EEET ECOLOGICAL ENGINEERING & ENVIRONMENTAL TECHNOLOGY

Ecological Engineering & Environmental Technology 2021, 22(6), 105–113
https://doi.org/10.12912/27197050/141528
ISSN 2719-7050, License CC-BY 4.0

Received: 2021.08.02
Accepted: 2021.09.04
Published: 2021.09.17

Urban Ecology Aspects: Theory and Development

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ABSTRACT

Issues of spatial development, including Urban Development, based on the principles of "balanced spatial development", are reflected in the main paradigm of the XXI century – sustainable economic, social and environmental development. The study of the problems of sustainable development of settlements, especially cities, is now one of the core areas of scientific justification of the planetary concept of sustainable development. On the one hand, the sustainability of Human Settlements Development is often one of the leading topics when discussing in scientific circles the possibilities of a global transition of modern civilization to a model of sustainable development. Today, it is not possible to conduct a professional discussion on sustainable development without the participation of specialists. The concept of sustainable development of Human Settlements has developed into an independent branch, both theoretical and applied, which is now perceived by the scientific community as a natural and integral part of the paradigm of sustainable economic, social and environmental development of our planet. In fairness, we also note that the concept of Sustainable Human Settlements Development has not always occupied its rightful place among the various aspects of sustainable development that it has today. From the Stockholm Summit in 1972 until habitat II in 1996, issues of Sustainable Human Settlements Development were at the periphery of the attention of the international scientific community. Although a separate section is devoted to promoting the sustainable development of human settlements in the "agenda for the XXI Century", however, this document does not contain a definition of this concept and is mainly devoted to the issues of effective management and planning of Human Settlements Development. Moreover, the Johannesburg Declaration on Sustainable Development, as well as the plan of implementation adopted at the Johannesburg Summit in 2002, also do not include it among its provisions related to the sustainable development of human settlements. Thus, from the moment of approval of the planetary concept of sustainable economic, social and environmental development, it should have been quite a long time before the balance of Human Settlements Development acquired its inherent level of problematic relevance today, and most importantly – understanding of its content part. This is due to a number of reasons, both objective and subjective. They are associated with both patterns of development of scientific knowledge and organizational reasons.

Keywords: smart cities, urban development, ecological aspect, concept.

INTRODUCTION

The need to achieve the strategic goals of sustainable development requires the justification and development of certain measures that ensure the creation of foundations for the balanced development of such spheres of society as economic, social and environmental. In modern conditions, this problem is particularly relevant for cities, since a significant increase in the urban population leads to an increase in many challenges to local development (Bhagya et al., 2018). The development of a smart city concept is seen as one of the most effective ways to solve this problem, since the introduction and implementation of measures based on the latest information and communication technologies in various areas of urban functioning is a step that will create prerequisites for a decent lifestyle for many generations of people.

Globalization trends inherent in modern world development cause the emergence of certain challenges that threaten the sustainable functioning of many sectors of the economy and, accordingly, require the definition of

certain measures to solve them (Bibri, 2017). The main directions in which the Sustainable Development Goals will be achieved and are fair social development; sustainable economic growth and employment; effective governance; environmental balance and Sustainability Development. It should be noted that these areas highlight goals such as overcoming poverty; overcoming hunger, Agricultural Development; good health and well-being; quality education; gender equality; clean water and adequate sanitation; affordable and clean energy; decent work and economic growth; industry, innovation and infrastructure; reducing inequality; sustainable development of cities and communities; responsible consumption and production; climate change mitigation; conservation of marine resources; protection and restoration of land ecosystems; peace, justice and strong institutions; partnership for Sustainable Development.

The analysis of the above directions allowed us to state their close relationship with the provisions that form the basis of Urban Development Strategies. Thus, the main means of achieving the goal of "sustainable development of cities and communities" is to create conditions and ensure access to sufficient, safe and inexpensive housing and basic living services; the development of reliable, safe and convenient transport and other infrastructure; the development of settlements and territories based on the principles of integrated planning and management, provided that existing and new cultural and natural heritage sites are preserved and identified; development of a system for notifying the population about the threat of emergency situations, preventing the occurrence of these situations, ensuring response to them and overcoming their consequences; minimizing the negative impact on the life and health of residents in any dimension

URBAN ECOLOGY CONCEPT

A smart city can be considered as an innovative city that uses information and communication technologies and other means to improve the standard of living, efficiency of activities and services in cities, as well as competitiveness to ensure the satisfaction of present and future generations in needs based on a combination of economic, social and environmental aspects (Britton, 2019).

