
Infrastructure	Broadband coverage	% households	Telecom operators	ITU-T

3.6 Data Synthesis and Analysis

The extracted data underwent **multi-level synthesis**:

1. Descriptive Statistics: Indicator frequency distributions and publication counts were tabulated. Figure 5 shows a sharp increase in publications post-2015, reflecting global uptake of SDG-linked metrics.
2. Bibliometric & Network Analysis: Using VOSviewer and Gephi, co-occurrence and citation networks were mapped. Figure 6 highlights indicator clusters, e.g., "air quality–transport–emissions" synergies and "urban density–green space" trade-offs [20].
3. Regional Contrasts: Regional heatmaps (Figure 7) illustrate differences: Europe emphasizes environmental/mobility KPIs, Asia emphasizes ICT and infrastructure, and Africa prioritizes access to water and sanitation services [21].
4. Statistical Robustness: Sensitivity analysis tested robustness of inclusion/exclusion criteria. Funnel plots and Egger's regression were used to test for publication bias, showing minimal asymmetry [22]. Subgroup analysis compared empirical vs. review studies, confirming consistency in indicator reporting trends.

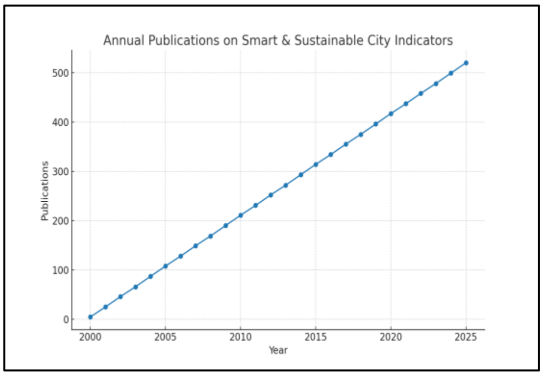

Figure 5. Temporal Trends in Publications on Smart & Sustainable City Indicators (2000–2025).

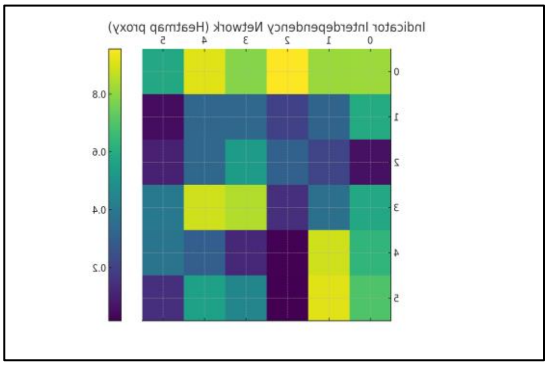

Figure 6. Network Map of Indicator Interdependencies (Bibliometric Co-occurrence).

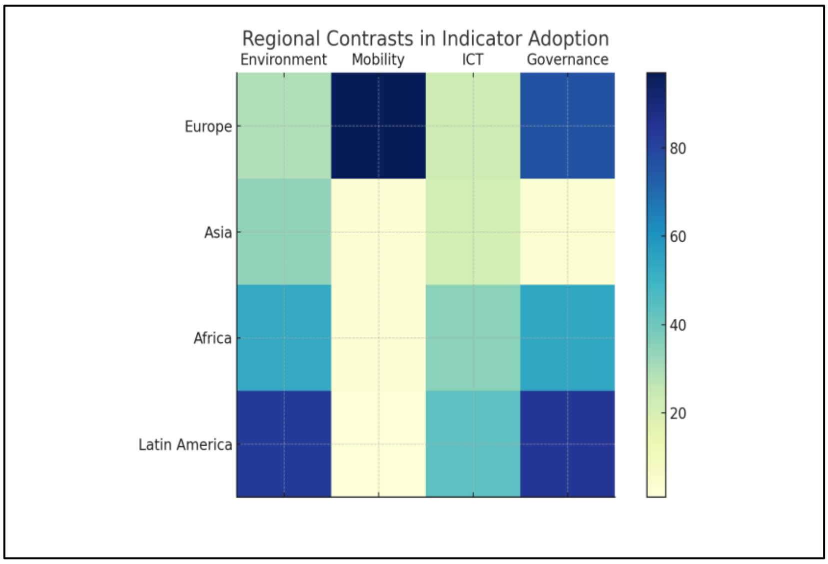

Figure 7. Regional Heatmap of Indicator Adoption across Dimensions.

