Urban Sustainability Towards European Missions and Challenges: Where Do We Stand?

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Abstract. The centrality of cities and urban processes in sustainable development and the green transition has been recognized by the 2030 Agenda for Sustainable Development, the New Urban Agenda and the Green Deal. In this context, this paper aims to explore the conceptualizations of cities that have received attention, such as "inclusive city", "knowledge city", "low carbon city", "resilient city", "smart city", and "sustainable city". Since measuring progress through the reaching of sustainable development in contemporary cities is a current and relevant issue, the paper reflects on both theory and practice levels: (i) by developing a conceptualization of current challenges in pursuing urban sustainability; (ii) by discussing available (and/or needed) measurement and assessment tools, such as indicators, to support the construction and evaluation of such sustainable urban policies. In doing so, the research specifically focuses on the European Union's (EU) framework for urban sustainability, outlined in the Horizon Europe Program for Research and Innovation for 2021–2027. Accordingly, the Strategic Plan 2021–2024 and the work programmes 2023–2024 of "Clusters" and "Missions" are analyzed to understand where we stand towards European challenges in urban sustainability. Moreover, the paper explores indicators provided by different European institutions in order to outline a set of indicators useful for monitoring the city conceptualizations encouraged at the European level.

Keywords: Sustainable Cities · European Union · Urban Sustainability · Indicator framework · Horizon Europe

1 Introduction

Over the last decades, several conceptualizations of "cities" emerged in the literature and policy discourse [1], which have gradually developed, modified and, to some extent, hybridized [2, 3]. Accordingly, scholars and practitioners from different fields defined a variety of sustainable approaches to contribute to sustainability and its improvement. Some of these conceptualizations have been deepened in the literature and are considered conceptually distinct enough to define their key aspects in relation to ongoing sustainability challenges [1–7]. The categories that received more attention than others are: "eco-city"; "low carbon city"; "global city"; "creative city"; "knowledge city"; "resilient city"; "inclusive city"; "smart city"; "sustainable city" [2, 3].

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Contemporary debates in both academic and policy contexts focus on the role of sustainability in urban development, to respond to the substantial challenges implied by cities [5, 8]. Planners and policymakers play a crucial role in shaping cities, given the power to choose which urban concepts to adopt [6, 9]. This decision-making process should be informed by an awareness of the different dimensions of urban conceptualizations. Accordingly, clarifying these conceptualizations, in theory, have implications for how they are pursued in policies and in practice, as concrete frameworks for action through strategic plans [6, 10].

The abovementioned reflection on both theory and practice levels is pursued by addressing the following questions: *what are the key aspects, debates, and challenges relating to each conceptualization of "city"? What are the available and worth exploring indicators to evaluate them?*

In answering these questions, the aim of this paper is twofold: i) to outline which city conceptualizations are encouraged in the EU framework and define the related key aspects to assess their development; ii) to define a set of indicators to monitor these aspects starting from existing indicator frameworks.

In a short overview of these conceptualizations, the "sustainable city", as the most frequently occurred, is intricately linked with the majority of the others, as a comprehensive umbrella [1] addressing the different pillars of sustainability. A "sustainable city" aims to meet present needs without compromising future generations [11], balancing human activity and the environment while promoting social equality, economic well-being, and environmental quality [1, 5, 6, 12].

The "eco-city" [1, 5, 7] encompasses ecological and cultural diversity, renewable resources, and sustainable transportation, while the "low-carbon city" [1, 7, 13] prioritizes policies that promote low-carbon urban development. The "global city" requires specialized infrastructure and a critical mass of functions to support a comprehensive modernization plan, while the "creative city" [1, 4, 6] aims to attract young professionals but has been criticized for promoting inequality and gentrification. The "knowledge city" [1, 5, 7] emphasizes the knowledge and innovation economy but does not centrally promote ecological sustainability. An "inclusive city" fosters social cohesion and quality of life for all citizens, and addresses social inequalities, through smart and sustainable urban planning, citizen participation and co-creation, and digital and technological solutions for urban challenges (Sharifi and Salehi, 2022). The "smart city" [4–7] connects residents to urban infrastructure and services through technology and data analytics but focuses more on social and economic aspects. Finally, the "resilient city" [2, 3, 7] refers to a city's ability to withstand and recover from the effects of hazards in a timely and efficient manner, promoting smart growth and building social cohesion.

In exploring these conceptualizations, a focus can be proposed in terms of both the context of reference and the time scale of observation, to circumscribe theoretical observation and to direct practical action in the short term. In doing so, this paper does not pretend to provide an exhaustive overview in terms of theoretical conceptualization since such categories are not universally recognized in the literature, neither in their use in practices worldwide [6].

