ARBOR Ciencia, Pensamiento y Cultura
Vol. 200, 811, enero-junio, a001 | ISSN-L: 0210-1963
https://doi.org/10.3989/arbor.2024.811.001

URBAN PERFORMANCE: A SYSTEMATIC LITERATURE REVIEW

PERFORMANCE URBANA: UNA REVISIÓN SISTEMÁTICA DE LA LITERATURA SOBRE ESTUDIOS URBANOS

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Cómo citar este artículo/Citation: Beck, Donizete; Ferasso, Marcos (2024). Urban performance: a systematic literature review. Arbor, 200(811): a001. https://doi.org/10.3989/arbor.2024.811.001

Recibido: 14 febrero 2022. Aceptado: 24 enero 2024
Publicado: 30 septiembre 2024

Abstract: The focus here is to explore and organize the literature of urban studies on urban performance and the main indicators used. This study applies a literature review analysing a sample of 47 papers gathered from the Scopus database. All of the selected papers are concerned with urban studies, urban management, and urban planning. This study provides a guide for scholars and practitioners containing the main indicators used for measuring urban performance and how they can effectively explore those indicators to produce better research and policies. Findings reveal a synthesis of the most used indicators for measuring the urban performance of the mainstream approaches in urban studies (socioeconomic and demographic; environmental; smart cities; urban design, built environment, and territory; public administration, government, and governance; energy efficiency; sustainability and sustainable development; transportation and mobility; benchmarking; and global cities). Also provided are how these indicators can be better explored by scholars and practitioners. The social and managerial contributions of this paper lie in its synthesis of urban performance indicators, which can be useful for scholars to improve their research as well as to enable urban planners and managers to work more efficiently with urban policies and thus improve the desired urban performance for one or various approaches.

Keywords: urban performance; urban studies; urban management; urban planning; urban policy

Resumen: El objetivo de esta investigación es explorar y organizar la bibliografía de estudios urbanos sobre el rendimiento urbano y los principales indicadores que se utilizan. Se analiza una muestra de 47 artículos recogidos en la base de datos Scopus que se refieren a estudios urbanos, de gestión y planificación urbana. Este artículo proporciona una guía para académicos y profesionales que muestra los principales indicadores utilizados para medir el rendimiento urbano de los principales enfoques de los estudios urbanos (socioeconómico y demográfico; medioambiental; ciudades inteligentes; diseño urbano, entorno construido y territorio; administración pública, gobierno y gobernanza; eficiencia energética; sostenibilidad y desarrollo sostenible; transporte y movilidad; evaluación comparativa; y ciudades globales). Las aportaciones sociales y de gestión de este documento residen precisamente en la síntesis que ofrece de los indicadores de rendimiento urbano, que pueden ser útiles para que mejoren las investigaciones académicas, así como para que quienes planifican y gestionan el urbanismo trabajen de forma más eficiente con las políticas urbanas y mejoren así el rendimiento urbano deseado.

Palabras clave: performance urbana; estudios urbanos; gestión urbana; planificación urbana; política urbana

1. INTRODUCTION

In the contemporary urban environment, the concept of urban performance is crucial due to rapid urbanization and urban complexity (Bettencourt et al., 2010). In this way, urban managers and governance that understand and optimize urban performance can effectively manage urban growth and enhance residents' quality of life. In other words, it empowers effective management in complex urban-related challenges, enabling tailored policies and interventions for an enhanced and sustainable quality of life.

Also, the challenges that urban planners and managers face have intensified as urban stakeholders possess diverse and often conflicting needs and aspirations. The diverse stakeholder network increases the complexity of urban performance measurement (Beck and Storopoli, 2021). Urban performance refers to the comprehensive evaluation of a city's effectiveness, efficiency, and achievement in various dimensions, including socioeconomic, environmental, and infrastructural (Bettencourt et al., 2010; Caragliu et al., 2012; Shmelev and Shmeleva, 2018; Molinaro et al., 2020; among others). For this reason, it is important to comprehend existing issues related to urban performance and tackle the conceptual and practical complexities of urban performance. In this way, It involves assessing how well a city simultaneously meets its objectives and stakeholder needs (Beck and Storopoli, 2021), creating value for a wide range of urban stakeholders (Beck and Ferasso, 2023; Beck et al., 2023).

While the concept of urban performance is widely recognized (Bettencourt et al., 2010), there exists a significant gap in understanding how to effectively measure and evaluate it across its multifaceted dimensions. In other words, the absence of a comprehensive framework for assessing urban performance hinders the formulation of intersectoral policies that can address the multidimensional aspects of urban development. The vagueness in the measurement of urban performance poses obstacles to effective decision-making, resource allocation, and sustainable urban management.

This research bridges this gap by systematically exploring and organizing the main urban performance indicators utilized in urban studies and discusses how these indicators can serve as a foundation for developing intersectoral policies. Therefore, the purpose of this paper is twofold: first, to synthesize and organize the main urban performance indicators used in urban studies; and second, to explore the urban performance indicators for building intersectoral policies.

After this introduction, the remainder of this study is as follows. The second section details the research design and how the systematic literature review was performed. The third section has a synthesis of the mainstream approaches and the main indicators used in each of them. The fourth section contains information and recommendations on how to explore the urban indicators by considering indicator types, uses, stakeholder participation, and the Sustainable Development Goals. Finally, the conclusion section ends with research and practical contributions and future directions.

2. RESEARCH DESIGN

This study employs a *Systematic Literature Review* (SLR) as a methodological approach to comprehensively explore urban performance dimensions. SLR rigorously examines existing scholarly works, enabling insight synthesis, trend identification, and gap recognition in urban performance measurement knowledge. This section outlines the review protocol of our research design for SLR, including data collection, screening, analysis, and synthesis; facilitating a comprehensive exploration of urban performance evaluation methods.

2.1 Data Collection

Firstly, we chose the Scopus database due to its comprehensive coverage of articles in the field of social applied sciences, which includes urban studies and urban planning (Mongeon and Paul-Hus, 2016; Martín-Martín, Orduna-Malea and López-Cózar, 2018a; Martín-Martín, Orduna-Malea and López-Cózar, 2018b; Beck and Ferasso, 2022). For the systematic literature review, a comprehensive search was conducted on the Scopus database to identify peer-reviewed articles published before 2021 containing the term "urban performance" in their title, abstract, and/or keywords. Our search expression reaches articles published in all languages, methods, and impact. The main exclusion criteria are Conference abstracts, book chapters, and editorials. The search expression employed was: TITLE-ABS-KEY ("Urban Performance") AND (PUBYEAR < 2021) AND (LIMIT-TO (DOCTYPE, "ar")).

ARBOR Vol. 200, 811, enero-junio 2024, a001 | ISSN-L: 0210-1963 https://doi.org/10.3989/arbor.2024.811.001

Thus, we collected *83 documents* obtained from this search. This comprehensive search strategy was employed to capture a broad spectrum of literature pertinent to urban performance evaluation. By systematically leveraging the Scopus database, the study endeavored to encompass a diverse array of research contributions that align with the study's objectives. The next subsection further delves into the process of data refinement, ensuring the ultimate selection of pertinent scholarly works for the systematic literature review.

2.2 Data Screening

We screened the abstract, introduction, and method sections to ensure that these 83 articles concern indicators or conceptual development on urban performance in urban studies, policy and planning. When screening, we removed 36 documents, in which 34 of them were not about our topic (the majority was related to artistic urban performance), and 2 of them are only one and were in the sample due to an error on the Scopus search mechanism (i.e. Maia, Netto and Da Costa, 2019). In other words, the inclusion criteria encompass articles focusing on indicators or conceptual development related to urban performance in urban studies, policy, and planning. Exclusion criteria target documents unrelated to this topic, particularly those centered on artistic urban performance. An error led to the inadvertent inclusion of two documents, which were subsequently removed. In this way, the final sample has 47 papers (see the list of sample papers at: https://osf.io/hvsxm/?view_only=a6b4b9cfe83649c09732132f006e8eee).