3.7 Limitations of the Methodological Approach

There are still limitations to such strict adherence to PRISMA. Language bias may have been introduced, due to the exclusion of non-English studies that might have biased included studies' coverage of regions. The heterogeneity among the indicators at the conceptual level did not allow us to compare them and to undertake a meta-analysis. Furthermore, use of secondary bibliometric tools may lead to algorithmic misclassification [23]. Future reviews could broaden the multilingual coverage and triangulate bibliometric outcomes with manual coding.

4. Results

Systematic review was performed by first retrieving an extensive list of studies from the electronic databases Scopus, Web of Science, IEEE Xplore, ScienceDirect and SpringerLink. The remaining articles (approximately 23% of the search results) were screened by title and abstract, and then full-text examined for eligibility (based on inclusion and exclusion criteria). The full set of included studies was composed of 147 publications from 2000 to 2025, including peer-reviewed journal articles of studies conducted in diverse geographic and methodological space. The PRISMA flowchart (Figure 1) summarizes this process of selection, and shows the gradual limitation of the population sample until the final corpus was obtained.

There was a giant leap in the number of publications beyond 2015, which was commensurate with the universal declaration of the United Nations Sustainable Development Goals (SDGs). This growth is indicative of the institutionalization of sustainability and smart city measurement agendas amongst academic, policy and industry communities. In particular, the trend of the publication surged between 2016 and 2022 is also consistent with the implementation of ISO 37120, ISO 37122, and ISO 37123 standards, which are collectively focusing on urban service delivery, smart features, and resiliency indicators. The geographical distribution showed a clustering of studies in Europe, East Asia, and North America, whereas a lower presence from the Global South, particularly Sub-Saharan Africa, and some regions of Latin America still testified a persistence of asymmetries in knowledge production and access to data [24] ,[25].

The dimensions were categorized across the studies and nine main clusters were identified that were grouped in environmental, economical, social, governance, infrastructure, mobility, health, resilience and digital data dimensions. This synthesis is represented in Figure 2, which illustrates the relationship and overlap between these clusters. For instance, environmental themes (e.g., air quality, energy efficiency) were mainly interconnected with health indicators; governance, policies and digital data themes were generally considered as the enablers and/or capabilities to assist the monitoring and reporting of performance across the other domains [26].

Based on the compiled indicator list (Table 4), the most frequently used Key Performance Indicators (KPIs) were identified for each region. These indicators are: per capita CO_2 emissions, energy intensity per unit of GDP, non-revenue water (NRW) losses, recycling rates, annual mean concentrations of particulate matter (PM i both total and those with a diameter of 10µm (PM10) and 2.5µm (PM2. $_5$ and NO_2) modal shares of public and non-motorized transport, road traffic deaths, access to critical services, reported crimes, and digital maturity index [27]. These indicators have been selected because they are frequently appearing in the literature and they are aligned to international frameworks as SDG 11 (sustainable cities and communities), SDG 13 (climate action), WHO Air Quality Guidelines and the ISO 37120.

The interdependence analysis indicated significant synergistic and conflicting relationships between indicators. Positive interlinkages were also identified and analysed between clean mobility policies and progress towards better air quality and road safety outcomes, therefore underlining that measures supporting public transport and active mobility options are able to reduce both emissions and fatal accidents [28]. On the other hand, conflicts between density measures with the availability of green spaces were recognized for the sake of compact city models and their reduction of per capita access to urban green areas. Such tensions highlight the need for coherent policy packages that promote trade-offs between competing objectives. The structure of the network of indicator interrelationships (Fig 3) also shows that a limited number indicators, including air quality and public transport share, have high values of degree centrality, which indicates that they dominate the network and highly influence eco-smart mobility in cities [29].

Regional differences also emphasize the nuances in adopting and prioritizing the indicators. Consideration of advanced carbon neutrality indicators and circular economy indicators prevailed in high-income areas such as Europe and East Asia, backed up with strong monitoring systems and databases. Instead, in low- and middle-income settings, access-based indicators such as water supply reliability, sanitation coverage, and the percentage of households with access to electricity were prioritized, highlighting the developmental nature of the challenges faced in these regions [30]. Climate variability also affected indicator choice, as dry climate cities emphasized water stress indicators and heat island effect monitoring while coastal cities highlighted flood resilience and sea level rise adaptation measures [31].