Specifically, this paper focuses on which of these "cities" conceptualizations are encouraged by the European Union (EU) and are present in the framework of the "Horizon Europe Program for Research and Innovation" for the period 2021–2027, as a guiding program of future research and innovations, in order to observe which city concept is encouraged for future urban developments. In particular, we refer here to the Strategic Plan 2021–24 [14], that defines the key strategic orientations for the first four years and sets the priorities towards sustainable development. The focus of the Strategic Plan is on the "Global challenges and European industrial competitiveness" pillar, and it has been prepared through a co-design process involving Member States, EEA members, the European Parliament, stakeholders and the public. In particular, the current work programmes 2023–2024 on "Clusters" and "Missions" are taken into account, to understand where we stand towards European missions and challenge in urban sustainability. For further details on the structure of the "Horizon Europe Program for Research and Innovation" 2021–2027, see [15].

The following section describes the research design and approach to categorizing "cities" and explores relevant indicators. Sections 3 and 4 present results from analyzing city categorization and identifying indicators. Section 5 discusses the findings and implications for future research and actions.

2 Research Design

To answer the provided questions, the research is structured into two phases, namely: (i) a content analysis of the selected documents, to outline which city conceptualizations encouraged in the EU framework, defining key aspects to assess their development; (ii) a screening of the existing institutional frameworks of indicators, to define a set of indicators to monitor these aspects.

2.1 Phase 1: Content Analysis

The selected documents on Horizon Europe are reviewed and analyzed, in the first phase, via a textual analysis through ChatGPT (Chat Generative Pretrained Transformer, see [16]), as a tool for Natural Language Processing (NLP), in different steps (Fig. 1):

1) a textual analysis of the Strategic Plan 2021–2024 [14] is provided, to define which conceptualizations of "city" are mentioned into the document;
2) starting from the highlighted categories, a textual analysis of the 7 work programmes 2023–2024 on "Clusters" [17–22] and "Missions" [23] is provided, to define which of the abovementioned conceptualizations are mentioned or envisaged in the documents, to define which documents touch the totality of the conceptualizations (as a selection criterion);
3) starting from the previous selection, a textual analysis of the selected "Clusters" and "Missions" is provided, to highlight which are the key aspects related to each city conceptualization that need to be assessed. It has to be specified that, starting from the analysis provided by ChatGPT, all the results have been revised and elaborated by the authors of this paper.

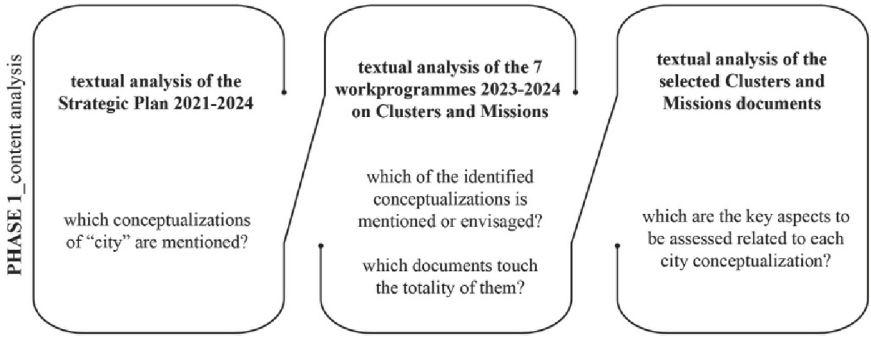


Fig. 1. The steps in Phase 1 of the research.

2.2 Phase 2: Indicators' Screening

The actual institutional framework at the European level includes the following leading Institutes that provide sustainable development indicators on cities [24–29]: i) Eurostat provides statistical data on European cities, while the ii) Joint Research Centre (JRC) of the European Commission, iii) the European Environment Agency (EEA), and iv) the Organization for Economic Co-operation and Development (OECD) provide indicators for monitoring sustainable urban development across Europe.

Considering the key aspects related to each city conceptualization identified in Phase 1, the research starts from the institutional European frameworks outlined above, to detect how they can be assessed. Thus, a screening of the existing institutional frameworks of indicators is provided consisting of the following steps (Fig. 2):

1) analysis of European institutional publications to select those with existing sustainable development indicators for cities;
2) screening of selected publications to identify which indicators assess the key aspects identified in Phase 1.

