Determination of Environmental Indicators in the Context of Sustainable Urbanization: The Case of Türkiye

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Abstract

The socio-economic conditions provided by the cities become centers of attraction to improve the quality of life of people. On the other hand, the uncontrolled growth of urban areas in meeting the needs of the increasing population has adverse effects on natural resources. Sustainable urbanization aims to increase the socio-economic quality of life by ensuring the rational use of natural resources, minimizing non-renewable resources, and meeting people's basic needs. However, due to the unconscious use of natural resources and increasing pressure on the environment, environmental components are seen as the basis of sustainable urbanization and affect economic and social sustainability development. This study aims to explain the process of determining the indicators related to environmental sustainability. In this context, by examining the studies carried out in the national and international arena, 20 indicator sets were created under eight themes at the national level, which will be beneficial in spatial planning decisions. It is thought that the determined indicator set will make important contributions to institutions and managers from the local level to regional and national levels in spatial planning studies to ensure environmental sustainability.

Keywords: Urbanization, sustainable development, sustainable city, environmental sustainability, indicators.

Sürdürülebilir Kentleşme Bağlamında Çevresel Göstergelerin Belirlenmesi: Türkiye Örneği

Öz

Kentlerin sağladığı sosyo-ekonomik koşullar, insanların yaşam kalitesini artırmak için çekim merkezi haline gelmektedir. Öte yandan artan nüfusun ihtiyaçlarının karşılanmasında kentsel alanların kontrolsüz büyümesi doğal kaynaklar üzerinde olumsuz etkiler bırakmaktadır. Bu bağlamda sınırlı doğal kaynakların gelecek nesillerin ihtiyaçları doğrultusunda kullanılarak sürdürülebilir kentleşme anlayışının benimsenmesi gerekmektedir. Sürdürülebilir kentleşme doğal kaynakların rasyonel kullanımını sağlayan, yenilenmeyen kaynakların kullanımını en aza indirgeyen, insanların temel ihtiyaçlarını karşılayarak sosyo- ekonomik açıdan yaşam kalitesinin arttırmayı hedeflemektedir. Ancak doğal kaynakların bilinçsiz kullanımı ve çevre üzerinde artan baskılardan dolayı çevresel bileşenler sürdürülebilir kentleşmenin temeli olarak görülmekte olup, ekonomik ve sosyal sürdürülebilirlik gelişimini de etkilemektedir. Bu çalışmanın amacı çevresel sürdürülebilirliğe ilişkin göstergelerin belirlenme sürecinin açıklanmasıdır. Bu bağlamda ulusal ve uluslararası alanda yapılan çalışmalar incelenerek, mekânsal planlama kararlarında yarar sağlayacak ulusal düzeyde sekiz tema altında ve toplam 20 adetten oluşan bir gösterge seti oluşturulmuştur. Belirlenen gösterge seti çevresel sürdürülebilirliğin sağlanmasına yönelik yerel düzeyden bölgesel ve ulusal düzeylere kadar kurum ve yöneticilere mekânsal planlama çalışmalarında önemli katkılar sağlayacağı düşünülmektedir.

Anahtar kelimeler: Kentleşme, sürdürülebilir kalkınma, sürdürülebilir kent, çevresel sürdürülebilirlik, göstergeler.

1. Introduction

Nowadays, more than half of the world's population lives in urban areas. The main reason urban areas, which are developed socio-economic conditions, are centers of attraction for people. In this context, while the urbanization process seems to be in a positive relationship with socio-economic development, the expansion of urban areas has adverse effects on natural resources, such as loss of agricultural lands, increase in CO_2 emissions, and decrease in water resources (Li et al., 2009; Shen & Zhou, 2014). Therefore, all the effects should be handled in line with the principles of sustainable urbanization.

Many studies in the literature show that there are different definitions of the concept of sustainable urbanization. However, the basic approach of sustainable urbanization is based on ensuring long-term human well-being by balancing the economic, social, and environmental dimensions of sustainable development, minimizing negative impacts on natural resources, maximizing resource use efficiency, and accessing essential services (Huang et al., 2015). Shen et al. (2011) emphasized three key components of a sustainable city. For future generations, firstly, it is to ensure the protection-use balance of natural resources. Secondly, to increase the quality of life by taking into account the basic needs of the society, and finally, to develop it by providing economic vitality.

Sustainable urbanization was also referred to through sustainable development in the report "Our Common Future", prepared in 1987. Some of the issues addressed in the report are as follows; poverty and the pressures on the environment, the rapid increase and concentration of the population blocking the rise of the standards of life quality, the excessive consumption of environmental resources and the urban problem can be given as urban growth and uncontrolled expansion of cities. To solve all these problems, it is necessary to strengthen local governments and increase local opportunities, save energy in energy use, produce policies to prevent population growth and concentration, protect species and ecosystems, and use natural resources efficiently. It is seen that the stated problems and solution proposals shed light on the concept of sustainable urbanization (Karakuzulu, 2010).

Evaluating the sustainable development of cities, should be handled with a quantitative approach because it is known that something that cannot be measured cannot be developed to evaluate sustainable urban development (Gürel Üçer, 2017). Therefore, it is necessary to benefit from indicators contributing to sustainability by considering the environment and development systems, which provide the basis for decision-making at all levels (Pupphachai & Zuidema, 2017).

At the UN World Summit (Rio Conference) held in Rio, Brazil in 1992, the concept of sustainable development was discussed more broadly and the Agenda 21 document, consisting of 40 chapters, was accepted. Within the scope of Agenda 21, it was emphasized that indicators should be used to ensure sustainable urban development (Moldan et al., 2012; Michael et al., 2014; Huang et al., 2015).

Indicators help to evaluate trends, simplify, analyze, communicate problems, and compare sustainability performances by revealing the current state (Jain & Tiwari, 2017). Sustainability indicators add descriptive quality to the information on the current state of an area and quantify and transform it into meaningful information (Tanguay et al., 2010).