2.3 Data Analysis and Synthesis

The data analysis and synthesis were made by comprehensively reviewing and categorizing the 47 final articles in our sample based on the thematic alignment with the concept of urban performance, which refers to the comprehensive evaluation of a city's effectiveness, efficiency, and achievement in various dimensions, including socioeconomic, environmental, and infrastructural (Bettencourt et al., 2010; Caragliu et al., 2012; Shmelev and Shmeleva, 2018; Molinaro et al., 2020; among others). It is important to note that the categorization process was executed organically, i.e., without imposing any predetermined categories *a priori*. Instead, these categories, or approaches, emerged iteratively during the review process, guided by the initial assessment of the first author and subsequently validated by the second author. Following this categorization, a systematic compilation of the primary indicators corresponding to each identified approach was undertaken, resulting in the creation of distinct tables for clarity and comparison. Furthermore, a qualitative investigation was conducted to deepen the understanding of how urban performance was conceptualized within each unique approach. This step ensures the comprehensive exploration and unbiased interpretation of the diverse facets of urban performance, enhancing the robustness and reliability of our research outcomes.

3. URBAN PERFORMANCE

Measuring urban performance depends upon the variables, the dimensions, and the specific topic and phenomenon in which the researcher is studying. For instance, some scholars have studied the phenomenon of smart cities (Nicolas, Kim and Chi, 2020; Caragliu, Del Bo and Nijkamp, 2011; Shmelev and Shmeleva, 2018; among others), in which they will highlight variables such as ICT infrastructure, because such phenomenon is inherent to the massive use of ICT infrastructure in the urban context.

Another example relies on the main approach used in the urban context - the socioeconomic - to measure the main societal issues, which are related to productivity, income, employment, safety and security, health, transportation, education, and so on. In this way, this study sheds light on the main approaches used for understanding urban performance as well as the most used variables for each one of those approaches.

In the mainstream literature on urban performance, the top-10 approaches are consecutively: (1) socioeconomic; (2) environmental; (3) smart cities; (4) urban design, built environment and territory; (5) public administration, government, and governance; (6) energy efficiency; (7) sustainability and sustainable development; (8) transportation and mobility; (9) benchmarking; and (10) global cities. Table 2 shows the number of occurrences for each one of these approaches in the literature, and their respective references.

Table 2. The Mainstream Approaches on Urban Performance in the literature of Urban Studies

%(Pp)	Approaches	References
74.4% (35)	Socioeconomic and demographic	(Brown and Kirby, 1971; Xu *et al.*, 2020; Wang *et al.*, 2017; Apreda, D'Ambrosio and Di Martino, 2019; Webster and Wu, 1999a; Webster and Wu, 1999b; Zhao and Zhang, 1995; Greasley, John and Wolman, 2011; Portnov and Schwartz, 2009; Jiao *et al.*, 2020; Lozano *et al.*, 1974; Arbabi, Mayfield and Dabinett, 2019; Wu and Webster, 1998; Nicolas, Kim and Chi, 2020; Caputo, Pasetti and Ferrari, 2019; Cohen, 1996; Parrado *et al.*, 2013; Webster, 1998; Caragliu, Del Bo and Nijkamp, 2011; Golubchikov, 2006; Bettencourt *et al.*, 2010; Shmelev and Shmeleva, 2018; Agnoletti *et al.*, 2015; McCarthy, 2000; Duarte and Ultramari, 2012; Molinaro *et al.*, 2020; Kitchin, Lauriault and McArdle, 2015; Caragliu and Del Bo, 2012; Kourtit, Nijkamp and Suzuki, 2021; Caragliu and Del Bo, 2018; Trovato and Giuffrida, 2014; Moraci, Fazia and Errigo, 2018; Moertiningsih, Nurgandarum and Nurfanty, 2020; Marchand, 1987; Caragliu *et al.*, 2012)
25.5% (12)	Environmental	(Stossel, Kissinger and Meir, 2015; Apreda, D'Ambrosio and Di Martino, 2019; Pasetti and Ferrari, 2019; Parrado *et al.*, 2013; Shmelev and Shmeleva, 2018; Molinaro *et al.*, 2020; Kitchin, Lauriault and McArdle, 2015; Arcidiacono and Ronchi, 2019; Maia, Netto and Da Costa, 2019; Moraci, Fazia and Errigo, 2018; Moertiningsih, Nurgandarum and Nurfanty, 2020; Staniscia, Spacone and Fabietti, 2017)
19.1% (9)	Smart Cities	(Nicolas, Kim and Chi, 2020; Caragliu, Del Bo and Nijkamp, 2011; Shmelev and Shmeleva, 2018; Caragliu and Del Bo, 2012; Kourtit, Nijkamp and Suzuki, 2021; Caragliu and Del Bo, 2018; Maltese, Mariotti and Boscacci, 2016; Moraci, Fazia and Errigo, 2018; Caragliu *et al.*, 2012)
14.8% (7)	Urban Design, Built Environment and Territory	(Noyman *et al.*, 2019; Chang *et al.*, 2019; Charlton *et al.*, 2015; Chokhachian *et al.*, 2020; Seles and Afacan, 2019; Moertiningsih, Nurgandarum and Nurfanty, 2020; Caragliu *et al.*, 2012)
14.8% (7)	Public Administration, Government, and Governance	(Greasley, John and Wolman, 2011; Parrado *et al.*, 2013; Webster, 1998; McCarthy, 2000; Molinaro *et al.*, 2020; Kitchin, Lauriault and McArdle, 2015; Cesme *et al.*, 2017)
8.5% (4)	Energy Efficiency	(Wang *et al.*, 2017; Chang *et al.*, 2019; Keirstead, 2013; Maltese, Mariotti and Boscacci, 2016)
8.5% (4)	Sustainability and Sustainable Development	(Chang *et al.*, 2019; Keirstead, 2013; Stossel, Kissinger and Meir, 2015; Chokhachian *et al.*, 2020; Agnoletti *et al.*, 2015)
6.3% (3)	Transportation and Mobility	(Xu *et al.*, 2020; Duarte and Ultramari, 2012; Cesme *et al.*, 2017)
4.2% (2)	Benchmarking	(Wang *et al.*, 2017; Keirstead, 2013)
2.1% (1)	Global Cities	(Wang *et al.*, 2017)

Note. %(Pp) = Percentage and its respective number of sample papers in the literature for each approach. Sorce: Own elaboration.

More than a half of publications on urban performance have measured socioeconomic and demographic related issues, and approximately a quarter of studies have worked on environment issues as urban performance. The more salient urban performance measures are those related to socioeconomic, demographic, and environmental ones. The next subsections deep the discussion into each one of the identified dimensions in the literature.

3.1 Socioeconomic and Demographics

From micro to macro parts of the urban system, the literature has shown the importance of the whole urban system in urban performance. In this way, socioeconomic and demographics are the most used approach in the literature, which have been a key for understanding and prescribing efficient policies to the urban system (Webster and Wu, 1999a; Kitchin, Lauriault and McArdle, 2015), and then, creating and attracting opportunities (e.g. jobs, places to shopping and leisure), a good business climate, and providing quality of the neighborhood for urban stakeholders (Brown and Kirbt, 1971; Marchand, 1987; among others).

Thus, in socioeconomic and demographics approach, cities have to consider social policies and mechanisms to manage an efficient urban mobility; provide accessibility within its limits and to other cities; to promote livability; to foster a vibrant, competitive and productive economy; an innovative research and development (R&D) system; excellent health, cultural, and educational systems; an appropriate standard of living; an efficient sanitation and waste disposal system; safety and security; Informational and Technological Communications (ICTs) and Infrastructure; and other topics that were mentioned in this paper in other specific sections due to the need of analyzing them separately and more attentively (Xu *et al.*, 2020; Wang *et al.*, 2017; Zhao and Zhang, 1995; Nicolas, Kim and Chi, 2020; Kourtit, Nijkamp and Suzuki, 2021; Moraci, Fazia and Errigo, 2018; among others mentioned in Table 2).