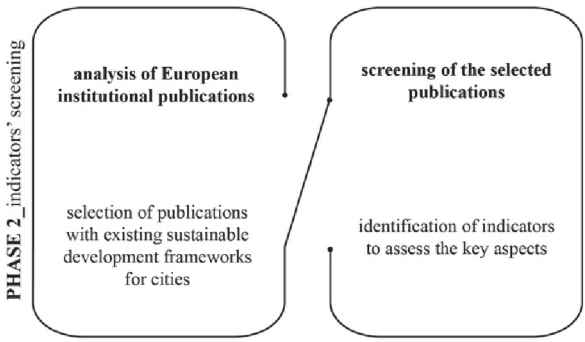


Fig. 2. The steps in Phase 2 of the research.

3 City Conceptualizations and Related Aspects in EU Framework

The aim of this section is to define which conceptualizations of city are mentioned and are meant to be pursued in the Strategic Plan 2021–2024 and work programmes 2023–2024 of "Clusters" and "Missions", at the European level.

In this phase, a textual analysis is conducted through ChatGPT. It's increasingly recognized how ChatGPT, as an advanced AI language model, can contribute to research by supporting researchers in NLP [30–32] and improving data analysis and interpretation [33] without human involvement. This experimental analysis proposes to define conceptualizations of cities, searching for their mentions, and to identify related key aspects in the documents more efficiently. Due to the risk of inconsistent performance or biased output [31], traditional qualitative analysis is used for refinement.

3.1 Step 1: Strategic Plan 2021–2024

A textual analysis of the Strategic Plan 2021–2024 is provided through ChatGPT, to define which conceptualizations of "city" are mentioned into the document and how they are defined. This step aims at setting such definitions as a starting point to frame the subsequent analyses.

Accordingly, ChatGPT has been questioned through the following formula: "Please make a textual analysis of the document at this link https://www.eeas.europa.eu/sites/default/files/horizon_europe_strategic_plan_2021-2024.pdf to find a definition of **city conceptualization** ", substituting from time to time the city conceptualizations already mentioned, in both the singular and plural forms ("creative city"; "eco-city"; "global city"; "inclusive city"; "knowledge city"; "low carbon city"; "resilient city"; "smart city"; "sustainable city").

With respect to the "creative", "eco", "global", and "knowledge" city conceptualizations, ChatGPT highlighted that not a mention, neither a specific definition could be found in the document, answering through different formulas, such as:

- *After conducting a thorough textual analysis of the Horizon Europe Strategic Plan (2021 – 2024) document, I could not find a specific definition of "creative city". […] it does not appear to be a central concept in the Horizon Europe Strategic Plan (2021 – 2024) […];*
- *After reviewing the Horizon Europe Strategic Plan (2021 – 2024) document, I could not find any specific sections where the term "just city" is explicitly mentioned […].*

With respect to the "inclusive", "low carbon", "resilient", "smart", and "sustainable" city conceptualizations, ChatGPT highlighted that a specific mention and a definition could be found in the document, answering through different formulas, such as:

- *Upon analyzing the document, the phrase "inclusive city" appears several times, primarily in the context of research and innovation activities related to urban development. […] Despite the lack of a direct definition, the document does provide some guidance on the characteristics of an inclusive city […];*

- *The term "low carbon city" is mentioned in several places throughout the document, particularly in the section titled "Building a climate-neutral, green, and circular economy […].*

Then, ChatGPT has been further questioned through the following formula: "In which sections of the document is mentioned the **city conceptualization**?", only with respect to the five city conceptualizations emerged in the document.

Accordingly, the city conceptualizations for which a mention and a definition are provided, through ChatGPT, are reported in Table 1, with the specific sections in which they are found.

Table 1. City conceptualizations and mentions in the Strategic Plan 2021–2024.

Conceptualization	Definition	References
Inclusive city	An inclusive city fosters social cohesion and quality of life for all citizens, while addressing social inequalities and exclusion. Specific research and innovation areas that can contribute to creating more inclusive cities are smart and sustainable urban planning; citizen participation and co-creation; and digital and technological solutions for urban challenges	Sections: "Global Challenges and European Industrial Competitiveness"; "Culture, Creativity and Inclusive Society"; "Civil Security for Society"; "Digital, Industry and Space"
Low carbon city	A low-carbon city reduces greenhouse gas emissions and negative environmental impacts while enhancing the well-being of its citizens. It is designed and managed to minimize carbon emissions from energy production, buildings, transport, and waste, while maximizing the use of renewable energy and promoting circular economy practices. Collaboration between different sectors and deployment of low-carbon technologies and systems in urban areas are crucial to achieving this goal	Sections: "Executive Summary"; "Building a climate-neutral, green, and circular economy"; "Sustainable and smart mobility"; "Food, bioeconomy, natural resources, agriculture and environment"; "Health"

(*continued*)