A narrower interpretation of the smart city is to position it as a highly efficient system based on vertical and horizontal integration of urban processes and the use of the Internet of things. However, the goal of creating a smart city should be to invest in technology to stimulate economic growth, accelerate social progress, and improve the environment. This is an important national task, which is associated with the growth of globalization risks.

Domestic realities convincingly show that the main idea for creating smart cities should be the transformation of city management based on the modernization of urban infrastructure, the implementation of projects and interaction of the population, business and public organizations, which will ensure the successful functioning of all areas of the city. Integrated management is designed to provide more understanding to the city authorities regarding the main aspects of the city's functioning (Raven et al, 2017).

Complementing the above definition of a smart city is the emphasis on using information and communication technologies not only to improve the efficiency of certain economic activities, but also to manage this process, taking into account its role in the broader local ecosystem.

The concept of a smart city can also be considered as a means of more rational use of available resources to achieve high-quality services to the population based on the integration of city services and control of their work, as well as the participation of citizens in city management.

In this context, smart cities are considered as a means of improving the efficiency of city authorities and achieving their communication with citizens. Of course, the use of innovative technologies, in particular information and communication technologies, plays an important role in this process, but it is the transformation of understanding of local governance that is more significant. Innovative technologies will increase the transparency of local authorities ' activities and interest the population in using public information by accessing online services.

According to such a document as the "city protocol", which was developed in Barcelona, which is considered a classic example of a smart city, the main components of local development should be the promotion of interaction between city authorities, scientific institutions, public organizations and the population; providing promising guidelines and creating new economic opportunities (Siemens, 2017).

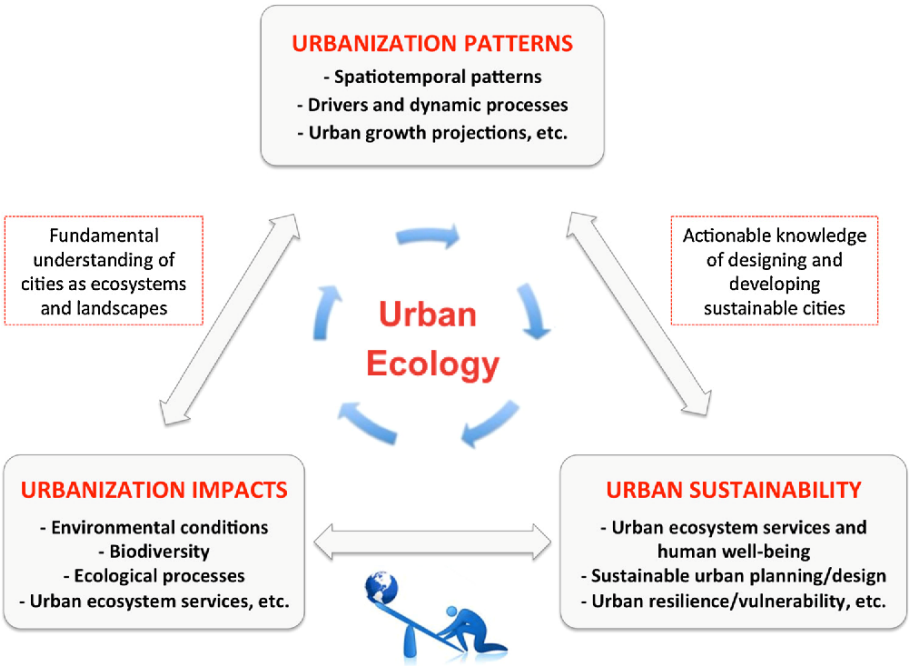
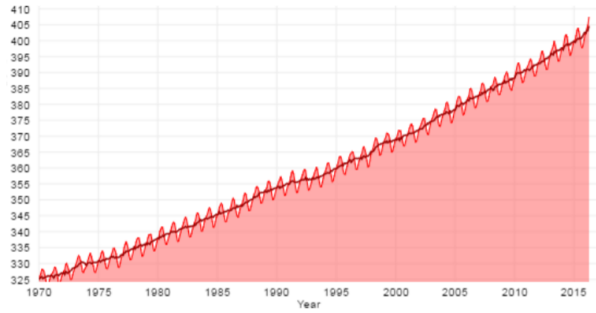