On the urban economy, the literature has shown that income, the degree of urbanization, and the outcomes from the multiple industries are interrelated to the urban performance (Cohen, 1996), in which these last ones and the government have to employ their resources efficiently to avoid over or underconsumption, and then, avoiding the welfare loss of their supplies (Webster, 1998). Even more, "the most important measure of urban success, viz. per capita wealth" (Caragliu, Del Bo and Nijkamp, 2011: 77). In this way, urban managers should consider socioeconomic issues in policy-making, because stimulating urban development by having economic policies and incentives can lead the city to have a better urban performance (McCarthy, 2000)

As for demographics and logistic issues, studies have highlighted the importance of urban mobility and accessibility. Pornov and Schwartz (2009) have found in 40 European countries that the proximity, demographical, and geographical patterns are important to the urban success, and then, higher proximity to high-population cities, accessibility to the main road of the region are important to classify a city as having "location package" and a privilege location. On land-use policies, a Chinese study reveals that urban land-use efficiency is similar in geographically closest cities (Jiao *et al.*, 2020).

Arbabi, Mayfield and Dabinett (2019) found that urban economic underperformance is related to inappropriate urban mobility, an issue that practitioners should have in mind to improve the urban performance, which is explained by the settlement scaling theory. Such theory has four assumptions, all of them are based on the interaction among the population: (1) the number of human interactions is related to the urban economic outputs; (2) a uniform-mixed population in the urban territory means more citizen accessibility to multiple resources; (3) the urban infrastructure is related to the actual networks and connections within the city; and (4) the average baseline human production is constant across the cities in an urban network.

Other issues that urban managers should consider are the social cost of the industrial development and the social cost for each municipal jurisdiction, and then, they will counterbalance the cost and benefits in their policy-making and move the city toward a social efficient development (Webster and Wu, 1999a; Webster and Wu, 1999b; Wu and Webster, 1998). Table 3 shows the variables most used in the literature to measure the urban performance on the socioeconomic and demographic approach.

Table 3. Socioeconomic and demographic indicators for urban performance

Indicators	References
Employment rate, unemployment rate, number of jobs for specific industry sectors or jobs growth	(Caragliu, Del Bo and Nijkamp, 2011; Shmelev and Shmeleva, 2018; Golubchikov, 2006; Nicolas, Kim and Chi, 2020; McCarthy, 2000; Caragliu *et al.*, 2012; Molinaro *et al.*, 2020; Caragliu *et al.*, 2012; Caputo, Pasetti and Ferrari, 2019; Greasley, John and Wolman, 2011)
National, Regional or Municipal Gross Domestic Product *per capita*.	(Caragliu, Del Bo and Nijkamp, 2011; Caragliu and Del Bo, 2012; Caputo, Pasetti and Ferrari, 2019; McCarthy, 2000; Molinaro *et al.*, 2020; Caragliu *et al.*, 2012; Shmelev and Shmeleva, 2018; Jiao *et al.*, 2020)
Attractiveness (in relation to market, services, academia, tourists, non-governmental organizations)	(Wang *et al.*, 2017; Agnoletti *et al.*, 2015; Nicolas, Kim and Chi, 2020; Apreda, D'Ambrosio and Di Martino, 2019; Brown and Kirby, 1971)
Security, safety, feeling of security, public safety, digital security, health security, infrastructure security, violent crime	(Wang *et al.*, 2017; Nicolas, Kim and Chi, 2020; Kourtit, Nijkamp and Suzuki, 2021; Bettencourt *et al.*, 2010; Parrado *et al.*, 2013)
Personal income, median annual household income, disposable income per head, average salary, and Income by urbanized levels.	(Bettencourt *et al.*, 2010; Keirstead, 2013; Shmelev and Shmeleva, 2018; Cohen, 1996; Nicolas, Kim and Chi, 2020)
Human and social capital	(Wang *et al.*, 2017; Molinaro *et al.*, 2020; Caragliu, Del Bo and Nijkamp, 2011; Caragliu *et al.*, 2012)
Population density	(Apreda, D'Ambrosio and Di Martino, 2019; Caragliu and Del Bo, 2018; McCarthy, 2000; Caragliu *et al.*, 2012)
Research and Development achievement and/or expenditure	(Wang *et al.*, 2017; Caragliu and Del Bo, 2018; Molinaro *et al.*, 2020)
Population and population size	(Keirstead, 2013; Portnov and Schwartz, 2009; Jiao *et al.*, 2020)
Working age population	(Greasley, John and Wolman, 2011; Caputo, Pasetti and Ferrari, 2019; Caragliu *et al.*, 2012)
Patents	(Bettencourt *et al.*, 2010; Molinaro *et al.*, 2020)
Total profitability of a cell for residential and for industrial development	(Webster and Wu, 1999a; Webster and Wu, 1999b)
Industrial outputs, e.g.material output; per capita output, capital output	(Zhao and Zhang, 1995; Cohen, 1996)
Investment: Fixed capital investment per capita or Foreign Direct Investment	(Golubchikov, 2006; Molinaro *et al.*, 2020)
Number of registered firms per population in a period	(Golubchikov, 2006; Caragliu *et al.*, 2012)
Life Expectancy (per years)	(Keirstead, 2013; Shmelev and Shmeleva, 2018)
Affordable social services, early access to services	(Nicolas, Kim and Chi, 2020; Keirstead, 2013)
Population growth	(Greasley, John and Wolman, 2011; Portnov and Schwartz, 2009)

Source: Own elaboration.

In this approach, urban performance refers to the quantitative and qualitative assessment of various socioeconomic and demographic factors that collectively contribute to the overall well-being, development, and functionality of an urban area. The indicators of the socioeconomic and demographic approach serve as a baseline for formulating targeted policies and interventions. Thus, by identifying areas of improvement, cities can design strategies to enhance job creation, education, and social services, ultimately contributing to sustainable urban development.

In a nutshell, under the perspective of socioeconomic and demographic approach, the urban performance has the ability (1) to create opportunities (e.g. employment, businesses, industries, and leisure); (2) neighborhood quality for the urban stakeholders (e.g. infrastructure, public service facilities, health, safety, security, education, and mobility); (3) an efficient allocation of wealth, supplies, and resources, counterbalancing socioeconomic costs and benefits; and (4) an optimization of the urban logistics, transportation, and mobility, which are based on the improvement of the urban accessibility and connectivity within and beyond the municipal limits.

3.2 Environmental

When a city meets a certain degree of environmental quality, this city has performed on the environmental approach (Stossel, Kissinger and Meir, 2015). But the environmental approach should be used with other indicators, e.g. the city can formulate environmental policies to fight against climate change by applying not only environmental, but also considering physical and socioeconomic indicators (Apreda, D'Ambrosio and Di Martino, 2019).

Considering the mainstream literature (Apreda, D'Ambrosio and Di Martino, 2019; Caputo, Pasetti and Ferrari, 2019; Moertiningsih, Nurgandarum and Nurfanty, 2020; Shmelev and Shmeleva, 2018; Moraci, Fazia and Errigo, 2018; Arcidiacono and Ronchi, 2019; Staniscia, Spacone and Fabietti, 2017; Maia, Netto and Da Costa, 2019; among others), the main topics mentioned in the urban environmental approach on urban performance are: (1) climate change; (2) sustainable mobility; (3) sustainable socioeconomic approach, as an indispensable complement of the socioeconomic approach; (4) sustainable built-environment; (5) managing data and ICTs technologies to improve environmental policies and systems; (6) urban resilience; (7) pollution issues; and (8) problems stemmed from soil permeability.

Table 4 shows the variables most used in the literature to measure the urban performance on the environmental approach.