Table 1. (*continued*)

Conceptualization	Definition	References
Resilient city	A resilient city is able to adapt to and recover from shocks and stresses while maintaining its essential functions, structures, and identity. It can thrive in the face of uncertain and changing conditions. Building resilient cities requires addressing key areas including climate adaptation, digital transformation, circular economy, and social cohesion. It is emphasized the importance of resilience in urban areas, as critical for building resilient cities	Sections: "Introduction"; "Europe in a changing world – inclusive, innovative and reflective societies"; "Global challenges and European industrial competences"; "Innovative Europe"; "A climate-neutral, green, fair, and social Europe"; "Digital, industry and space"
Smart city	Smart cities use digital technologies and sustainable solutions to address societal challenges and improve urban services. It is emphasized the importance of data and digital technologies in developing, testing, and deploying innovative solutions, such as improving mobility and other urban services	Sections: "Societal Challenges"; "Digital, Industry and Space"; "Climate, Energy and Mobility"; "Bioeconomy, Natural Resources, Agriculture and Environment"
Sustainable city	A sustainable, liveable, and resilient city can adapt to climate change and resource scarcity. It requires a holistic approach that considers social, economic, and environmental dimensions, involving citizens and stakeholders. Key priorities include innovative and low-carbon urban technologies, sustainable mobility options, circular economy principles, and investing in green spaces and social infrastructure. Overall, sustainable cities promote well-being in a socially, economically, and environmentally sustainable manner	Sections: "Introduction"; "Civil Security for Society"; "Digital and Industry Transformation"; "Climate, Energy, and Mobility"; "Food, Bioeconomy, Natural Resources, Agriculture, and Environment"; "Health"

3.2 Step 2: Clusters and Missions 2023–2024

After highlighting analyzing the Strategic Plan, a textual analysis of the 7 work programmes 2023–2024 "Clusters" and "Missions" is conducted through ChatGPT, to

define if the five city conceptualizations emerged are mentioned or envisaged in the documents. The aim of this step is to define which "Clusters" and "Missions" can be related to the totality of the city conceptualizations highlighted, as a selection criterion to circumscribe the research on the work programmes that fully cover the several aspects of urban sustainability, and as a starting point to go in-depth in the subsequent screening.

In this step, the 7 documents analyzed namely are: Cluster 1, "Health" [17]; Cluster 2, "Culture, creativity and inclusive society" [18]; Cluster 3, "Civil security for society" [19]; Cluster 4, "Digital, industry and space" [20]; Cluster 5 "Climate, energy and mobility" [21]; Cluster 6, "Food, bioeconomy, natural resources, agriculture and environment" [22]; Missions [23].

According to each document, ChatGPT has been questioned through the following formula: "Please make a textual analysis of the document at this link **link** to find mentions of **city conceptualization**", substituting from time to time the city conceptualizations already mentioned, in both the singular and plural forms ("inclusive city"; "low carbon city"; "resilient city"; "smart city"; "sustainable city").

The search produced three different sorts of caseloads:

- the city conceptualization is explicitly mentioned in the work programme (∈);
- the city conceptualization is not explicitly mentioned in the work programme, however related concepts can be identified and linked to it (≅);
- the city conceptualization is not explicitly mentioned, neither related concepts can be identified.

A synthesis of this analysis is reported in Table 2.

Table 2. City conceptualizations in "Clusters" and "Missions".

Conceptualization	Clusters' work programmes 2023–2024						Missions' work programme 2023 2024
	1	2	3	4	5	6	
Inclusive city		≅		≅	∈		≅
Low carbon	≅	∈	≅	≅	∈	≅	∈
Resilient city		≅	∈	≅	≅		≅
Smart city		≅		≅	≅		∈
Sustainable city	≅	≅		≅	≅		∈

As an example of each case:

- the city conceptualization "low carbon city" results as explicitly mentioned in the work programme of "Cluster 2", namely: *After conducting a textual analysis of the document at the provided link, I have found the following mentions of "low carbon city" or "low carbon cities" […]*;
- the city conceptualization "smart city" results as not explicitly mentioned in the work programme of "Cluster 4", however related concepts can be identified and linked

to it, namely: *After analyzing the document at the provided link, I have found that there are no direct mentions of "smart city" or "smart cities" in the document. […] However, there are some indirect references to topics related to smart cities […]*;
- the city conceptualization "resilient city" results as not explicitly mentioned in, neither related concepts can be identified: *After conducting a textual analysis of the document at the provided link, I found no mentions of "resilient city" or "resilient cities". […] there is no specific mention of "resilient city" or "resilient cities".*

According to this screening, the selected documents for further analysis are "Cluster 2", "Cluster 4", "Cluster 5", and "Missions", as related to the totality of the city conceptualizations highlighted.