The concept of sustainability is mainly discussed in cities because massive cities are both the primary consumers of natural resources and the leading producers of pollution and waste. Ertürk (1996) emphasized the importance of solving urban problems to achieve sustainable development goals and stated that being sustainable in cities requires adopting a sustainable development strategy. In this context, it is necessary to use indicators to measure the sustainability of cities and evaluate their performance. Therefore, indicators provide information that can help us understand a system's sustainability and pressures (Pınarcıoğlu & Kanbak, 2020).

This article discusses the steps to be taken to develop concrete indicators at the global and national levels to achieve sustainability evaluation. Discussions on measuring sustainable development date back to the 1990s and are included in the 40th article of Agenda 21. In this article, it was also emphasized that commonly used indicators related to Gross National Product and measurement of individual resources or pollution would not provide sufficient evidence for the measurement of

sustainability, and a call was made for the determination of sustainable development indicators to be used in evaluating sustainability as a whole. Ten years after the decisions taken in Agenda 21, these decisions were reaffirmed at the Conference on Environment and Development held in Rio de Janeiro in 2002. This movement was decisive, and after that international organizations and many countries have begun to explore the determination of sustainable development indicators, and the importance of the studies has increased gradually (Kara, 2019).

Sustainable development depends on natural resources to meet the needs of social and economic development. In this context, the environmental dimension forms the basis of sustainable development due to increasing pressures on natural resources. Therefore, evaluating environmental sustainability progress is critical for achieving sustainable development and guiding policy development and implementation (Wang et al., 2022).

Yılmaz (2019) defines the concept of environmental sustainability in general as a system that considers the protection of life support systems by ensuring the continuity of the essential functions of nature, where renewable resources are consumed without exceeding their renewal rate. In this context, it has been emphasized that the regulation function is fulfilled in ensuring environmental sustainability.

It is emphasized in the literature that the environmental dimension is an important pillar in the evaluation of sustainability. Therefore, the determined indicator sets play an important role in producing policies in this direction by determining the effects of urbanization on the environmental sustainability dimension. Reyhan (2017) stated that environmental indicators are vital to developing environmental policies and reporting the environmental situation. In this context, the environmental indicator set is an essential tool for producing environmental policies, reporting the environmental condition, measuring environmental performance, and monitoring and reporting sustainable development goals.

This study aims to determine the indicators related to the environmental dimension that provides the basis for sustainable urban development. In this context, the literature on the subject was examined. Indicators for the environmental sustainability dimension were determined within a systematic process. At the same time, a holistic evaluation was made by revealing the relations with the sustainable development goals represented by the indicator sets determined for environmental sustainability. Therefore, it is thought that the determined indicator set will make essential contributions to institutions and managers from the local, regional, and national levels in spatial planning studies to ensure environmental sustainability.

2. Material and Method

Thus, environmental indicators play a crucial role in spatial planning processes by determining the city's current state. This study covers the determination of appropriate indicator sets to reveal the environmental effects of indicators that will help the sustainable development of cities. The study material comprises national and international academic studies on sustainable city indicators. The method phase of the study is discussed in three parts, and the method phase is given in Figure 1.

Inventory studies are included in the first part of the method. Literature searches related to this study subject (sustainable city, sustainable city indicators) were done. In addition, all data (natural and cultural components) regarding the current state of the study area should be examined.

The second part of the method explained the process of determining the indicators. The selection process of indicators is not easy as it involves many factors. In this context, indicators must have specific features that they should have. This section covers the stages of the selection process of indicators.

In the third (last) part of the method, the special indicators for Türkiye have been evaluated. A summary has been created in Table 1.
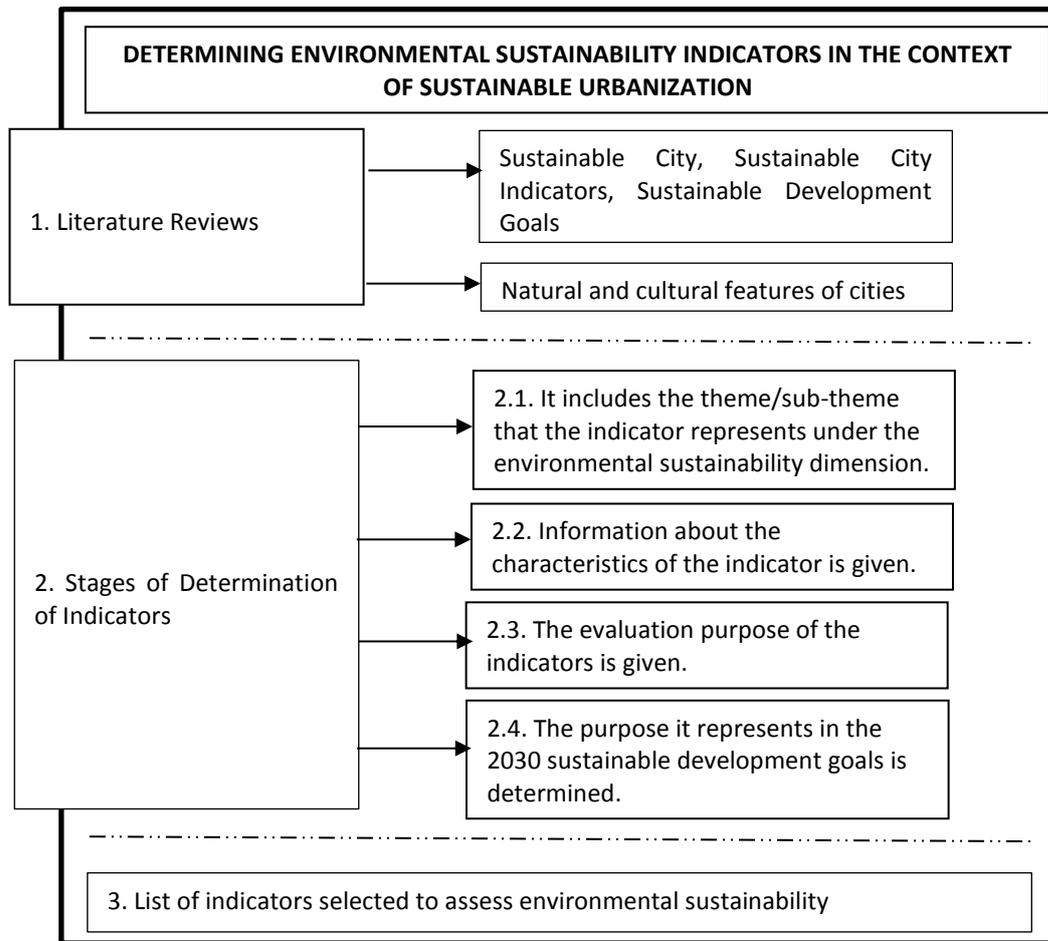
DETERMINING ENVIRONMENTAL SUSTAINABILITY INDICATORS IN THE CONTEXT OF SUSTAINABLE URBANIZATION