Table 4. Environmental indicators for urban performance

Indicator	References
Indicators of energy efficiency explored as a specific subsection of this paper as well as some indicators of "efficiency of buildings" in the urban design on solar exposure and accessibility	(Keirstead, 2013; Caputo, Pasetti and Ferrari, 2019; Chang *et al.*, 2019; Maltese, Mariotti and Boscacci, 2016; Nicolas, Kim and Chi, 2020; Apreda, D'Ambrosio and Di Martino, 2019; Chokhachian *et al.*, 2020)
Air Pollution Indicators: Carbon Dioxide Emissions (t/year), Carbon dioxide emissions per person per year, PM10 average annual concentration (mg/m³), Air quality (O3, SO2, PM10, CO2), CO2, NOX, PM10 and ozone precursors produced by transportation, Clean Air	(Keirstead, 2013; Shmelev and Shmeleva, 2018; Stossel, Kissinger and Meir, 2015; Caputo, Pasetti and Ferrari, 2019; Maia, Netto and Da Costa, 2019; Nicolas, Kim and Chi, 2020)
Meteorological Indicators: Cooling degree days, Heating degree days, Potential Urban Heat Island, Wind direction and speed, Rainfall, Air Temperature	(Keirstead, 2013; Chokhachian *et al.*, 2020; Maia, Netto and Da Costa, 2019)

Indicator	References
Waste Management: Municipal solid waste (Kg per person per year), Municipal solid waste recycling rate (%), Percentage of buildings with permant waste disposal (solid waste), Waste Disposal	(Shmelev and Shmeleva, 2018; Stossel, Kissinger and Meir, 2015; Nicolas, Kim and Chi, 2020)
Environmental Policies: Government Performance on Environment, Environmental impact (sustainable urban development), Sustainability (sustainable urban development)	(Parrado *et al.*, 2013; Molinaro *et al.*, 2020)
Urban Forestation Indicator: Normalized difference vegetation index, Urbanization of agricultural land	(Apreda, D'Ambrosio and Di Martino, 2019; Agnoletti *et al.*, 2015)
Water and Sanitation Management: Domestic water consumption (m^3 per person per year), River water quality within the city (BOD, total phosphorus, amon nitrogen, fecal coliforms), City supply system (coliform bacteria, Cr, Pb, Cu, Fe, Zn, Turbidity), Seawater quality within the city (fecal enterococcus, fecal coliforms), Percentage of buildings connected to sewerage system (sanitation),	(Shmelev and Shmeleva, 2018; Stossel, Kissinger and Meir, 2015)
Ecology	(Wang *et al.*, 2017)
Noise	(Stossel, Kissinger and Meir, 2015)
Radiation: Non-ionizing radiation, and ionizing radiation	(Stossel, Kissinger and Meir, 2015)
Environmental Transportation: Green movement share	(Caputo, Pasetti and Ferrari, 2019)

Note. Own elaboration.

In this approach, urban performance is defined by the sustainable management of natural resources, mitigation of environmental impacts, and the creation of resilient and ecologically balanced urban ecosystems. This approach focuses on assessing how well a city maintains environmental quality, conserves natural resources, and minimizes its ecological footprint. Thus, its main strengths are maintaining ecosystem health, fostering long-term sustainability, building resilience, and making cities adaptive to climate change. The most used environmental indicators for measuring performance are energy related to efficiency, air pollution, meteorological, waste management, policies, urban forestation, water and sanitation management, ecology, noise, radiation, and environmental transportation. However, environmental indicators can vary widely across regions and contexts, making it difficult to establish uniform standards for measuring urban performance. This can lead to challenges in benchmarking and comparing cities on a global scale.

In urban environmental studies, the city is seen as a living organism, in which has its own metabolism requiring inputs to perform in an optimal way, and then, resulting in desired outputs to their stakeholders' activities (Caputo, Pasetti and Ferrari, 2019), in such that the city meets the needs for their urban stakeholders without damaging the environment. But, a merely environmental-focused perspective can not be confused with sustainability, this last one has a wider approach and has a unique posterior subsection in this paper.

3.3 Smart Cities

There is not a consensus on what actually smart cities are, some scholars argue that these cities are sustainable while others do not agree with this view (Bibri and Krogstie, 2017; Beck and Conti, 2021), that is, depending on the scholar, smart cities are also known as smart sustainable cities. However, all of the academic community agree that smart cities have massive use of ICTs in the urban context, urban environment, urban services, urban mobility, and so forth.

The point that matters here is that smart cities have highlighted the urban performance on the socioeconomic dimensions, mainly on the economic facets of the cities and the regions in which they are located. The group of Caragliu - one of the main seminal scholars on smart cities - appeared four times in this literature review on urban performance (Caragliu, Del Bo and Nijkamp, 2011; Caragliu and Del Bo, 2012; Caragliu *et al*. , 2012; Caragliu and Del Bo, 2018), and according to them, the wealth per capita is the main indicator of urban success, e.g. the *Gross Domestic Product* (GDP) in purchasing power parity, in which can be converted into good public services and urban mobility as well as can be an attractive for social capital and creative class, and then, causing a spillover effect at attracting more residents and industries. Moreover, urban density is related to a good urban economic performance (Caragliu and Del Bo, 2012). So, smart cities policies are straightforward to the urban development and economy.

Also, the literature has shown that in smart cities the urban performance is understood as when a city is able to provide quality of life, efficiency of urban functions, economic competitiveness (Nicolas, Kim and Chi, 2020; Beck *et al.*, 2020), in which the city has to be smarter and more sustainable on its economic, social, and environmental dimensions through the massive use of ICTs in the urban management (Shmelev and Shmeleva, 2018; Moraci, Fazia and Errigo, 2018), e.g. in the case of energy efficiency (Maltese, Mariotti and Boscacci, 2016). Other issue is on safety and security, in which managers should be aware of the digital security, health security, infrastructure security, and personal security in the urban context, in which the safety and security issues are important to the urban attractiveness and quality of life (Kourtit, Nijkamp and Suzuki, 2021).

As for smart cities, the most used indicators to measure their urban performance are the ICT and general infrastructure, smart policies, innovation, smart mobility, and smart buildings. Table 5 shows the variables most used in the literature to measure the urban performance on the smart cities approach.

Table 5. Smart Cities indicators for urban performance

Indicator	References
ICT and General Infrastructure: Average broadband internet speed (Mb/c), ICT availability (public wifi coverage, fiber coverage, technology deployment), ICT Performance (Broadband Latency, Network Bandwidth), ICT Affordability (Local Call Tariff, Internet Tariff), ICT and Digital Security (Internet Security, Cyber Security Effort), ICT Adoption (Internet Users, Smartphone Penetration), Infrastructure Security.	(Shmelev and Shmeleva, 2018; Nicolas, Kim and Chi, 2020; Kourtit, Nijkamp and Suzuki, 2021)
Policies: Smart Policies (policy intensity), Health Security, Personal Security	(Caragliu and Del Bo, 2018; Kourtit, Nijkamp and Suzuki, 2021)
Innovation: Number of patents per thousand inhabitants	(Shmelev and Shmeleva, 2018)
Mobility: Number of underground stations per million inhabitants	(Shmelev and Shmeleva, 2018)
Smart Buildings	(Nicolas, Kim and Chi, 2020)

Source: Own elaboration.

In this approach, urban performance is defined by the effective integration of advanced technologies, data-driven decision-making, and innovative solutions to enhance the quality of life for residents, optimize resource

utilization, and improve urban governance. This approach emphasizes the use of digital infrastructure and smart solutions to create efficient, responsive, and sustainable urban environments. Urban performance within the Smart Cities context is measured through a set of key indicators that assess a city's technological readiness, digital connectivity, utilization of data analytics, and implementation of smart services and infrastructure. Thus, the Smart Cities approach to urban performance centers on leveraging technology to enhance urban services, efficiency, and quality of life. While it offers promising benefits, careful consideration must be given to inclusivity, privacy, sustainability, and the potential trade-offs between technological advancement and social well-being.