3.3 Step 3: Key Aspects

Starting from the previous selection, a textual analysis of the selected "Clusters" and "Missions" is provided through ChatGPT, to highlight which are the key aspects related to each city conceptualization that need to be assessed.

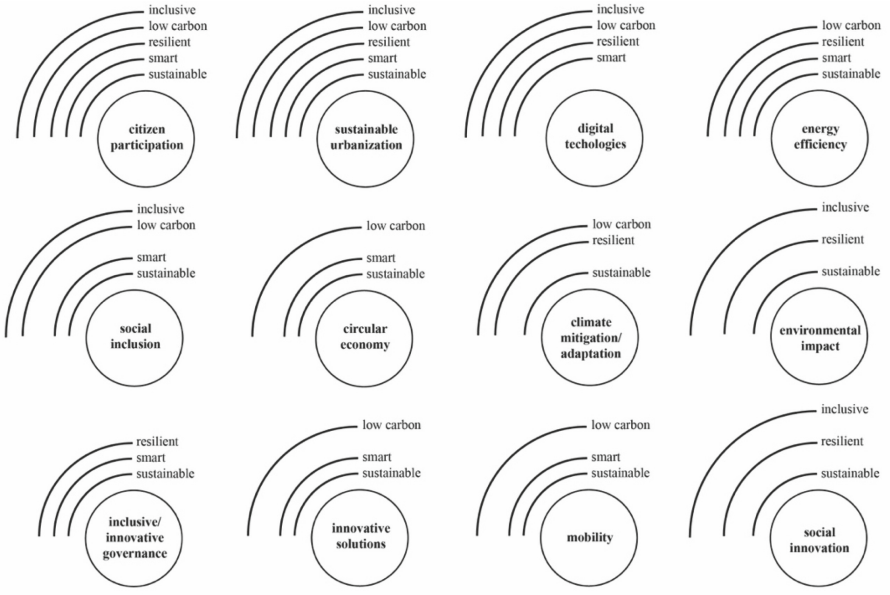
Indeed, if the previous steps provide a general definition and positioning in the work programmes of the different ways in which cities are defined, this step aims at exploring the implications of these definitions for sustainable urban development, in terms of key aspects to be assessed. Accordingly, this step is preliminary to give guidance for decision-making, enable target setting for cities as well as allow assessing whether the development is proceeding, through the definition of existing or worth exploring indicators.

According to each document, and in relation to each city conceptualization, ChatGPT has been questioned through the following formula:

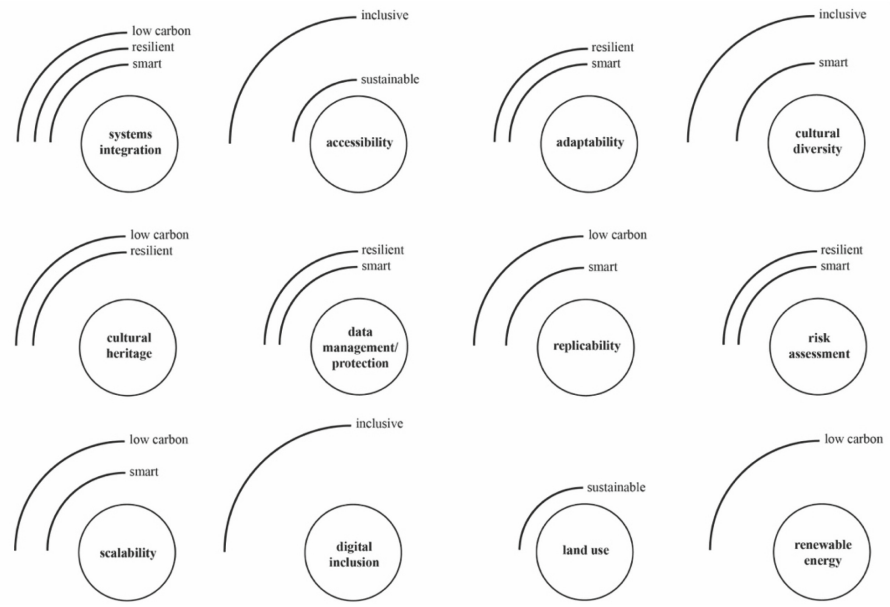
"Please define which are the key aspects to be assessed related to the**city conceptualization** in the document at this link **link of the specific work programme***", substituting from time to time the different city conceptualizations.

The results of this analysis were elaborated by the authors and synthesized in Fig. 3, in which the circles represent the key aspects emerged and the surrounding arches relates to the city conceptualizations to which they are linked.