1. Literature Reviews
→ Sustainable City, Sustainable City Indicators, Sustainable Development Goals
→ Natural and cultural features of cities

2. Stages of Determination of Indicators
→ 2.1. It includes the theme/sub-theme that the indicator represents under the environmental sustainability dimension.
→ 2.2. Information about the characteristics of the indicator is given.
→ 2.3. The evaluation purpose of the indicators is given.
→ 2.4. The purpose it represents in the 2030 sustainable development goals is determined.

3. List of indicators selected to assess environmental sustainability

Figure 1. Flow chart of the method

Many studies in the literature reveal the sustainability of cities using indicators. One of the issues that should be considered in the selection process of the indicators is that they should provide us with the most accurate information about the application status. Therefore, indicators must meet specific criteria. On this issue, Mega & Pedersen (1998) stated that indicators should be clear, simple, scientifically meaningful, verifiable, and reproducible (Shen et al., 2011). Therefore, in selecting sustainable city indicators, the principles given in the introduction have been considered by the following criteria (Jain & Tiwari 2017).

Achievable indicators should help to represent problems by being controlled through policy and strategic actions. Measurable indicators should be theoretically sound and quantifiable in an easy way to understand. Policy-relevant indicators should provide relevant information to decision-makers to change policies to achieve desired goals. Specific/interpretable indicators should be easily understood by intended users and applicable to decision-makers. Ability to be predictable with time series data, indicators should be predictable using accepted methods to identify potential changes. The selected indicators must be sensitive to the pressure on the system under study. The comprehensiveness indicator set should provide a holistic view of the system covering causes and effects.

Data availability, data to measure indicators should be readily available from reliable sources at a reasonable cost. Consistent, controversial indicators should be avoided. Local priorities and selected indicators should reflect site characteristics and local community needs. The speed of data availability, time tag between the data collected, and changes in the phenomenon under study should be minimum. Quantitative indicators should present problems quantitatively. There should be a minimum time lag between collected data and changes in the phenomenon under study.

Based on this framework; a unique classification system has been designed to choose environmental indicators contributing to sustainable urbanization. The second stage of the method is explained in detail in Table 1.

Table 1. Sustainable city indicator selection stages

Part	Name of The Column	Description	Contribution
Part 1	Theme	It facilitates the selection of indicators under the topics related to environmental sustainability.	In this context, indicators provide information to decision-makers with their controllable feature, by helping them represent problems.
	Sub-theme		
	Name of the indicator	It is the name of the indicator under the theme.	
Part 2	Unit	The unit of the display must be specified so that users can easily understand it.	Thanks to the interpretability and consistency of the indicators, it is beneficial for decision-makers.
	Data sources	Data on indicators should be obtained from reliable sources, and data availability should be indicated.	Obtaining data from official sources is essential for correctly evaluating indicators.
	Data year	It should be obtained from up-to-date data to observe possible changes.	The minimum time interval between the collected data and the changes in the investigated phenomenon will facilitate the appropriate assessment of the indicator.
	Frequency of use	The frequency of use of the indicator in national and international literature has been examined.	The current situation should be evaluated holistically in the context of indicators generally taken in the literature.
Part 3	Purpose	The benefit it provides in the evaluation of the indicator is stated.	The indicators chosen should be sensitive to their effects on the system under study.
Part 4	Sustainable Development Goals	It reveals the link between the Sustainable Development Goals, consisting of 17 goals, and the indicators.	It is beneficial that the indicator can be controlled through policy and strategic actions and represent problems.

3. Findings and Discussion

This section gives clear explanations of the three stages mentioned in the method.

3.1. Literature Research

Under this title, some information is provided about the literature reviews that form the basis of the study and the studies that are effective in selecting indicator sets.

Many factors enable urban development. Therefore, a systematic process method should be adopted to select the appropriate indicator specific to the cities. Feleki et al. (2018) emphasize creating a methodological approach that will eliminate the free choice of indicators to be evaluated in terms of sustainability and ensure a rational choice. Thus, the indicator set will provide a consistent and comparable evaluation. Likewise, Gonzalez-Garcia et al. (2019) stated that particular processes should be considered when selecting a region's city-specific indicators. He said that to apply similar indicator sets in all cities and make comparisons, cities should also be adapted according to certain characteristics.

There are many frameworks for measuring sustainable development. The main differences between the frameworks to be used for selecting indicators are conceptualizing the dimensions of sustainable

development, revealing the connections between these dimensions, and selecting and combining the indicators (Kara, 2015).

Topic/Theme-based frameworks are among the most commonly used frameworks for determining official national indicator sets in many countries worldwide. Theme-based frameworks have significant benefits. First, the theme-based indicators facilitate the relationship between policy processes and goals. Thus, it increases public awareness by providing understandable information for decision-makers. Second, theme-based indicators reveal whether the sustainable development goals have been achieved. Finally, it provides flexibility in adapting new or current targets to planning studies (Kara, 2015).