In short, the urban performance in smart cities are focused on the socioeconomic and environmental dimensions of the city, mainly on the economic dynamicity of the city. The main challenge of the smart city relies on exploring more the urban social and environmental issues in harmony with the already existent economic challenges.

3.4 Urban Design, Built Environment and Territory

As for the urban design, the built-environment, and the urban territory, the literature has shown that urban performance has multi-facet ways of understanding: (1) by emphasizing the urban capacity to have stay events, in which people enjoy more time in an urban area (Noyman *et al.*, 2019); (2) by emphasizing the urban capacity to have clusters, in which the size, the persistence, and the diversity of their members shed lights on their importance in the urban context (Noyman *et al.*, 2019); (3) by having an urban design that explores and saves more energy, i.e. energy efficiency and solar accessibility (Chang *et al.*, 2019; Chokhachian *et al.*, 2020); (4) by providing walkability and comfort for pedestrians, e.g. aspects related to pedestrians' movement, noise, wind, temperature, and a healthy built-environment (Charlton *et al.*, 2015; Seles and Afacan, 2019); (5) by having quality of the soil infrastructure, to avoid permeability as an example (Moertiningsih, Nurgandarum and Nurfanty, 2020); and (6) by providing an attractive, sustainable, and quality urban place and structural design to their urban stakeholders do their respective activities (Caragliu *et al.*, 2012; among others).

Table 6 shows the variables most used in the literature to measure the urban performance on the urban design, built environment and territorial approach.

Table 6. Urban Design, Built Environment and Territorial indicators for urban performance

Indicators	References
Urban density, floor, and built-up area indicators: Retails floorspace, office floorspace, factory floorspace, warehouse floorspace, other floorspace, ground-floor activities, floor area ratio, built-up area, continuous built-up area, Ground Space Index.	(Keirstead, 2013; Apreda, D'Ambrosio and Di Martino, 2019; Chang *et al.*, 2019; Chokhachian *et al.*, 2020; McCarthy, 2000; Jiao *et al.*, 2020; Arbabi, Mayfield and Dabinett, 2019; Caputo, Pasetti and Ferrari, 2019)
Efficiency of buildings: building volume, solar exposure of building envelope, building coverage ratio, number of buildings, energy consumption of heating in residential buildings, Total electricity consumption in residential buildings, building vertically (morphology), water consumption in buildings	(Apreda, D'Ambrosio and Di Martino, 2019; Chang *et al.*, 2019; Caputo, Pasetti and Ferrari, 2019; Maia, Netto and Da Costa, 2019; Maia, Netto and Da Costa, 2019)
Spatial distributions of land-use pattern, profit and social costs, and income residuals	(Bettencourt *et al.*, 2010; Webster and Wu, 1999a; Webster and Wu, 1999b; Jiao *et al.*, 2020)
Thermal Indicators: thermal lag, thermal decrement factor, potential urban heat island, solar access, daylight	(Apreda, D'Ambrosio and Di Martino, 2019; Chokhachian *et al.*, 2020)
Urban forestation: normalized difference vegetation index, Greenspace	(Apreda, D'Ambrosio and Di Martino, 2019; Jiao *et al.*, 2020)
Sky view factor (urban design for energy efficiency)	(Apreda, D'Ambrosio and Di Martino, 2019; Chang *et al.*, 2019)
Open spaces areas, public space per capita, external wall area	(Apreda, D'Ambrosio and Di Martino, 2019; Stossel, Kissinger and Meir, 2015; Chang *et al.*, 2019)

Source: Own elaboration.

In this approach, urban performance is defined by the physical and spatial characteristics of the urban landscape, including the design, layout, and functionality of buildings, infrastructure, public spaces, and transportation systems. This approach emphasizes the role of the built environment in shaping the livability, functionality, and sustainability of cities. In this context, urban performance is measured through a set of key indicators that assess the quality of urban design, land use patterns, accessibility, infrastructure provision, and the overall functionality of the built environment. However, in order to create thriving, inclusive, and sustainable urban spaces for stakeholders, it is also important to consider socioeconomic and environmental indicators. The main challenges in this approach are urban sprawl, displacement, and inadequate infrastructure.

In short, the urban performance of the urban design, built-environment, and urban territory is related to efficient employment of the urban density, efficiency of buildings, efficient spatial distribution, thermal efficiency, urban forestation, sky view factor, and open and public spaces.

3.5 Public Administration, Government, and Governance

In Public Administration, Governance, and Governmental studies, the mainstream research on urban performance in this topic has shown the importance of political leadership and government activity (Greasley, John and Wolman, 2011; McCarthy, 2000), exploiting urban data and ICTs to improve urban policies and governance (Cesme *et al.*, 2017; Kitchin, Lauriault and McArdle, 2015), and considering the stakeholders' satisfaction with how the government has performed in each of urban policy issue is important at assessing the urban performance, even more, the trust of urban stakeholders in relation to the government is linked to the urban performance of the public administration (Parrado *et al.*, 2013).

In this way, the public administration and the government should formulate policies binding sustainability and socioeconomic issues, in which the urban stakeholders have their demands on resources and services met, and then, theses last ones should be assured for all households of the city, even more stimulating urban partnerships will strengthen the urban performance, development, and efficiency (Webster, 1998; McCarthy, 2000; Molinaro *et al.*, 2020).

Table 7. Indicators of public administration, government, and governance for urban performance

Indicator	References
Policies and Services: Government Performance on Public Safety, Government Performance on Environment, Government Performance on Health, Planning performance, Service performance, Expenditure on planning and economic development, Regulations, Urban Policy Failures; Urban planning and resilience.	(Parrado *et al.*, 2013; Greasley, John and Wolman, 2011; Webster, 1998; Molinaro *et al.*, 2020)
Governance and Institutions: Governance structure, Political stability; Governance capacity, Smart Policies for policy intensity, local quality institutions, Government Honesty, Government Reliability, Bureaucratic Quality, Urban Regulations, E-governance, Civic Activism, Citizen Participation, E-Participation, Government effectiveness, Corruption, Social equality, Taxes, Inflation.	(Greasley, John and Wolman, 2011; Caragliu and Del Bo, 2018; Nicolas, Kim and Chi, 2020; Molinaro *et al.*, 2020)
Digital: E-government, e-governance, e-participation, Data Privacy Policy, ICT Regulations, Electronic governance	(Caragliu, Del Bo and Nijkamp, 2011; Nicolas, Kim and Chi, 2020; Molinaro *et al.*, 2020)
Environmental Interests: Pollution Control Policy, Green Policies	(Nicolas, Kim and Chi, 2020)
Local Government Efficiency (annual expenditure per resident; municipal authority income; debt per resident)	(Caragliu *et al.*, 2012)

Source: Own elaboration.

Table 7 shows the variables most used in the literature to measure the urban performance on the public administration, government, and governance approach.

In this approach, urban performance is defined by the effectiveness, transparency, and responsiveness of public institutions and governance structures in managing and serving the urban population. This approach focuses on evaluating the quality of governance, public services, and administrative processes to ensure the well-being and satisfaction of urban residents. For this reason, this approach revolves around the effectiveness of governance structures, the provision of quality public services, citizen engagement, and transparent decision-making. The most used indicators of public administration, government, and governance for measuring urban performance are related to urban policies and services, governance and institutional arrangement, digital infrastructure, and local government efficiency. In this way, a well-performing urban administration ensures that the city's institutions are responsive to the needs of residents, contribute to equitable development, and uphold principles of accountability and transparency.

3.6 Energy Efficiency

Energy efficiency is an approach pertaining to urban sustainability studies, but even as a subtopic of urban sustainability and efficiency, energy efficiency has received more attention from the academic community and the market. On urban performance, the literature of energy efficiency has shown that it can be one of the proxies for urban sustainability (Wang *et al.*, 2017), it should be embedded in urban design and urban infrastructure (Chang *et al.*, 2019; Keirstead, 2013; Maltese, Mariotti and Boscacci, 2016). So, the energy efficiency *per si* can reveal to some degree how a city has performed in relation to its sustainable development.