Based on this analysis, it can be highlighted that: (i) the key aspects related to all the 5 conceptualizations are "citizen participation" and "sustainable urbanization", which are quite broad and likely related to different aspects of urban sustainable development; (ii) some other key aspects emerged as in common among different conceptualizations of the city, at least 3 or 4, and punctually cover the different sustainability pillars (e.g., "energy efficiency", "social inclusion", and "circular economy"; (iii) each city conceptualization has at least one key aspect that is strictly related to that particular one, or at maximum two (e.g., "renewable energy" for "low carbon city", or "risk assessment" for "resilient city" and "smart city"). Accordingly, it can be defined that, even if there are overlaps among city conceptualizations, these differ and should be pursued precisely on the basis of certain aspects that are completely absent in others.



(a)



(b)

Fig. 3. The key aspects emerged from the analysis of "Cluster 2", "Cluster 4", "Cluster 5" and "Missions", related to each city conceptualization.

4 Set of Indicators for Monitoring City Conceptualizations

The aim of this section is to provide a set of indicators through which assess the development of the emerged city conceptualization – namely "inclusive city", "low carbon city", "resilient city", "smart city", "sustainable city" – by detecting a connection between the identified key aspects (Fig. 3) and the existing European institutional indicators frameworks.

4.1 Step 1: Institutional European Framework of Indicators

Publications from Eurostat, JRC, EEA and OECD have been screened to select those that include sustainable development indicators for cities. This screening led to the identification of 11 publications:

- [34]: this publication provides a comprehensive set of statistics on urban areas in the EU, including indicators related to sustainable development.
- [35]: this report provides an overview of the progress made by the EU and its member states towards achieving sustainable cities and communities.
- [36]: this publication provides an updated version of the Regional Yearbook with a focus on the latest data available.
- [37]: this report proposes a reference framework for sustainable cities that aims to help cities monitor their progress toward sustainability goals.
- [38]: this report presents a set of indicators for measuring progress towards a circular economy from a systemic perspective.
- [39]: this report provides an overview of sustainable urban development in Europe, focusing on key environmental, social, and economic indicators.
- [40]: this report explores how cities can facilitate sustainable transitions, including the use of sustainable development indicators to measure progress.
- [41]: this report provides an overview of the state and outlook of Europe's environment, including urban sustainability indicators.
- [42]: this report presents an overview of the challenges facing regions and cities, including the use of indicators to measure progress and inform policy in areas such as sustainable development.
- [43]: this report assesses progress towards green growth in Southeast Europe, including the use of indicators to measure progress and inform policy in urban areas.
- [44]: this report provides an assessment of progress toward the Sustainable Development Goals (SDGs), including indicators for urban sustainability.

4.2 Step 2: Indicators to Assess the Emerging Key Aspects

An in-deep exploration of selected documents was conducted to identify indicators that can be used for assessing the emerging key aspects of sustainable development for each city conceptualizations identified in Phase 1. Table 3 reports the 114 indicators identified in the existing frameworks that can be traced back to the evaluation of the 24 key aspects.

Based on this analysis, it can be highlighted that: (i) at least one indicator is available for all the emerged key aspects; (ii) some key aspects, the environmental ones, are the most supplied by available indicators, namely "energy efficiency", and "renewable

Table 3. The available indicators for each emerging key aspect.

Key aspects	Indicators	References
Citizen participation	Voter turnout [%]	[35, 36]
	Participation in civil society organizations [n.]; Trust in government, and public satisfaction with public services [%]	[37]
Sustainable urbanization	Share of urban population [%]; Green space per inhabitant [sqm/inhab.]; Number of people living in overcrowded households [n.]	[34, 37, 39–41]
	Urban sprawl [%]; Population density [n.]; Green infrastructure [sqm]; Urban land uptake [sqm]; Green urban areas [smq]; Housing affordability [%]	[37, 39–41]
Digital technologies	Broadband penetration rate [%]; Percentage of internet users [%]	[38, 44]
Energy efficiency	Energy intensity of gross domestic product (GDP) in Purchasing Power Standards (PPS) per kg of oil equivalent (kgoe) [kgoe/GDP]; Share of renewable energy [%]; Share of cogeneration in electricity production [%]	[35, 38]
	Carbon intensity [CO2]; Energy productivity [kWh]; Energy efficiency [kWh/€]; Energy subsidies [€]	[38]
	Primary energy consumption [kWh]; Final energy consumption [kWh]; Energy-related greenhouse gas emissions [CO2]	[38, 44]
Social inclusion	At-risk-of-poverty rate [%]; Material deprivation rate [%]; Gender pay gap [%]	[36, 37, 39–41]
	Poverty and social exclusion rate [%]; Share of low-wage earners [%]	[37, 39–41]
	Unemployment rate [%]	[37, 39–42]