Theme-based frameworks make it easier to make arrangements on issues related to the city's development policies. To determine the subjects on which the study is based, 18 indicator sets in the literature were examined, and the intensity of use of the themes in these sets was revealed (Tuğaç, 2018). In the said criteria, the subjects based on sustainable development dimensions (environmental, social, economic) guide the studies. Figure 2 gives the percentage of the frequency of use of the themes in the examined indicator sets. Indicator sets discussed in the study are as follows: UN Sustainable Development Indicators, OECD, EU Sustainable Development Indicators, European Environment Agency Indicators, TUIK Sustainable Development Indicators, Millennium Development Goals, EU-2020 Goals, European Commission Green Capital Award, European Commission Green Leaf Award, European Foundation's Urban Sustainability Indicators, Urban Ecosystem Europe, Urban Blue Spaces Plan, Reference Framework for Sustainable Cities, Criteria Set Approach for Sustainability, China Urban Sustainability Index, ELITE Urban Metrics, Environmental Performance Index (EPI), Environmental Sustainability Index (Kara, 2015; Tuğaç, 2018).
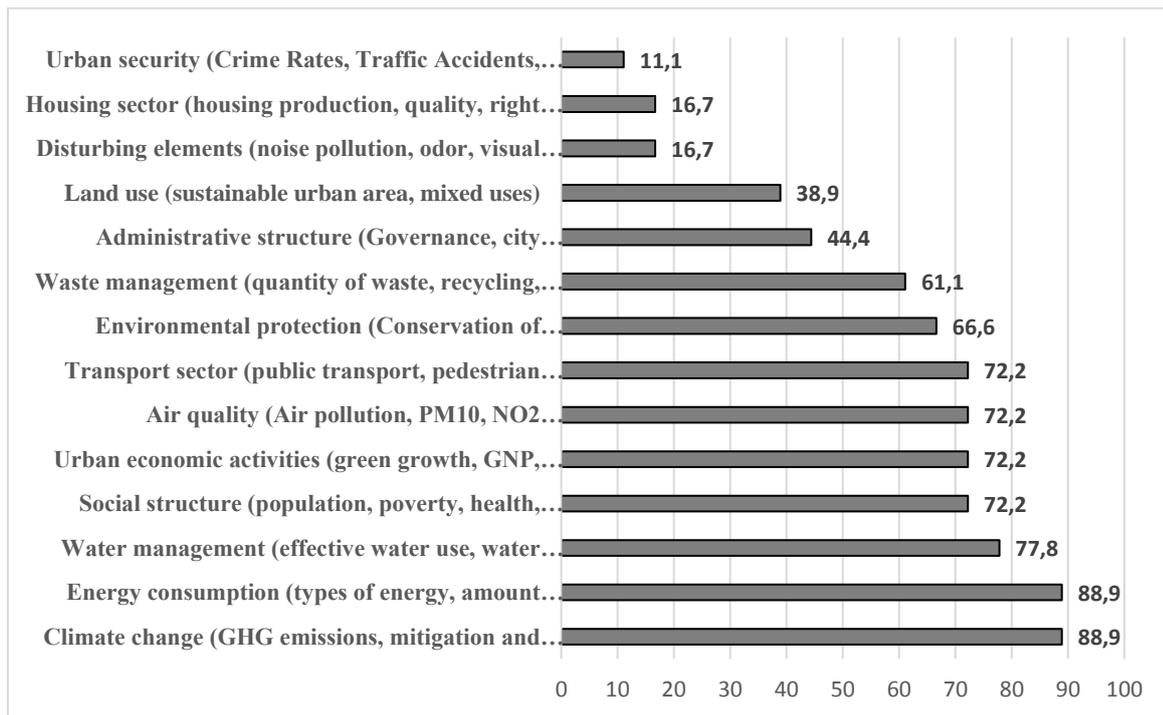

Figure 2. Frequency of use of the themes

3.2. Stages of Determination of Indicators

The prominent themes in evaluating environmental sustainability in the literature focused on issues such as air quality, climate change, energy consumption, water management, environmental protection (biodiversity), and waste management (Figure 2). Information about the themes and the indicators that may be under them is given in the first part of determining the indicators. In this context, atmosphere management, land use, water management, biodiversity, open green space systems, waste management, and renewable energy systems are the determined themes within the scope of the study.

Determining the appropriate indicator sets that can evaluate the city's environmental, social, and economic impacts, depending on the level of development and population density, constitutes an important pillar in ensuring sustainable urbanization. Zhou et al. (2015) emphasize that the effectiveness of the indicators selected to measure the city's sustainability performance has critical importance in making evaluations in line with the sustainable development mission. In this context, in the second part of the stage of determining the indicators, the characteristics of the indicators to be included in the study are included. Here, the basic features of the indicators, such as unit, data source, and year and frequency of use, are included. Thus, it aims to explain the current situation according to the years by providing a reliable data source for the indicators. The frequency of use, on the other hand, gives the importance of the indicator in the literature due to the frequency of occurrence in the sources provided in the upper sections within the scope of this study. Indicators with a frequency of use of more than five were evaluated. However, due to the importance of some indicators, the frequency of use of less than five was ignored.

There are three basic approaches to determining the frequency of use. First of all, in the surveys made with the keyword Scopusta (sustainability city indicator), indicator sets for environmental sustainability were examined from the literature sources between the years 2010-2020 (Rama et al., 2020; Gonz_alez-García et al, 2019; Tang et al., 2019; Feleki et al., 2018; Fouda & Elkhazendar, 2019; Tan et al., 2018; Mapar et al., 2017; Rajaonson & Tanguay, 2017; Ibrahim et al., 2015; Mascarenhas et al., 2015; Michael et al., 2014; Shen & Zhou, 2014; Jiang & Shen, 2013; Marzukhi et al., 2011; Shen et al., 2011; Mascarenhas et al., 2010; Tanguay et al., 2010).