Figure 1. Smart Cities and Urban ecology scheme

It should be emphasized that in modern conditions, the smart city concept can be considered as a component of the content Project "Integrated Urban Development", which is implemented by the German society for international cooperation (GIZ), commissioned by the Federal Ministry of Economic Cooperation and development of Germany in cooperation with the Ministry of regional development, construction and housing and communal services and funded by the governments of Germany and Switzerland. The project aims to prepare cities for decentralization and local self-government based on the use of integrated development approaches in accordance with the principles of the European Charter for Sustainable Urban Development (Leipzig charter). Integrated urban development is defined by the Leipzig charter as a policy aimed at taking into account the needs of Urban Development based on the decentralization of power through a balanced combination of the interests of the state, regions, cities, citizens and business entities in order to more efficiently allocate limited financial resources (McFarlane, 2017). A characteristic feature of the Integrated Urban Development Policy is the involvement of citizens in solving challenges and threats to the existence of cities.

The Ad Hoc Working Group acts as a focal point and has the authority to implement measures on strategic issues of Urban Development.

Consequently, the achievement of Sustainable Urban Development under the Leipzig charter is proposed to be implemented, first, as noted above, through the use of integrated urban development



N	Year	Anomaly	N	Year	Anomaly
1	**2016**	**0.94 ℃**	6	2005	0.66 ℃
2	2015	0.90 ℃	7	2009	0.64 ℃
3	2014	0.74 ℃	8	1998	0.63 ℃
4	2010	0.70 ℃	9	2012	0.62 ℃
5	2013	0.67 ℃	10	2003, 06, 07	0.61 ℃

Figure 2. World carbon dioxide concentration (ppm) and temperature ranking (1880–2016) (McFarlane, 2017)

policies, and secondly, through the implementation of measures in areas of cities that are in a difficult situation. As for the Integrated Urban Development Policy, its main components are the creation and maintenance of high-quality public areas, modernization of infrastructure networks and Energy Efficiency Improvement; Active policies in the field of innovation and education. In urban areas that require measures to improve the socio-economic situation, the necessary areas are improving urban planning; implementing an active labor policy; training of children and youth; and modernizing the transport system.

Thus, it can be argued that the strategic priorities of sustainable development of the European Charter for Sustainable Urban Development and the Integrated Development Policy developed in accordance with it (Fig. 1) are aimed at creating conditions that contribute to improving the functioning of all spheres that determine the foundations of a decent lifestyle of a person. That is, they are directly related to the concept of a smart city, which aims to create comfortable and safe living conditions for citizens, and correspond to its components, such as a smart economy, smart people, smart management, Smart Mobility, Smart Life, Smart ecology (Trencher, 2018).

The listed documents on Sustainable Development also define the basis for the formation of a smart city architecture, which provides for the relationship between all components and subsystems to ensure that local development meets "reasonable" criteria. Thus, specific measures taken by city administrations to create a smart city should be implemented in accordance with the Sustainable Development Goals and using elements of its architecture such as innovative technologies, including information and communication technologies; infrastructure that meets the needs of a modern city and the goals of Sustainable Development; Management taking into account the requirement to introduce a body responsible for creating a smart city; programs and projects aimed at implementing the components of a smart city; activities of the national economy in relation to which the latest developments are applied (Viitanen, 2014).

The modern world is characterized by unprecedented access to Information, new emerging technologies, and the convergence of information, Energy, and transport networks. On the road to developing smart sustainable cities, it is important that cities are aware of and assess the stage of transition they are currently in so that they can take the necessary steps to make further progress. In addition, it is important that stakeholders have tools to evaluate the results of implementing various smart sustainable city projects after they are launched. However, not every city has the necessary knowledge base or specific strategy to move to a "smart" sustainable city (RSM).