(*continued*)

Table 3. (*continued*)

Key aspects	Indicators	References
Circular economy	Material footprint [tons]; Recycling rate of municipal waste [%]; Share of recycled material in material consumption [%]	[34, 38–41]
	Resource productivity [€/tons]; Waste generation per capita [kg/inhab.]	[38–41]
	Circularity rate [%]	[38–41, 43]
Climate mitigation/adaptation	Greenhouse gas emissions [CO2]; Renewable energy share [%]; Energy consumption from renewable sources [kWh]	[35–41]
	Climate change vulnerability [%]	[37, 39–41, 43]
Environmental impact	Environmental footprint [tons of CO2]; Air and water quality [micrograms/cbm]; Waste and recycling rates [%]	[37, 39–41]
	Carbon footprint [CO2]	[37, 43]
Inclusive/innovative governance	Public expenditure on education [€]; Health and social protection [€]	[34, 38, 44]
Innovative solutions	Research and development expenditure [€]; Patents applications [patent unit]	[35, 36, 44]
Mobility	Modal split of transport [%]; Average commute time [minutes]	[34, 37, 39–41, 44]
	Transport-related emissions [CO2]	[37, 39–41, 44]
Social innovation	Social investment [€]; Social protection expenditure [€]	[35, 37, 39, 41, 44]
	Social impact investment [€]	[37, 39, 41, 44]
Systems integration	Energy and water use efficiency [kWh]; Green public procurement [%]	[34, 37, 40, 41, 44]
	Resource efficiency [€/tons]; Sustainable public procurement [%]	[37, 38, 40, 41, 44]
Accessibility	Share of population with access to broadband internet [%]	[34, 39, 41, 44]

(*continued*)

Table 3. (*continued*)

Key aspects	Indicators	References
	Accessibility to natural areas and green spaces [sqm]; Access to basic services (e.g., healthcare, education, water, sanitation) [n.]	[39, 41, 44]
Adaptability	Share of employed population with high level of education and training [%]	[35, 39, 41]
	Diversity of economic activities and employment opportunities [n.]	[39, 41]
	Resilience to economic shocks and natural disasters [%]	[39, 41–43]
Cultural diversity	Share of foreign-born population and language diversity [n.]	[34]
	Diversity of cultural heritage sites and institutions [n.]; Cultural diversity in natural areas and landscapes [n.]	[39, 41]
	Ethnic and linguistic diversity and integration [%]	[39, 41, 42]
Cultural heritage	Number of cultural heritage sites and institutions [n.]	[36, 39, 41]
	Conservation and restoration of cultural heritage sites [%]; Protection and management of cultural heritage in natural areas [%]	[39, 41]
	Investment in cultural heritage preservation and promotion [€]	[39, 41, 42]
Data management/protection	Compliance with data protection regulations [%]	[35]
	Adoption of open data policies and measures [%]	[43]
Replicability	Standardized data collection methods and metadata availability [%]	[34]

(*continued*)

Table 3. (*continued*)

Key aspects	Indicators	References
	Availability of detailed information on the methodology used, including sources, data collection and processing procedures [%]; Data and methodology transparency, replicability, and availability of quality assurance and control procedures [%]; Transparency of data sources, methodologies, and assumptions, with clear documentation and traceability [%]	[35]
Risk assessment	Assessment of the probability and consequences of environmental risks and their impacts on human health and ecosystems [%]; Assessment of the likelihood and potential impact of risks on economic, social, and environmental outcomes [%]	[38, 41]
Scalability	Deployment of sustainable technologies and infrastructure in different cities and regions [n.]	[34–36]
Digital inclusion	Individuals using the internet for personal purposes [%]; Households with internet access at home [%]	[34, 41]
	Broadband coverage and quality [%]; Access to digital devices [%]; Access to high-speed internet [%]; Access to mobile broadband [%]; Access to online public services [%]; Internet usage rate [%]	[41]
Land use	Land use by type [sqm]; Land cover by type [sqm]; Agricultural land use [sqm]; Forest land use [sqm]; Urban land use [sqm]	[34, 38, 41, 42]

(*continued*)

Table 3. (*continued*)