Secondly, the presence of indicators within the scope of the research in the indicator sets developed by international organizations (UN, EU and OECD) has been tried to be determined. Finally, the selection was supported by the studies carried out by national organizations. Thus, the total frequency of use of the indicator in all approaches was revealed (Figure 3).
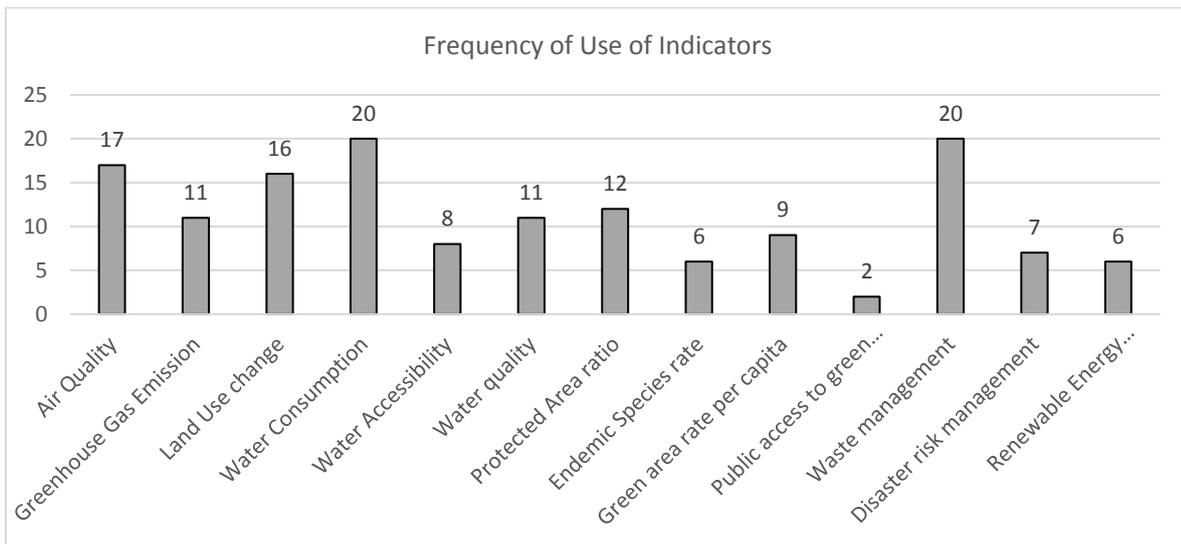

Figure 3. Frequency of use of indicators

When Figure 3 is examined, it is seen that the indicators related to water consumption and waste management are the most common in all the sources examined. It has also been determined that air quality, land use distribution, greenhouse gas emissions, water quality, and protected area ratio are more than ten times used in studies. In addition, as a result of the examinations, it is seen that the studies on the accessibility indicator of green areas do not take place much. However, this indicator is vital to the per capita ratio of open green areas. Yaman & Doygun (2014) state that ensuring the circulation of individuals in public spaces and accessibility in public spaces in sustainable urban development should be arranged in an integrative and fair way, that is, meeting the needs of all users (Cüce & Ortaçeşme, 2020). Therefore, this indicator is evaluated within the scope of the study.

According to Shen et al. (2011), identifying indicators should not just be about managing a large number of indicators, preferably assessing those that are more fundamental and more likely to produce the most accurate information about the state of implementation. In addition, the usability of the data in the indicator development process, its scope, and its basic features should be easily measurable for all decision mechanisms (Michael et al., 2014; Jain et al., 2017).

In the third part of the stage of determining the indicators, there is information about the purpose or benefit of evaluating them and the source they refer to. Thus, as a result of evaluating the indicators, it will guide the planning decisions. Dizdaroğlu (2015) emphasizes the qualities indicators should have as being suitable for making policy decisions, being analytically sound and measurable.

In the last part of determining the indicators, the relationship between the indicators determined in evaluating the environmental dimension of the sustainable development of cities and the sustainable development goals represented. Klopp & Petretta (2017) emphasize that the sustainable development of cities can be under the supervision of sustainable development goals. Thus, it is an essential indicator for integrating development with 17 sustainable development goals globally. In this context, the relationship between sustainable development and environmental sustainability goals is given in Table 2 (Çoban & Uzun, 2022).

Table 2. The relationship between SDG and environmental sustainability

No	SDG	Environmental Sustainability Goals	References
SDG 6	Clean Water & Sanitation	Water is an essential resource for human survival. Access to adequate clean water and sanitation is a fundamental human right. Therefore, the protection and sustainable use of water resources should be ensured.	Carino & Xie, 2013
SDG 7	Affordable & Clean Energy	Considering that energy contributes to climate change and accounts for approximately 60 percent of total global greenhouse gas (GHG) emissions, using clean and affordable energy sources to combat climate change should be increased.	Cîrstea et al., 2018
SDG 11	Sustainable Cities and Communities	Urban sustainability is critical to achieving environmental sustainability. For environmental services and products such as green spaces, air quality, and waste management, plans should be made to "provide" or "guarantee" their assessment.	Thomas et al., 2021
SDG 13	Climate Action	Climate change is one of the most critical problems of our time. Human activities, such as increased greenhouse gas emissions (such as CO2), are accelerating climate change and threatening biodiversity and ecological services. Therefore, climate change is inevitable, and plans must be made to adapt to its effects.	Arora & Mishra, 2019
SDG 14	Life below water	Human activities have had a noticeable negative impact on life in water and land. Our survival must be ensured by protecting both marine and terrestrial ecosystems.	Selim et al., 2015
SDG 15	Life on Land	Quantifying terrestrial and marine ecosystem services contributes to the sustainable management of natural resources.	

3.3. List of Indicators Selected to Assess Environmental Sustainability

Urban sustainability indicators and their appropriate selection are important in successfully achieving sustainable development goals. Although there are studies in the literature in which urban sustainability indicators are applied effectively, the fact that the stages of the selection process of the indicators are not shared causes difficulties in creating appropriate indicator sets (Shen et al., 2011). Verma & Raghubanshi (2018) state that the usability (measurability) of the data in the implementation and evaluation process of the indicators depends on the determination of the indicators for the targets and the creation of the appropriate conceptual framework of the indicators. Therefore, the main

difficulties in selecting sustainable city indicators are closely related to the measurability of the data in determining and evaluating the indicators. Therefore, in this study, indicators for Türkiye were determined within the framework of the method developed and explained regarding the selection process of environmental sustainability indicators. A theme and sub-theme were determined first in creating show sets for Türkiye. Then, the unit, data source, years, scale, and frequency of use of the indicator determined in this context were determined. Likewise, the purpose of the indicator and its relationship with sustainable development goals are presented (Table 3). In this context, by examining the studies carried out in the national and international arena, a total of 20 indicator sets were created under eight themes that will be beneficial in spatial planning decisions.

4. Conclusion and Suggestions

Sustainable urbanization is defined as a city that considers future generations' needs uses natural resources correctly, minimizes non-renewable resources, meets people's basic needs, and aims to increase the quality of life in socio-economic terms. The United Nations Human Settlements Program (UN-Habitat, 2004) defined sustainable urbanization as a dynamic process combining environmental, social, economic, political, and institutional sustainability (Shen et al., 2011).