Table 8 shows the variables most used in the literature to measure urban performance on the energy efficiency approach.

Table 8. Energy efficiency indicators for urban performance

Indicators	References
Indicators for Energy demand and consumption: Total final energy consumption (GWh), Total final energy consumption (MWh/per capita), Annual Energy Demands (kWh/m²), Energy Coverage Ratio, Energy consumption of heating in residential buildings, Total electricity consumption in residential buildings; Solar electric deployment on public buildings	(Keirstead, 2013; Caputo, Pasetti and Ferrari, 2019; Chang *et al.*, 2019; Maltese, Mariotti and Boscacci, 2016)
Solar Energy Indicators: Solar exposure of building envelope, Average Solar Radiation (kWh/m²), Potential Solar Power (kWh/m²), Sky View Factor; Solar electric deployment on public buildings	(Apreda, D'Ambrosio and Di Martino, 2019; Chang *et al.*, 2019)
Solar electric deployment on public buildings	(Maltese, Mariotti and Boscacci, 2016)
Energy Policy: Presence of a Local Energy Plan	(Maltese, Mariotti and Boscacci, 2016)

Source: Own elaboration.

In this approach, urban performance is defined by the effectiveness of energy management and consumption patterns within an urban context. Its main indicators are energy demand and consumption, solar energy, the adoption of public buildings on solar energy, and energy policies. This approach focuses on evaluating the efficiency, sustainability, and environmental impact of energy use in urban areas. However, energy efficiency implementation involves overcoming challenges related to costs, technology, behavior change, and policy support. For this reason, addressing these weaknesses requires a comprehensive and holistic approach that considers the unique context and characteristics of each urban area.

3.7 Sustainability and Sustainable Development

Although energy efficiency has been the most used approach to study urban sustainability (Chang *et al.*, 2019; among others), there are other important issues to be considered. As for the whole sustainability and sustainable development, not only the environmental dimension, but the socioeconomic should be also taken into account (Agnoletti *et al.*, 2015; among others). Furthermore, the urban resilience also matters, in which a city has the ability to face disasters and chaotic contexts, having a resilient infrastructure, governance and urban system (Staniscia, Spacone and Fabietti, 2017; Arcidiacono and Ronchi, 2019; Molinaro *et al.*, 2020).

Table 9 shows the variables most used in the literature to measure the urban performance on the sustainability and sustainable development approach.

Table 9. Indicators of sustainability and sustainable development for urban performance

Indicators	References
Urban Resilience Indicators: Integration volume, Routine maintenance, Emergency maintenance, Restructuring, Restoration, Demolition, Routine maintenance and new construction, Emergency maintenance and new construction, Restructuring and new construction, Demolition and construction with an in cubage increase, Decorum, Type of intervention, Solar exposure of building envelope, Normalized difference vegetation index, Building coverage ratio, Roof Typology, Open spaces areas, Soil permeability, Flow capacity of storm drainage system, Maintenance of storm drainage system, Actual Damage, Recovery time, Ecosystem service capacity	(Trovato and Giuffrida, 2014; Apreda, D'Ambrosio and Di Martino, 2019; Staniscia, Spacone and Fabietti, 2017; Caputo, Pasetti and Ferrari, 2019)
Ecology (sustainability)	(Wang *et al.*, 2017)

Source: Own elaboration.

In this approach, urban performance refers to the extent to which a city or urban area successfully integrates and balances social, economic, and environmental dimensions, ensuring the well-being of current and future generations. It involves the city's capacity to achieve harmonious and equitable development across these dimensions while preserving the natural environment and enhancing resilience. Its main challenges are related to: (1) complexity derived from processes that can cause conflicts between competing priorities; (2) trade-offs between economic growth, social equity, and environmental protection; (3) implementation challenges such as limited resources, bureaucratic hurdles, and resistance to change; (4), measurement; and (5) lack of consensus among stakeholders. However, effective governance, stakeholder collaboration, and innovative solutions (Beck *et al*., 2023) can address these challenges.

In short, on sustainable related-issues, the city should consider a harmonic development on its social, economic, and environmental dimensions as well as fomenting the resilience within the urban system. Thus, the city will meet the needs of its current and future stakeholders without harming the environment.

3.8 Transportation and Mobility

On urban transportation and mobility, urban managers and scholars ought to improve the urban performance at lowering fixed travel costs and time (Xu *et al.*, 2020), by providing better conditions and accessibility to urban stakeholders work, study, have leisure activities, and own their own business (Duarte and Ultramari, 2012), and by exploiting a data-driven urban governance in order to promote more efficient urban policies and systems as in the case of urban transportation (Cesme *et al.*, 2017).

Table 10 shows the variables most used in the literature to measure the urban performance on the transportation and mobility approach.

Table 10. Indicators of transportation and mobility for urban performance

Indicator	References
Availability of cars: Households with two cars (in percentage), Car-available-residents's utility level by utility unit, Car-unavailable-residents' utility level by utility unit	(Keirstead, 2013; Xu *et al.*, 2020)
Public Transportation Infrastructure Capacity: number of underground stations per million inhabitants; length of public transport network by km	(Shmelev and Shmeleva, 2018; Caragliu *et al.*, 2012)
Quality of Public Transportation Services: Smart Parking, Car Sharing Services, Public Transport Reliability, Utilization of Public Transportation; Traffic Flow; Traffic Safety	(Nicolas, Kim and Chi, 2020)
Environmental-friendly mobility: energy consumption per transportation, CO2, NOX, PM10 and ozone precursors produced by transportation, green movement share, kilometers covered per year	(Caputo, Pasetti and Ferrari, 2019)
Mobility index	(Caputo, Pasetti and Ferrari, 2019)
Pedestrian (Sidewalk availability, Sidewalk congestion, Walkability index, Route directness, Pedestrian safety, Pedestrian network connectivity, Pedestrian volume, Pedestrian signal delay, and Pedestrian commute mode share)	(Cesme *et al.*, 2017)
Bicycle (Number of bicycle trips, Bicycle level of traffic stress, Bikeshare availability, Bicycle commute mode share, Average bikeshare trips per resident, Bikeshare system coverage area, Miles of bike lanes or cycle tracks, Route directness, and Bicycle safety;)	(Cesme *et al.*, 2017)
Transit (Ridership, Service frequency, On-time performance, Vehicle crowding, Farebox recovery, Passenger accident rate, Transit to automobile travel time ratio, Transit service coverage, Bus speed, Headway adherence, Passenger miles or passengers per mile, Transit commute mode share, and Vehicle accident rate)	(Cesme *et al.*, 2017)
Automobile (Vehicle miles traveled, Vehicle hours of delay, Travel time index, Duration of congestion, Average vehicle occupancy, Vehicle crash frequency or rate, Vehicle miles traveled in congestion, Level of service, Automobile speed, Planning time index, Cost of congestion, Single occupancy commute mode share, and Incident clearance time)	(Cesme *et al.*, 2017)
Urban characteristics: Critical location in Km, City boundary in Km)	(Xu *et al.*, 2020)

Source: Own elaboration.

In this approach, urban performance is the efficient and effective functioning of a city's transportation systems and mobility options. It encompasses the accessibility, affordability, reliability, safety, and environmental sustainability of various transportation modes and their impact on urban life and development. Its main challenges include data accuracy, integration of diverse transportation modes, infrastructure limitations, equity concerns, and the need for behavior change.

In order to measure the urban performance on transportation and mobility, as detailed in Table 10, scholars have used indicators for the availability of cars, the capacity of the public transportation infrastructure, the quality of the public transportation services, the degree in which urban mobility is environmental-friendly, the mobility

index, and the urban geo-characteristics. Also, indicators can be utilized for each specific type of transportation (e.g. pedestrian, bicycle, and automobile means) as well as for the analysis of the transit (see Cesme *et al.*, 2017).