In order to support cities, especially in developing countries and countries with economies in transition, to improve their sustainable growth with a focus on more transparent and efficient use of resources, in 2014 the United Nations Economic Commission for Europe (UNECE) in cooperation with the International Telecommunication Union (ITU) – The International Telecommunications Union (ITU) launched the "United Smart Cities "project, which developed a set of indicators of" smart" sustainable cities, or performance indicators, aimed at ensuring the global application of these indicators to characterize the "smartness" of cities.

Indicators are designed as a tool for assessing how "smart" and sustainable a city is, as well as a starting point for making specific decisions and taking measures to increase the level of sustainability of the city. They provide an ideal basis for statistical assessment of progress made in the transition to a "smart" sustainable city.

Key indicators of the effectiveness of "smart" sustainable cities developed by the UNECE and ITU correlate with indicators for monitoring the achievement of the Sustainable Development Goals, and thus help cities evaluate the results of their activities in accordance with the Sustainable Development Goals.

The need to apply key performance indicators in smart sustainable cities developed by the UN Economic Commission for Europe (ECE) in cooperation with the International Telecommunication Union (ITU) are based on the following factors (Wiig, 2016):

- indicators are a tool for evaluating the results of the city's activities, so that you can recommend specific measures that will contribute to development;
- indicators can be used as a tool to monitor the progress of cities towards their sustainable development in accordance with the Sustainable Development Goals. Indicators of "smart" sustainable cities should not be considered as a "problem-solving tool", but as a support tool that can help cities achieve more sustainable and "smart" growth;
- indicators can be used by cities to participate in the United Smart Cities project to profile cities and provide them with UNECE support in improving their sustainable development.

Figure 3. Project of Satna smart city with ecological zones

There are several advantages to using this set of indicators. First of all, they help you assess the strengths and weaknesses of the city. By analyzing the city's performance based on the proposed indicators, it is easier to understand which areas are most important or in which of them the city is achieving success. Second, they can be used to determine priorities. After identifying the strengths and weaknesses of the city, indicators allow you to set priorities, that is, select the aspects that are most important for the sustainable development of the city, and determine ways to solve them.

Indicators can also be considered as an effective means of monitoring the city's performance over a certain period of time and/or after the implementation of management decisions (Marvin et al, 2019).

Performance indicators are based on the following principles:

- completeness: the set of indicators should cover all aspects of the RSM, comprehensively characterize the object being evaluated, primarily the functioning of information and communication technologies (ICTs) and their impact on Sustainable Urban Development;
- compatibility: performance indicators should be defined in such a way that it is possible to compare data from different cities on a scientific basis in accordance with different stages of urban development, that is, performance indicators should be comparable in time and space;
- accessibility: performance indicators should be quantitative, and retrospective and up-to-date data should be either easily accessible or easily collected;
- independence: performance indicators that relate to the same aspect should be independent, meaning that duplication of these indicators should be avoided as much as possible;
- simplicity: the concept of each indicator should be simple and easy for the city's stakeholders to understand. Counting related data should also remain simple and intuitive;
- timeliness: the formation of performance indicators should be linked to the emerging pressing issues of RSM construction and development.

Figure 4. One of eight ecological zones in Satna smart city

Each indicator represents part of a holistic view of the city's performance in three areas: "Economy", "Environment" and "society and culture". Each of these areas represents a separate view of progress, and together they provide a holistic view of the "reasonableness" and sustainability of the city's development (Zvolska et al, 2019).

Each area is detailed on topics that focus on more specific aspects. An example is the ICT infrastructure, which provides a deeper understanding of the development and use of ICTs within the city.

The UNECE–ITU list of smart sustainable cities indicators contains 71 indicators. The proposed set of indicators is structured in accordance with the following sections: area; topic; typology (sub-topic, category).

Areas are more general structural elements that form the basis for a set of indicators. They correspond to the three main components of sustainability: the economy, the environment, and society and culture.

The topic indicates a group of specific indicators that describe the area of potential development. Each indicator is assigned to one topic. Some topics include sub-topics that can be considered as keywords that more fully define the nature of indicators.