As a result of the research, it is seen that there are three basic components, namely economic, social, and environmental, in ensuring urban sustainability. With the increasing population density in urban areas, the increase in environmental pollution, and the unconscious use of natural resources, the importance of the environmental dimension in sustainable urban development is increasing. Therefore, revealing the status of environmental variables helps in ensuring sustainable development. Thus, environmental sustainability shows the result of the interaction between human activities and natural resources (Zhang & Chen, 2021).

Indicators play an essential role to evaluate environmental sustainability in sustainable urban development. Saraç & Alptekin (2017) state that indicators provide simple and valuable information to the public and decision-makers and are seen as a tool to summarize the versatility of sustainable development. In addition, it helps people understand the concept and makes it possible to assess cities or regions regarding sustainability.

Environmental sustainability indicators help to take spatial planning decisions. Therefore, the determined indicator sets play an important role in producing policies in this direction by determining the effects of urbanization on the environmental sustainability dimension.

Spatial planning is making land use decisions prepared to create healthy and safe environments with high quality of life to protect and develop natural and cultural values by supporting sustainable development at the Türkiye, regional and city levels (Yılmaz Kaya & Uzun, 2019). According to this definition, it is obvious that spatial planning parallels the goals of sustainable urbanization.

Table 3. List of indicators selected to assess environmental sustainability

	Part 1			Part 2			Part 3	Part 4
Theme	Sub-theme	Indicator	Unit	Data source	Data year	Frequency	Purpose	Sustainable Development Goal
Atmosphere Management	Air Quality	Average PM10 Concentration	$\mu g/m_3$	Provincial Air Quality Station	2021	17	This indicator provides a measure of the state of the environment in terms of air quality. Improving air quality is important for promoting sustainable human settlements.	11
	Greenhouse Gas Emission	Carbon Storage Rate	%	USGS	2021	11	This indicator measures carbon dioxide emissions, which are known to be the most important in their impact on global warming. The increase in the concentration of CO_2 in the atmosphere has a very negative effect on economic, social and environmental conditions.	13
Land Use	Land Use Distribution	The covered area ratio of the residential area	%	CORINE	1990-2018	16	This indicator provides information on changes in land use to facilitate sustainable land use planning and policy development. From an environmental perspective, unsustainable land use is a significant factor in land degradation, can threaten ecosystems and lead to natural habitat loss and landscape changes (UN, 2007).	15
		Area covered by forest areas						
		Agricultural areas covered area ratio						
Water Management	Water consumption	Water consumption per person	lt/ capita day	TSI	2020	20	This indicator provides information on consumption in line with daily needs in the city. Depleting water resources can negatively affect sustainability, limiting economic and regional development and leading to biodiversity loss (UN, 2007).	6
	Water Accessibility	Water Access Rate	%	TSI	2020	8	This indicator assesses the accessibility of drinking water in the city. It measures the percentage of households with access to drinking water infrastructure compared to the total households in the city. (Drinking water is evaluated regarding water safety and sanitation (Chan & Lee, 2019).	
	Water Quality	Water Quality ratio		Basin Protection Action Plans	2013	11	Availability and accessibility of potable clean water resources are important for sustainable development (UN, 2007). This indicator assesses the quality of water available to communities for basic needs. Identifies communities where water at the source or supply threatens health by contamination.	
Biodiversity	Ecosystem	Protected Area Ratio	%	Nature Conservation and National Parks	2021	12	The indicator shows the extent to which the proportion of areas important for biodiversity, cultural heritage, scientific research (including baseline monitoring), recreation, maintenance of natural resources and other values are preserved. Protected areas are essential for maintaining ecosystem diversity in countries and ecoregions, and managing human impacts on the environment (UN, 2007).	15
	Species	Presence of endemic species	%			6	This indicator allows monitoring of the extinction risk of species over time. It also demonstrates the effectiveness of local, national, regional and global measures to protect endangered species (UN, 2007).	
Open Green Spaces	Adequacy of open green	Green space per capita	m²	Municipal Boundaries	2020	9	These indicators are connected areas that develop within the framework of minimizing the effects on the natural environment by using the open green areas by protecting the resources and the amount of open and green areas. As well as the ratio of the areas accessible to these areas at the specified distances is essential for sustainable urbanization.	11
	Open green space Accessibility	Public access to green spaces	%	Municipal Boundaries	2020	2		
Waste Management		Impact of irregular solid waste landfills	m	Municipality/ Environmental Status Reports	2021	20	This indicator, the irregular storage of solid wastes, pollutes the underground and aboveground spring waters. Therefore, the areas where the wastes are stored affect the natural ecosystem processes and cause environmental pollution. Thus, disposal without harming the environment is to form	12

							the basis of a livable and sustainable environment.	
Disaster Risk Management	Risks	The density of fault lines	%	AFAD	2021	7	These indicators contribute to a better understanding of the vulnerability to natural hazards in a given country and thus encourage long-term, sustainable risk reduction programs to prevent disasters. High vulnerability means greater exposure to natural disasters without disaster mitigation measures.	11
		Rate of Landslide Susceptibility						
		Rate of Erosion risk area						
		The proportion of the population affected by floods		Flood Management plans	2018			
Renewable energy		Solar Power Plant	MVe	https://www.enerjiatlasi.com/sehir	2021	6	These indicators make a significant contribution to reducing greenhouse gas emissions by replacing fossil fuels with the use of renewable energy sources.	7
		Wind Power Plant						
		Hydroelectric Power Plant						

In the study on Environmental Sustainability indicators, it has been seen that the themes that can be used in Türkiye are related to air (atmosphere management), soil (land use), and water (water management). In addition, biodiversity and open green spaces, which have a critical role in these three themes, have been determined as the main themes of environmental sustainability. Waste management, renewable energy, and risk management related to possible disasters, which are among the important environmental processes in the formation of resilient /resilient cities, have also been determined as the central theme.