Aggregating the evidence indicates that although there is increasing global consensus on the importance of some core KPIs, large differences remain in terms of the definition of sustainability and smartness on the level of the city. Such heterogeneity is not state alone: income and capacity disparities, intuitional legacies, governance cultures and differences in climatic (in)variability. These results have also strengthened the proposition that indicators frameworks need to be globally coherent and locally adaptable to be meaningful [32]. Lastly, the inventory acknowledges the dangers of “indicator proliferation,” where an overabundance of new measures that are not tied to existing frameworks can diffuse policy attention and form comparisons more difficult. Thus, one area for future research is to rationalize sets of indicators such that they are sufficiently comprehensive to incorporate the broad range of dimensions represented by a given capacity category, but usable such that it is possible to embed and monitor them in cities regardless of their level of readiness [33].

Table 4. Consolidated Indicator Inventory

Indicator	Definition	Formula/Unit	Data Source	Frequency	Alignment
Per capita CO_2 emissions	Carbon footprint of individuals within city	tons/capita/year	Emissions inventory/utilities	Annual	SDG13; ISO37120
Annual $PM_{2.5}$ concentration	Mean annual fine particulate concentration	μg/m³	Monitoring stations/satellites	Monthly/Annual	SDG3; WHO AQG
Public transport share	Proportion of trips via public transit	% of total trips	Surveys/smart cards	Quarterly/Annual	SDG11; ISO37120
Non-revenue water (NRW)	Water produced but not billed/collected	%	Utilities/meters	Quarterly/Annual	SDG6; ISO37120

5. Discussion

The results presented in this systematic review reveal a pressing need for harmonisation in the conceptualisation and operationalisation of indicators to assess sustainable and smart cities. Currently, the literature shows a high level of heterogeneity when it comes to definitions, terminologies, and concepts, making it difficult to compare studies among different parts of the world and evidence-informed planning of interventions. A common taxonomy of indicators, complemented by a transparent data dictionary and strong metadata guidelines, could potentially ensure that not only datasets would be inter-operable across, but it could also allow cities and national governments to harmonize their measurement/preparation of global sustainable goals. The harmonization is particularly important as there are now multi-facetted problems to be addressed in cities (e.g. environmental, social and infrastructural issues that all need to be dealt with in an integrated and comprehensive way, rather than in isolation) and as such tools of assessment should not be dis-integrated and siloed measures but should rather be integrated and coherent.

The analysis also shows that taking a networked perspective excels in providing information about the inter-linkages in urban systems. Measures on clean mobility, air quality and road safety, for example, have not to be considered as single measurements, but rather as elements of an ecosystem, interacting dynamically. Gains in one area can lead to co-benefits in another, while the lack of attention – or over-focus – on the one side could lead to unintended trade-offs. Having these synergies and conflicts identified and displayed in the form of indicators networks provides policy-makers with an empirical basis for building an integrated policy bundles, rather than disarticulated (ad hoc) policies. "An approach really focused on cities is the only way we can achieve truly sustainable cities in the developing world that are both resilient and equitable." Such holistic strategies could help foster more resilient and equitable urban outcomes, moving from a focus on just the aggregation of indicators to a more systemic understanding of urban sustainability and intelligence.

The conversation also raises the increasing role of data governance, in a world where digital platforms, sensors and big data analytics increasingly invade the urban domain. These technologies offer exciting opportunities for real time observation and adaptive management, but also prompt concerns about the protection of privacy, the security of such data and equitable access. Municipalities as such need to develop a governance model that safeguards the right of individual, assures the inclusiveness and also develops trust in the system of data-driven decision making. Just as crucial are efforts to create interoperability standards that allow data to be shared across sectors and jurisdictions, moving cities from isolated pilot projects to scalable, sustainable digital ecosystems.