3.9 Benchmarking

Benchmarking is a systematic search to solve problems through efficient ways, in which has been applied to urban studies related to promoting energy efficiency (Wang *et al.*, 2017; Keirstead, 2013) as seen before. Even more, according to Keirstead (2013: 576), "there are at least three fields in which benchmarking techniques have been applied to urban environments: urban competitiveness, urban sustainability, and urban infrastructure systems." In this way, benchmarking techniques can enhance the urban performance in a wide range of urban issues and further studies should explore this incipient approach.

In this approach, urban performance is a systematic process of comparing and evaluating a city's performance indicators against established benchmarks or best practices. It involves assessing various aspects of urban development, such as competitiveness, sustainability, and infrastructure, by measuring them against standardized criteria. This approach helps identify areas for improvement, set targets, and make informed policy decisions based on successful models from other cities. While benchmarking offers valuable insights and a basis for performance enhancement, challenges may include the availability and reliability of benchmark data, the potential lack of context specificity, and the need for a well-defined benchmarking methodology.

3.10 Global Cities

Global Cities have the urban performance assessed through a multidimensional approach, which they consider is related to a vibrant economy, a productive R&D system, a vibrant culture, livability, accessibility, and sustainability (Wang *et al.*, 2017; Molinaro *et al.*, 2020). Even smart cities have considered a global environment as a characteristic of a post industrialized and globalized context as a factor for growth, development and performance success of the cities (Caragliu and Del Bo, 2012) as well as the urban stakeholders inserted in a global context can benefit the urban locality with more networking and opportunities (Caragliu *et al.*, 2012).

Instead of indicators, the *Global Power City Index*, the *Global City Competitiveness Index*, the *Global Urban Competitiveness Index Score* and the *Global Cities Index* have been used by scholars as a proxy for global cities (as seen in Wang *et al.*, 2017; Molinaro *et al.*, 2020). In sum, considering a city as a global one will indicate that its performance and competitiveness are superior to those without this global status.

In this approach, urban performance refers to the multifaceted evaluation of a city's attributes and capabilities that position it as a global hub of economic, cultural, and social activities. Urban performance in this approach encompasses factors such as economic vibrancy, research and development prowess, cultural richness, livability, accessibility, and sustainability. Global cities are assessed based on their ability to attract international investment, foster innovation, and provide an environment conducive to global networking and opportunities. Thus, by meeting and exceeding these indicators, a city can assert itself as a key player in the interconnected global landscape, contributing to advancing various Sustainable Development Goals through its influential role.

4. EXPLORING URBAN INDICATORS

In this section, this research discusses the type of urban indicators and their purposes based on the study of Kitchin, Lauriault and McArdle (2015), and the hidden problems of using *per capita* indicators in the urban context in the perspective of Bettencourt *et al.,* (2010).

4.1 Types and purposes

There are multiple ways of handling urban indicators, either in the academic or in practitioner context. Kitchin, Lauriault and McArdle (2015) point out the types and purposes of urban indicators. Indicators can be assumed as (1) single or (2) composite, and in relation to their distinct purposes, they can be classified as (1) descriptive

or contextual, (2) diagnostic, performance and target, and (3) predictive or conditional. Thus, depending on the formula and context, an indicator can be used by scholars, urban planners, and public urban managers.

On the one hand, "single indicators consist of the measurement or a statistic related to a single phenomenon" (Kitchin, Lauriault and McArdle, 2015: 8). In the socioeconomic and demographic approach, employment rate is an example (Caragliu, Del Bo and Nijkamp, 2011; Shmelev and Shmeleva, 2018; among others). In the environmental approach, the ionizing-radiation is another indicator (Stossel, Kissinger and Meir, 2015). On the other hand, composite indicators are indexes composed of multiple single indicators (Kitchin, Lauriault and McArdle, 2015), for instance, the *Global Power City Index* as a proxy for the urban performance of global cities (Wang *et al.*, 2017), and the *Mobility Index* for measuring urban mobility (Caputo, Pasetti and Ferrari, 2019).

Scholars and practitioners can be benefited by utilizing descriptive or contextual indicators in order to understand a specific phenomenon, to make better and efficient urban policies, and to improve the urban urban systems and services (Kitchin, Lauriault and McArdle, 2015). For instance, all of the variables discussed on socioeconomic and demographic issues describe the socioeconomic condition of the city or provide more detailed socioeconomic characteristics of the city.

As for diagnostic, performance and target indicators, they are used "to diagnose a particular issue or assess performance" (Kitchin, Lauriault and McArdle, 2015: 9). For instance, the environmental indicator for "governmental performance on environment" (Parrado *et al.*, 2013; Molinaro *et al.*, 2020), the mobility indicator for measuring the "utilization of public transportation" (Nicolas, Kim and Chi, 2020), and some indicators of public administration, government, and governance, such as those assessing the urban performance of safety, health, planning, government effectiveness, inflation, and so on (Parrado *et al.*, 2013; Greasley, John and Wolman, 2011; Webster, 1998; Molinaro *et al.*, 2020; among others).

Predictive and conditional indicators are used to provide a simulation of any specific issue of the city and are useful to the decision-making processes of urban managers and planners (Kitchin, Lauriault and McArdle, 2015). For instance, the "average bikeshare trips per resident" indicator acknowledges previous data on bikeshare trips per resident in a period and then stipulates an average (Cesme *et al.*, 2017), which is one of a wide range of statistics methods of prediction. But analysts should be aware of how they will utilize these methods, because other conditional characteristics should be added in a model, such as, considering the day of week, the genre, the goal of the utilization, among others. Furthermore, smart cities have used ICT devices and smart infrastructure to automatically generate data and information for urban managers on the prediction of the urban system dynamism (Caragliu *et al.*, 2012; Bibri and Krogstie, 2017; among others).

4.2 The problem with *per capita* indicators in the urban context

Considering that many papers have used *per capita* indicators as previously seen (e.g. GDP, fixed capital investment, public space per capita, and so on), Bettencourt *et al.* (2010) have noticed that *per capita* indicators rely on the idea that the urban growth is linear, but actually it does not fit to measure the urban performance due to the - agglomeration phenomenon - in the urban size, population, and other socioeconomic indicators. Hence, nonlinear urban scaling laws can minimize the agglomeration effect at measuring urban performance.

In this way, Bettencourt *et al.* (2010: 7) separated the "true local dynamics" from "generic universal behavior", and proposed a new urban metrics, in which is a scale-adjusted metropolitan indicator considering an urban ranking with a spatial-temporal analysis of data. So, instead of using *per capita* indicators, urban scholars can use the urban metric proposed by Bettencourt *et al.* (2010) in their analysis in order to provide more reliable indicators for urban performance.

4.3 Participation, Urban Stakeholders, and Intersectoral Policies

An essential facet of assessing urban performance and advancing sustainable development resides in the active engagement of diverse urban stakeholders and the execution of efficacious intersectoral policies. The intricate interplay of urban dynamics necessitates a comprehensive framework that transcends simplistic evaluations and

linear metrics. Building upon the elucidations garnered from exhaustive scrutiny of urban indicators and their multifarious applications, as delineated in the antecedent segments, the current discourse embarks upon an exploration of participation, urban stakeholders, and the pivotal function of intersectoral policies in shaping the trajectory of urban centers.

In this way, participation and inclusive decision-making matter. In the ever-evolving urban landscape, the engagement of diverse urban stakeholders becomes paramount (Beck and Storopoli, 2021). The spectrum of participation extends from residents, businesses, and local communities to governmental bodies and non-governmental organizations. The discussion surrounding urban indicators elucidates that inclusive decision-making empowers stakeholders to actively contribute to the planning, development, and management of their cities. By involving residents in the decision-making process, cities can harness local knowledge and insights, leading to more contextually relevant policies and sustainable urban development. Therefore, the multifaceted nature of urban indicators offers a lens through which stakeholders can contribute their perspectives, ensuring that policies resonate with the city's unique needs and aspirations.