The contributions of the indicators determined for sustainable urbanization to environmental sustainability in taking spatial planning decisions are listed below:

- To the creation of strategies for the city's air pollution by reducing the use of fossil fuels by examining air quality values, etc.,
- To develop strategies to protect and increase carbon storage potentials,
- To establish policies for conservation by examining the changes in agricultural and forest areas for land use over the years,
- To ensure universal and equal access to safe and accessible drinking water for all by assessing the city's water consumption and accessibility,
- To improve water quality by eliminating unorganized solid waste, minimizing the release of harmful chemicals and substances, halving untreated wastewater, and dramatically increasing recycling and safe reuse globally,
- To develop conservation, planning, and management plans to ensure the continuity of biological diversity by evaluating the fragmentation numbers of habitats,
- To create green infrastructure systems to improve the quality of life by examining open green spaces in terms of adequacy and accessibility,
- To evaluate the effects of landslides, erosion, and fault lines and to develop actions to minimize disaster risk,
- To examine the potential of renewable energy sources, increase the potential with conformity map studies, and integrate spatial plans of different scales with environmental sustainability indicators.

Environmental sustainability is one of the primary components in ensuring urban development. Therefore, evaluating all factors affecting environmental sustainability through indicators will enable us to obtain information about the functioning of the process. As a result, it is thought that these processes will contribute to the city's development, both by the regional organization of the central government and the local governments, with the indicator set to be created for each city and the holistic evaluation of the results.

References

Arora, N. K. & Mishra, I. (2019). United Nations sustainable development goals 2030 and environmental sustainability: Race against time. *Environmental Sustainability*, 2, 339–342.

Carino, T. & Xie, Y. (2013). Water and sanitation in six villages in Guizhou and Guangxi Provinces, China: a critical perspective. *Water International*, 38(7), 954-966.

Chan, P. & Lee, M. H. (2019). Developing sustainable city indicators for Cambodia through Delphi processes of panel surveys. *Sustainability*, 11(11), 3166.

Cîrstea, S. D., Moldovan-Teselios, C., Cîrstea, A., Turcu, A. C. & Darab, C. P. (2018). Evaluating renewable energy sustainability by composite index. *Sustainability*, 10(3), 811.

Cüce, B. & Ortaçeşme, V. (2020). Kentsel yeşil alanlara erişilebilirlik. *Peyzaj*, 2(2), 65-77.

Çoban, G. & Uzun, O. (2022). Sürdürülebilir Kalkınma Hedefleri, Kentleşme Göstergeleri ve Türkiye' *Sosyal ve Beşerî Bilimlerde Güncel Araştırmalar – I*, Ankara, Türkiye: Gece Kitaplığı, böl. 9, pp. 179-203.

Dizdaroglu, D. (2015). Developing micro-level urban ecosystem indicators for sustainability assessment. *Environmental Impact Assessment Review*, 54, 119-124.

Ertürk, H. (1996). Sürdürülebilir Kentler, Yeni Türkiye Habitat II Özel Sayısı. Yeni Türkiye Medya Hizmetleri, Ankara, 171 s.

Feleki, E., Vlachokostas, C. & Moussiopoulos, N. (2018). Characterization of sustainability in urban areas: An analysis of assessment tools with an emphasis on European cities. *Sustainable Cities and Society*, 43, 563-577.

Fouda, Y. E. & Elkhazendar, D. M. (2019). A criterion for modelling the 'live-and-work city index using sustainable development indicators. *International Journal of Urban Sustainable Development*, 11(1), 24-47.

Gürel Üçer, Z. A. (2017). Kentsel politikaların belirlenmesinde bir araç: Sürdürülebilirlik göstergeleri. *Çağdaş Yerel Yönetimler*, 26(1), 103-124.

González-García, S., Rama, M., Cortés, A., García-Guaita, F., Núñez, A., Louro, L. G., ... & Feijoo, G. (2019). Embedding environmental, economic and social indicators in the evaluation of the sustainability of the municipalities of Galicia (northwest of Spain). *Journal of Cleaner Production*, 234, 27-42.

Huang, L., Wu, J. & Yan, L. (2015). Defining and measuring urban sustainability: a review of indicators. *Landscape Ecology*, 30(7), 1175-1193.

Ibrahim, F. I., Omar, D. & Mohamad, N. H. N. (2015). Theoretical review on sustainable city indicators in Malaysia. *Procedia-Social and Behavioral Sciences*, 202, 322-329.

Jain, D. & Tiwari, G. (2017). Sustainable mobility indicators for Indian cities: Selection methodology and application. *Ecological Indicators*, 79, 310-322.

Jiang, Y. & Shen, J. (2013). Weighting for what? A comparison of two weighting methods for measuring

urban competitiveness. *Habitat International*, 38, 167-174.

Kara, Y. (2015). Türkiye'de Illerin Sürdürülebilirliğinin Analitik Hiyerarşi Süreci Yöntemi Ile Ölçülmesi. Doktora Tezi, İktisat Ana Bilim Dalı, Sosyal Bilimler Enstitüsü, Muğla Sıtkı Koçman Üniversitesi, Muğla, Türkiye.

Kara, Y. (2019). Sürdürülebilir Kalkınmanın Ölçülmesinde Gösterge Seçimi ve Endeksler. Sosyal, Beşeri ve İdari Bilimler Alanında Araştırma ve Değerlendirmeler-I, Ankara, Türkiye: Gece Kitaplığı, böl. 2, pp. 25-39.

Karakuzulu, Z. (2010). Sürdürülebilir Kentler ve Kasabalar, Yerel Gündem 21 ve Bursa Örneği. Tücaum VI. Ulusal Coğrafya Sempozyumu, 3(5), 397-406.

Klopp, J. M. & Petretta, D. L. (2017). The urban sustainable development goal: Indicators, complexity and the politics of measuring cities. *Cities,* 63, 92-97.

Li, F., Liu, X. S., Hu, D., Wang, R. S., Yang, W. R., Li, D., et al. (2009). Measurement indicators and an evaluation approach for assessing urban sustainable development: a case study for China's Jining City. *Landscape and Urban Planning*, 90(3), 134e142.

Mapar, M., Jafari, M. J., Mansouri, N., Arjmandi, R., Azizinejad, R. & Ramos, T. B. (2017). Sustainability indicators for municipalities of megacities: Integrating health, safety, and environmental performance. *Ecological Indicators*, 83, 271-291.