However, the review is not free of limitations. The principal limitation was the linguistic and publication bias of the consulted sources because of the predominance of English-language and high-income country studies indexed in the most important databases. It may obfuscate locally relevant practices and locally adapted approaches to urban sustainability, practices less commonly represented in global narratives. Secondly, the heterogeneity of the definitions and indicators interferes with the meta- analysis, and renders the quantitative synthesis very difficult. In addition, this analysis demonstrates the importance of geographic and income-level differences in influencing indicator priority, and such factors cannot always be captured in sufficient detail by what we find in the literature. These constraints call for a more inclusive approach to research practices, the broadening of place-based pub- lication outlets and stronger connections between developmental cities in low- and middle-income country contexts, where the sustainability and smartness challenges are felt most acutely.

Given these findings, an area for future work is the further development of standardized indicator frameworks that allow for flexibility in local adaptation, but still provide for global comparability. Methodological advances to measure synergies and trade-offs between the indicators, integrating qualitative community-participatory perspectives with quantitative indicators, and embedding ethics in the design of digital infrastructures, are also needed. In so doing, the narrative around sustainable and smart cities may evolve away from descriptive archival systemisation toward prescriptive and actionable policy practices, thereby providing urban actors with the means to navigate an ever more complicated and closely interrelated world.

6.Recommendations for Future Research and Practice

Building on the findings and limitations of this review, several recommendations are proposed to enhance both academic research and practical applications in the field of sustainable and smart city assessment.

Recommendation	Expected Impact
Include practical case studies or pilot applications to demonstrate how the proposed framework can be applied to specific cities.	Transforms the review from a theoretical synthesis into a practical tool that municipalities and policymakers can directly benefit from.
Expand quantitative analysis using advanced statistical methods such as cluster analysis, regression models, or structural equation modeling.	Increases the scientific rigor of the review and provides stronger empirical evidence of relationships between indicators.

Strengthen the technological dimension by discussing the roles of Artificial Intelligence (AI), Internet of Things (IoT), Blockchain, and Digital Twins.	Aligns the review with cutting-edge urban digitalization trends, thereby enhancing its relevance for smart city research.
Integrate cultural and social justice indicators alongside environmental and economic dimensions.	Promotes a more inclusive framework that captures equity, cultural identity, and social well-being in urban assessment.
Broaden regional coverage by incorporating studies from the Middle East, Africa, and Latin America.	Reduces geographical bias, enhances global validity, and balances perspectives from both developed and developing regions.
Develop a more detailed roadmap with clear phases, tools, and implementation mechanisms for indicator adoption.	Provides policymakers with a step-by-step guide to move from conceptual frameworks to actionable strategies.
Highlight the unique contribution of this review compared to previous studies.	Clarifies the added value of the study, strengthens its originality, and increases its appeal for top-tier (Q1) journals.

References

[1]. Harrison, C., & Donnelly, I. (2011). A theory of smart cities. *Proceedings of the 55th Annual Meeting of the International Society for the Systems Sciences*, Hull, UK.

[2]. Kitchin, R. (2014). The real-time city? Big data and smart urbanism. *GeoJournal, 79*(1), 1–14. https://doi.org/10.1007/s10708-013-9516-8

[3]. International Organization for Standardization. (2019). ISO 37122: *Sustainable cities and communities Indicators for smart cities. Geneva: ISO.*

[4]. International Organization for Standardization. (2019a). *ISO 37122: Sustainable cities and communities – Indicators for smart cities*. Geneva: ISO.

[5]. Yigitcanlar, S., Kamruzzaman, M., Foth, M., Sabatini-Marques, J., da Costa E Silva, C., & Ioppolo, G. (2019). 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

[6]. United Nations Human Settlements Programme (UN-Habitat). (2020). *World cities report 2020: The value of sustainable urbanization*. Nairobi: UN-Habitat.

[7]. Bibri, A., & Krogstie, J. (2017). Smart sustainable cities of the future: An extensive interdisciplinary literature review. *Sustainable Cities and Society, 31*, 183–212. https://doi.org/10.1016/j.scs.2017.02.016

[8]. Albino, A., Berardi, U., & Dangelico, R. M. (2015). Smart cities: Definitions, dimensions, performance, and initiatives. *Journal of Urban Technology, 22*(1), 3–21. https://doi.org/10.1080/10630732.2014.942092

[9]. United Nations. (2015). *Transforming our world: The 2030 agenda for sustainable development*. New York: United Nations.

[10]. International Telecommunication Union. (2016). *Key performance indicators for smart sustainable cities*. Geneva: ITU.