The typology of indicators indicates the scope of application of the indicator itself. Indicators are divided into basic and additional (or advanced) indicators. The main indicators are those that all cities should be able to report on, providing a basic understanding of the city's intelligence and sustainability, as well as achieving a certain fairly high level of productivity. Additional indicators provide a deeper view of the city and assess progress based on more detailed characteristics.

SMART CITIES AND ENVIRONMENT

The Environment area includes the following topics and subtopics (typologies): Environment (sub – topics: air quality; water and sanitation; waste; environmental quality; public places and nature); energy (sub-topics: energy).

A detailed description of the Environment area by topic, sub-topic, and key indicators of the effectiveness of smart sustainable cities is shown in Figure 2. The following is a description of the key indicators of the effectiveness of "smart" sustainable cities in the "environment" region, justification, interpretation and relevance of each indicator is carried out. Specified data sources or corresponding databases for forming an information base for performing appropriate calculations.

The first topic is "Environment" area. This topic contains five sub-topics, namely: air quality; water and sanitation; waste; environmental quality; public places and nature.

The first sub-theme of the topic "environment" of the area "environment" – the sub-theme "air quality" is characterized by two indicators: air pollution and greenhouse gas emissions (Haarstad, 2017).

The high population density and concentration of industry put a lot of strain on the local environment. Air pollution from households, industrial power plants, and vehicles (motor vehicles) is a major problem. As a result, the greatest potential for human exposure to pollution and subsequent health problems occurs in urban areas. Improving air quality is an important aspect of promoting a sustainable city.

Table 1. Key indicators of the effectiveness of "smart" sustainable cities on the topic "environment" / Environment / air quality-air pollution

Characteristics	Description
Area	Environment
Subject	Environment
Typology (category)	Air quality
Indicator name	Air pollution
indicator number	EN: EN: AQ: 1C
Type	Main
Type	Steady (Steady)
Definition / description	Air Quality Index based on the published concentration of solid particles (PM10 and PM2.5), NO_2 (nitrogen dioxide), SO_2 (sulfur dioxide), O_3 (ozone).
Methodology	Calculated: Numerator: mass of the collected pollutant (MCG) Denominator: volume of air taken (M3) Annual average concentration report for each pollutant
Unit of measurement	mcg / m^3
Reference documents	SDG 11.6 goal: to reduce the adverse impact of cities on the per capita environment by 2030, in particular by paying special attention to air quality, utilities and other waste management enterprises SDG indicator 11.6.2: annual average levels of fine particles (e.g. PM2.5 and PM10) in cities (population weight)

In Table 1 describes the first of the key indicators of the effectiveness of "smart" sustainable cities in the field of "Environment", the topic environment, the sub – theme (typology) air quality - "air pollution".

This indicator is a measure of the state of the environment in terms of air quality and is an indirect measure of the impact of air pollution on the population, which is the subject of health problems in cities. It can be used to monitor trends in air pollution as a basis for prioritizing management activities:

- planning the level of air pollution in order to identify access points or areas that require special attention;
- help estimate the number of people suffering from excessive levels of air pollution;
- monitoring the level of compliance with air quality standards;
- Air Quality Policy Impact Assessment;
- help research the relationship between air pollution and health effects.

The World Health Organization (WHO) guidelines for all pollutants included in this indicator are given. Many countries have set their own air quality standards for most of these pollutants.

Data sources / relevant databases – WHO recommendations on air quality – European air quality database (Kong, 2018).

In Table 2 describes the second of the key indicators of the effectiveness of "smart" sustainable cities in the field of "Environment", the topic environment, the sub – topic (typology) air quality - "greenhouse gas emissions".

In order to prevent the most severe effects of climate change, countries have signed the United Nations Framework Convention on climate change (UNFCCC) and agreed to cooperate to limit the increase in average monthly temperatures and the impact of climate change. In this context, industrialized countries need to prepare and provide accurate and regularly updated greenhouse gas emission data on an annual basis.

At the international level, the Kyoto Protocol, which was adopted in 1997 and obliges parties to set internationally binding emission reduction targets, is the main instrument for limiting greenhouse gas (GHG) emissions.