Key aspects	Indicators	References
	Density [n.]; Green spaces [sqm]; Built environment [sqm]; Land use and land cover [sqm]; Land take [sqm]; Land cover change [%]; Land area per capita [sqm/ per capita]; Agricultural land area per capita [sqm/ per capita]; Forest area per capita [sqm]; Urban land area per capita [sqm/ per capita]	[38, 41, 42]
Renewable energy	Share of renewables in gross final energy consumption [%]; Renewable energy production [kWh]; Renewable energy consumption [kWh]; Share of renewable electricity in gross electricity consumption [%]; Installed capacity [MW]; Energy production [kWh]; Investment [€]; Renewable electricity generation [kWh]; Renewable heating and cooling [kWh]; Share of renewables in total primary energy supply [%]	[35, 41, 42]

energy"; (iii) some key aspects, the socio-cultural ones, are less investigate, namely "cultural diversity", and "cultural heritage". Accordingly, it can be defined that, even if there are available indicators for all the emerged key aspects, further research can be directed to the ones for which the available ones are less.

5 Discussion and Conclusions

This paper underscores the importance of assessing the development of the urban models according to the EU demands and missions, with the ultimate goal of achieving sustainable development. By scrutinizing how various city categories are employed and questioned in the EU Strategic Plan and work programmes, this research explicates the objectives and delineates crucial aspects of each emerging city model: (i) by developing a conceptualization of current challenges in pursuing urban sustainability; (ii) by presenting available (and/or needed) measurement and assessment tools, such as indicators, to support the evaluation of such sustainable urban policies.

Two main contributions can be highlighted in this research.

First, the research defines through the support of ChatGPT the five conceptualizations of cities encouraged in the European framework and identifies 24 key aspects, which are the elements that characterize them and to be pursued.

Second, it highlights 114 available indicators for the assessment of the 24 key aspects. Although at least one indicator is available for each emerging key aspect, some of them

are more explored than others. As an example, environmental key aspects (e.g., energy efficiency, renewable energy) emerge as more endowed with measures to monitor them, than socio-cultural ones (e.g., cultural diversity, or cultural heritage). Moreover, the key aspect of the scalability of cities reports only one indicator, since within the analyzed publications this concept relates more than indicators important qualitative issues to keep in mind for its measurement. Therefore, although indicators are available for all of the key aspects that have emerged, this paper allows us to focus first on those aspects that are less in-depth and on which further research may be needed.

Such contributions have implications on both theory and practice levels.

First of all, at a theoretical level, these findings about the city conceptualizations that can be found, and the overlapping among conceptualizations, can be the basis for further research that – at a critical level – can serve to refine and sharpen the conceptualizations themselves.

Second, at a practical level, the complexity given by the high amount of available indicators should be managed, on the one hand, by identifying some indicators more suitable than others, in a choice oriented: (i) by the specific city concept addressed and its specificities; (ii) by distinguishing their use in a measurement process, to frame the state or condition of a system or process, or in an evaluation process, to define the performance of an action, alternative, or element. On the other hand, based on the abovementioned distinction, possible evaluation methodologies to bring these indicators into an assessment process could be provided, to support monitoring activities through a stated correspondence between goals, indicators, and measures of these indicators – e.g., as in the Agenda 2030 framework – or to provide an assessment of urban sustainable development in a holistic and systemic way, to possibly provide input for cost-benefit analyses (CBA), and similar techniques such as social return on investment analysis (SROI); or Multi-Criteria Analysis (MCA); and finally Sustainability Assessment Tools (SATs).

Specific reflection can be made with respect to the experimental use of ChatGPT for functional text analysis to answer the research question. Since ChatGPT can be used to search for precise information, it has proven to be a useful support. In particular, it has been effective for carrying out repetitive tasks, such as searching for a specific mention or reference to keywords as in the case of this research, speeding up the work exponentially and doing so with the identification of very precise data, referring to punctual sections of the analyzed documents. ChatGPT is not the only tool that can do analysis of this kind, but it ensures useful comparisons between data, being an AI, thus also somehow managing to interpret sections of the text where reference to the conceptualizations sought is not explicit. This is precisely why, as done by the authors of this article, it is necessary to verify and triangulate the results and information received.

Regarding the limitations of the research, first of all it cannot be considered directly as an action framework, as much as a starting point for further actions and research. Moreover, it is important to note that the article focuses on the European Union's framework for urban sustainability, and the identified key aspects and indicators may not be applicable or relevant to other regions or countries. Also, going down to national, regional, and local levels may need to be further localized and declined to capture the specificities of each context. Finally, localizing such indicators would imply reflections

on operational aspects and challenges, such as data availability and homogeneity in terms of scale, time, levels of aggregation. Nevertheless, this research already offers insights into bridging the gap between theory and practice in confronting urban challenges and realizing sustainable development objectives within the EU framework.

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