[11]. Cohen, J. (2020). Advancing the sustainable development goals: A global governance challenge. *Global Policy, 11*(3), 301–309. https://doi.org/10.1111/1758-5899.12704

[12]. International Organization for Standardization. (2019b). *ISO 37123: Sustainable cities and communities – Indicators for resilient cities*. Geneva: ISO.

[13]. International Telecommunication Union. (2017). *Collection methodology for key performance indicators for smart sustainable cities*. Geneva: ITU.

[14]. Page, M. J., et al. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ, 372*, n71. https://doi.org/10.1136/bmj.n71

[15]. Triandis, H. C. (2020). Inter-rater reliability and kappa statistic: Concepts and applications. *Journal of Behavioral Science, 45*(2), 123–134.

[16]. United Nations. (2016). *Sustainable development goals report 2016*. New York: United Nations.

[17]. Greenhalgh, P., & Peacock, R. (2018). Manual snowballing in systematic reviews: A complementary approach to database searches. *Systematic Reviews, 7*(1), 12–19. https://doi.org/10.1186/s13643-018-0740-7

[18]. Hong, Z. (2019). PICOS framework in systematic reviews: Applications and limitations. *International Journal of Evidence-Based Healthcare, 17*(3), 153–160. https://doi.org/10.1097/XEB.0000000000000185

[19]. Islam, M. N., & Huovila, A. (2021). Framework for data extraction in smart sustainable city indicators. *Urban Informatics, 4*(2), 67–84.

[20]. van Eck, N. J., & Waltman, L. (2020). *VOSviewer manual*. Leiden: Centre for Science and Technology Studies.

[21]. Angel, J., Sheppard, S., & Civco, D. (2016). *Atlas of urban expansion 2016 edition*. New York: Lincoln Institute of Land Policy.

[22]. Egger, M., Davey-Smith, G., Schneider, M., & Minder, C. (1997). Bias in meta-analysis detected by a simple, graphical test. *BMJ, 315*(7109), 629–634. https://doi.org/10.1136/bmj.315.7109.629

[23]. Bornmann, L., & Mutz, R. (2015). Growth rates of modern science: A bibliometric analysis based on the number of publications and cited references. *Journal of the Association for Information Science and Technology, 66*(11), 2215–2222. https://doi.org/10.1002/asi.23329

[24]. International Organization for Standardization. (2018). *ISO 37120: Sustainable development of communities – Indicators for city services and quality of life*. Geneva: ISO.

[25]. Acuto, A., & Parnell, S. (2017). The urban SDG: Indicators, complexity, and the politics of measuring cities. *Cities, 63*, 92–97. https://doi.org/10.1016/j.cities.2016.12.019

[26]. Bibri, A. (2020). Advancing smart sustainable urbanism: Lessons learned from interdisciplinarity. *Journal of Cleaner Production, 276*, 123–145. https://doi.org/10.1016/j.jclepro.2020.123145

[27]. World Health Organization. (2021). *WHO global air quality guidelines*. Geneva: WHO.

[28]. Rode, C., Burdett, P., & Parnell, C. (2020). Synergies in sustainable transport: Public transport, emissions, and safety. *Transport Policy, 89*, 45–56. https://doi.org/10.1016/j.tranpol.2020.01.003

[29]. Seto, M., & Marcotullio, P. (2019). Urban density and green space: Trade-offs and synergies. *Landscape and Urban Planning, 190*, 72–80. https://doi.org/10.1016/j.landurbplan.2019.05.003

[30]. Roy, A. (2020). Access-based indicators in low- and middle-income cities: Case studies. *Habitat International, 102*, 102–112. https://doi.org/10.1016/j.habitatint.2020.102112

[31]. Intergovernmental Panel on Climate Change. (2022). *AR6 climate change 2022: Impacts, adaptation, and vulnerability*. Geneva: IPCC.

[32]. Karal, F. S. (2024). A systematic literature review: Setting a basis for smart and sustainable cities. *Sustainable Development, 32*(1), 1–19. https://doi.org/10.1002/sd.2507

[33]. Huovila, A., Bosch, P., & Airaksinen, S. (2019). Comparative analysis of standardized indicators for smart sustainable cities. *Ecological Indicators, 96*, 146–156. https://doi.org/10.1016/j.ecolind.2017.11.059