The Kyoto Protocol is implemented in two stages: the first began in 2008 and ended in 2012, and the second began in 2013 and will end in 2020. At the same time, the European Union (EU) has set climate change mitigation goals by 2020, committing to reduce its emissions by at least 20% compared to 1990 levels (30% subject to a comprehensive international agreement on climate change).

Methodologies for determining greenhouse gas emissions include (but are not limited to):

- global community-wide greenhouse gas emission data protocol;
- Intergovernmental Panel on climate change, IPCC guidelines on national greenhouse gas inventories;

Table 2. Key indicators of the effectiveness of "smart" sustainable cities on the topic "environment" / Environment / air quality-greenhouse gas emissions

Characteristics	Description
Area	Environment
Subject	Environment
Typology (category)	Air quality
Indicator name	Greenhouse gas emissions
indicator number	EN: EN: AQ: 2C
Type	Main
Type	Steady (Steady)
Definition / description	Greenhouse gas (GHG) emissions per capita
Methodology	Calculated: numerator: total greenhouse gas emissions (Eco2 ton) denominator: total number of city residents
Unit of measurement	Eco2 tones / person
Reference documents	SDG 11.6 goal: to reduce the adverse impact of cities on the per capita environment by 2030, in particular by paying special attention to air quality, utilities and other waste management enterprises

- global protocol for greenhouse gas emissions on a common scale;
- ISO 14064 standard for greenhouse gases.

Data sources / related databases: United Nations greenhouse gas inventory data.

The following is a description of the key indicators of the effectiveness of "smart" sustainable cities of the second sub – topic of the topic environment of the region "environment" - the subtopic (typology) "water and sanitation". This subtopic is characterized by four indicators: drinking water quality, water consumption, fresh water consumption, and wastewater treatment.

In Table 3 describes the first of the key performance indicators: "smart" sustainable cities by area "Environment", topic Environment, sub – topic (typology) water and sanitation - "quality of drinking water".

Water safety and quality are the foundation of human development and well-being. Access to safe water is one of the most effective tools for promoting health and reducing poverty.

Who develops international standards on water quality and human health in the form of guidelines that are used as the basis for regulation and standardization around the world (de Hoop et al, 2018).

Drinking water quality guidelines promote public health by advocating the development of local standards and regulations (health target indicators), the adoption of preventive risk management approaches covering reservoirs for consumers (water safety plans) and independent oversight to ensure the implementation and effectiveness of water safety plans and compliance with national standards (Coutard, 2016). Cities should measure the quality of drinking water in accordance with the latest WHO guidelines on drinking water quality, fourth edition.

Table 3. Key indicators of the effectiveness of "smart" sustainable cities on the topic "environment"/ Environment / Water and sanitation-drinking water quality

Characteristics	Description
Area	Environment
Subject	Environment
Typology (category)	Water and sanitation
Indicator name	Drinking water quality
indicator number	EN: EN: WS: 1C
Type	Main
Type	Steady
Definition / description	Percentage of households covered by the developed water conservation plan
Methodology	Calculated: numerator: number of relevant samples for WHO guidelines.
Unit of measurement	Denominator: total number of samples
Reference documents	Multiply by 100

Water consumption per person depends on: availability and price of water; climate; water use. In many cities, the drinking water supply is not constant, and households have several hours of access to water during the day. Water consumption is much higher in higher-income cities. Typically, people in cities in developed countries use 272 liters per day, and in Africa – 53 liters per day. North American cities use an average of twice as much water per person as Western European cities, and seven times as much as African cities (Batty et al, 2012). Water consumption should include all water used within the city limits. Per capita water consumption should correspond to sustainable water resources. Data sources / relevant databases: data can be obtained from water utilities, as well as from the United Nations: database of global indicators in the field.

CONCLUSIONS

The increasing pace of urbanization in the modern world causes a large number of problems that hinder the sustainable development of cities and, as a result, make it impossible to create the foundations for a decent existence of the urban population. The concept of a smart city, which has recently become increasingly relevant, can be considered as a basis for overcoming most urban problems and creating the basis for ensuring sustainable development of the country. Transformation processes in relation to smart cities, which are associated with the widespread use of innovative developments in the field of information and communication technologies in many areas of local development, should take place in accordance with the Sustainable Development Goals of the European Charter for Sustainable Urban Development.

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