Intersectoral Policies are also critical for holistic urban progress. Urban systems are intricately intertwined, transcending traditional sectoral boundaries. The exploration of various urban indicators underscores the need for intersectoral policies that recognize and address these complex interactions (Bettencourt et al., 2010). A siloed approach to policy formulation often needs to capture the full spectrum of urban dynamics. As revealed in the discussion, energy efficiency, sustainability, transportation, and other domains are inextricably linked. Intersectoral policies that integrate economic, social, and environmental dimensions offer a holistic approach to urban governance. Thus, by leveraging the insights provided by an array of urban performance indicators, cities can design policies that optimize resource allocation, enhance urban resilience, and foster sustainable growth.

The pitfalls of relying solely on per capita indicators, as highlighted by Bettencourt et al. (2010), underline the importance of nuanced and adaptive approaches to measuring urban performance. The intricate dynamics of agglomeration and nonlinear scaling underscore the limitations of simplistic metrics. For this reason, urban stakeholders and policymakers must consider the broader urban context and explore alternative indicators, such as the proposed scale-adjusted metropolitan indicator. By embracing such innovative metrics, cities can capture the true essence of their growth, better accounting for the complexities of urban systems and achieving more accurate assessments of their performance.

In conclusion, the intricate fabric of urban life demands a multifaceted approach to assessing and enhancing urban performance. As explored in the preceding sections, the synthesis of insights from diverse urban indicators illuminates the path toward meaningful participation, effective intersectoral policies, and accurate performance measurement. Through inclusive engagement of stakeholders, the formulation of intersectoral policies, and the judicious selection of indicators, cities can navigate the complexities of urban dynamics, steering toward sustainable, resilient, and prosperous futures. As urban landscapes continue to evolve, this holistic approach remains instrumental in shaping cities that thrive on the collective wisdom of their stakeholders and the harmonious synergy of their diverse sectors.

4.4 Urban Performance Indicators and the Sustainable Development Goals

The complex interrelation between urban development dynamics and the Sustainable Development Goals (SDGs) constitutes a compelling area of investigation, which draws upon the comprehensive analysis of urban indicators and their multifaceted applications and recognizes the pivotal roles of participatory governance and intersectoral policies in shaping urban trajectories.

The discerning exploration conducted in the preceding sections underscores the inherent versatility of urban indicators as critical tools for assessing progress across a diverse spectrum of SDGs. Notably, *SDG 11* on *Sustainable Cities and Communities* encompasses a focal point where urban indicators effectively capture and convey the trajectories of energy efficiency, sustainable transportation, and the robustness of urban infrastructure. Within this contextual realm, indicators clarify the intricate balance between environmental stewardship, economic

prosperity, and societal well-being, enabling stakeholders to gauge and evaluate the vibrancy and resilience of urban living environments.

Furthermore, a more granular examination unveils the multifarious intersections between urban indicators and other SDGs. For instance, *SDG 3* on *Good Health and Well-being* resonates with indicators that measure air and water quality, healthcare accessibility, and green spaces within urban domains. Similarly, SDG *4* on *Quality Education* resonates with indicators that assess educational accessibility, equity, and attainment. Also, *SDG 8* on *Decent Work and Economic Growth* resonates with indicators that measure employment opportunities and income distribution. Indicators related to energy efficiency (see subsection 3.6) inform strategies towards *SDG 7* on *Affordable and Clean Energy* through enhanced deployment of renewable energy sources and improved energy consumption practices. Indicators from the transportation and mobility domain (see subsection 3.8) steer policies aimed at reducing emissions and enhancing public transportation systems, which are vital to address *SDG 13* on *Climate Action*. Indicators pertaining to ecosystem preservation (see subsection 3.7) by guiding measures that protect aquatic and terrestrial environments are helpful to address *SDG 14* on *Life Below Water* and *SDG 15* on *Life on Land*. Regarding inclusive governance, *SDG 16* on *Peace, Justice, and Strong Institutions*, is critical related to citizen and stakeholder participation. In this context, indicators reflecting citizen engagement, governance efficacy, and participatory urban planning are pivotal metrics for more inclusive and accountable urban governance structures.

However, the relationship between urban indicators and the SDGs also reveals a complex network of interconnectedness, requiring coordinated policy interventions to tackle the SDGs. Thus, urban performance indicators can guide the formulation of intersectoral policies within the urban fabric. For instance, consider the indicator of "public transportation infrastructure capacity" (seen in subsection 3.8, Table 10), which pertains to the availability and accessibility of public transport options within a city. An intersectoral approach is vital to address this indicator and contributes to multiple SDGs, such as *SDG 7* on *Affordable and Clean Energy* and *SDG 11* on *Sustainable Cities and Communities*. In this scenario, effective policy formulation would require coordination between the urban planning, transportation, and environmental sectors of urban management. Therefore, embracing the intricate relationship between urban indicators and the SDGs through intersectoral policies underscores the collaborative path toward holistic and sustainable urban development.

In sum, the intricate pattern formed by urban performance indicators aligns smoothly with the broader SDGs' framework, which is critical for policymakers, urban planners, and various stakeholders to work together diligently to shape future sustainable cities. Therefore, by wisely aligning urban indicators and the SDGs, stakeholders transform the urban landscape into resilience, equality, and transformative growth in cities.

5. CONCLUSION

This paper synthesized the literature of urban studies on urban performance by providing an organized framework of the main urban indicators for measuring urban performance as well as a briefly contextualization of these indicators for each one of their approaches, which are: (1) the socioeconomic and demographic; (2) environmental; (3) smart cities; (4) urban design, built environment, and territory; (5) public administration, government, and governance; (6) energy efficiency; (7) sustainability and sustainable development; (8) transportation and mobility; (9) benchmarking; and (10) global cities.

Furthermore, this research demonstrated (1) how urban managers, scholars, and practitioners can exploit the indicators for urban performance by considering the types and purposes of urban indicators with some examples of the urban performance approaches; and (2) an alternative for *per capita* indicators proposed by Bettencourt *et al.* (2010) due to the false idea of linearity of the urban indicators given that the agglomeration phenomenon has been ignored.

The main limitations of this study arise from the specific keyword selection employed during the literature review process. The choice to focus primarily on the term "urban performance" in the title, abstract, and keywords of articles published before 2021 was made to establish a cohesive framework for our investigation. However, this

ARBOR Vol. 200, 811, enero-junio 2024, a001 | ISSN-L: 0210-1963 https://doi.org/10.3989/arbor.2024.811.001

deliberate focus may have resulted in the omission of relevant studies that could contribute valuable perspectives to the discourse on urban dynamics.

Our recommendations for future studies are: (1) to investigate the direct impact of intersectoral policies on urban performance indicators, focusing on specific case studies that highlight successful policy integration and its outcomes; (2) to perform a comparative analysis of urban performance indicators across different cities to identify best practices, challenges, and opportunities for improvement in urban sustainability and development; (3) investigate the causal relationships and correlations between different urban performance indicators, aiming to uncover complex interactions and potential trade-offs between various dimensions of urban development; (4) to examine how traditional urban performance indicators can be adapted and expanded to accommodate the unique characteristics and challenges of smart cities, ensuring their applicability in rapidly evolving urban environments; (5) to explore the integration of indicators that assess the circular economy practices within cities, measuring resource efficiency, waste reduction, and the promotion of sustainable consumption and production patterns; and (6) to investigate effective intersectoral policies that enhance urban resilience (critical for *SDG 11*), exploring how collaboration between sectors such as urban planning, environment, and disaster management can mitigate vulnerabilities and improve city preparedness.

DECLARATION OF COMPETING INTEREST

The authors of this article declare that they have no financial, professional or conflicts of interest that could have inappropriately influenced this work.

AUTHORSHIP CONTRIBUTION STATEMENT:

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Marcos Ferasso: Writing – review & editing.

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