Marzukhi, M. A., Omar, D., Leh, O. L. H., Hamir, M. S. & Barghchi, M. (2011). Malaysian urban indicators network: A sustainable development initiative in Malaysia. *European Journal of Social Sciences*, 25(1), 77-84.

Mascarenhas, A., Coelho, P., Subtil, E. & Ramos, T. B. (2010). The role of common local indicators in regional sustainability assessment. *Ecological Indicators*, 10(3), 646-656.

Mascarenhas, A., Nunes, L. M. & Ramos, T. B. (2015). Selection of sustainability indicators for planning: combining stakeholders' participation and data reduction techniques. *Journal of Cleaner Production*, 92, 295-307.

Mega, V. & Pedersen, J. (1998). Urban sustainability indicators. Dublin, Ireland.

Michael, F. L., Noor, Z. Z. & Figueroa, M. J. (2014). Review of urban sustainability indicators assessment–Case study between Asian countries. *Habitat International*, 44, 491-500.

Moldan, B., Janoušková, S. & Hák, T. (2012). How to understand and measure environmental sustainability: Indicators and targets. *Ecological Indicators*, 17, 4-13.

Pınarcıoğlu, N. Ş. & Kanbak, A. (2020). Sürdürülebilir Kent Modelleri. Ijopec Publıcatıon.

Pupphachai, U. & Zuidema, C. (2017). Sustainability indicators: A tool to generate learning and adaptation in sustainable urban development. *Ecological Indicators*, 72, 784-793.

Rajaonson, J. & Tanguay, G. A. (2017). A sensitivity analysis to methodological variation in indicator-based urban sustainability assessment: a Quebec case study. *Ecological Indicators*, 83, 122-131.

Rama, M., González-García, S., Andrade, E., Moreira, M. T. & Feijoo, G. (2020). Assessing the sustainability dimension at local scale: A case study of Spanish cities. *Ecological Indicators*, 117, 106687.

Reyhan, A. S. (2017). Küresel iklim değişikliği bağlamında çevresel bilgi yönetimi: Çevresel göstergeler seti. *Kesit Akademi Dergisi*, (12), 150-173.

Saraç, B. & Alptekin, N. (2017). Türkiye'de illerin sürdürülebilir kalkınma göstergelerine göre değerlendirilmesi. *Uluslararası Yönetim İktisat ve İşletme Dergisi*, 13(1), 19-49.

Selim, C., Mutlu, S. S. & Selim, S. (2015). Kentsel alanlarda biyolojik çeşitliliğin sürdürülebilirliği ve koruma yaklaşımları. *Türk Bilimsel Derlemeler Dergisi*, (1), 38-45.

Shen, L. Y., Ochoa, J. J., Shah, M. N. & Zhang, X. (2011). The application of urban sustainability indicators–A comparison between various practices. *Habitat International*, 35(1), 17-29.

Shen, L. & Zhou, J. (2014). Examining the effectiveness of indicators for guiding sustainable urbanization in China. *Habitat International*, 44, 111-120.

Tan, Y., Jiao, L., Shuai, C. & Shen, L. (2018). A system dynamics model for simulating urban sustainability performance: A China case study. *Journal of Cleaner Production*, 199, 1107-1115.

Tang, J., Zhu, H. L., Liu, Z., Jia, F. & Zheng, X. X. (2019). Urban sustainability evaluation under the modified TOPSIS based on grey relational analysis. *International Journal of Environmental Research and Public Health*, 16(2), 256.

Tanguay, G. A., Rajaonson, J., Lefebvre, J. F. & Lanoie, P. (2010). Measuring the sustainability of cities: An analysis of the use of local indicators. *Ecological Indicators*, 10(2), 407-418.

Thomas, R., Hsu, A. & Weinfurter, A. (2021). Sustainable and inclusive–evaluating urban sustainability indicators' suitability for measuring progress towards SDG-11. Environment and Planning B: *Urban Analytics and City Science*, 48(8), 2346-2362.

Tuğaç, Ç. (2018). Uluslararası sürdürülebilir kent ölçütleri bağlamında Türkiye için bir değerlendirme. *Kent Akademisi*, 11(4), 703-740.

UN-Habitat. (2004). Urban indicator guidelines. Kenya.

UN. (2007). Indicators of Sustainable Development: Guidelines and Methodologies. New York: Published by the United Nations, ISBN 978-92-1-104577-2.

Wang, Q., Liu, C., Hou, Y., Xin, F., Mao, Z. & Xue, X. (2022). Study of the spatiotemporal variation of environmental sustainability at national and provincial levels in China. S*cience of the Total Environment*, 807, 150830.

Verma, P. & Raghubanshi, A. S. (2018). Urban sustainability indicators: Challenges and opportunities. *Ecological indicators*, 93, 282-291.

Yaman, G. & Doygun, H. (2014). Yeşil alanların kent ekosistemine katkılarının Kahramanmaraş kenti örneğinde incelenmesi. II. Ulusal Akdeniz Orman ve Çevre Sempozyumu, Isparta, s.252-260.

Yılmaz, F. H. (2019). Sürdürülebilirlik Bağlamında Yeşil Kent Yönetimi: Avrupa Yeşil Başkentleri Üzerinden Bir Değerlendirme. Yüksek Lisans Tezi, Sosyal Bilimler Enstitüsü, Selçuk Üniversitesi, Konya, Türkiye.

Yılmaz Kaya, M. Y. & Uzun, O. (2019). Ekosistem hizmetleri ve mekânsal planlama ilişkisinin peyzaj planlama çerçevesinde değerlendirilmesi. *Düzce Üniversitesi Bilim ve Teknoloji Dergisi*, 7(3), 2166-2193.

Zhang, D. & Chen, Y. (2021). Evaluation on urban environmental sustainability and coupling coordination among its dimensions: A case study of Shandong Province, China*. Sustainable Cities and Society*, 75, 103351.

Zhou, J., Shen, L., Song, X. & Zhang, X. (2015). Selection and modelling sustainable urbanization indicators: A responsibility-based method. *Ecological Indicators*, 56, 87-95.