

Volodymyr NAZARENKO

**URBAN FUTURES REIMAGINED:
ADVANCED ECOLOGICAL-ECONOMIC FRAMEWORKS
FOR SUSTAINABLE GROWTH**

MONOGRAPH

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Reviewers:

Andrii MARTYN, Doctor Hab. in Economics, Professor, Head of the Department of Land-Use Planning, National University of Life and Environmental Sciences of Ukraine

Yosyp DOROSH, Doctor Hab. in Economic, Professor, Director of the Institute of Land Use of the NAAS of Ukraine, Corresponding Member of the NAAS of Ukraine

Oleksandra KOVALYSHYN, Doctor Hab. in Economics, Professor of the Department of Land Cadaster of the Lviv National University of Environmental Management.

Svitlana AMELINA, Doctor of Pedagogy, Professor, Head of Foreign Philology and Translation Department, National University of Life and Environmental Sciences of Ukraine

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The monograph explores the multifaceted phenomenon of urbanization, examining its theoretical foundations, measurement methodologies, and extended analytical models. The study begins by defining urbanization in the context of settlements, communities, and cities, analyzing its characteristics, dynamics, and sustainable development frameworks. It then delves into data collection techniques and methodological approaches for quantifying urbanization through spatial, economic, and ecological indicators. Finally, the research presents advanced models for understanding urbanization as both a state and a process, incorporating economic representations and future research directions. By integrating theoretical and empirical insights, this monograph provides a comprehensive perspective on urbanization, contributing to both academic discourse and practical urban policy development.

For teachers, postgraduate students, students, researchers, judges, attorneys and lawyers.

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INTRODUCTION

The scientific work is devoted to a comprehensive study of the process and state of urbanization in the general context of multidisciplinary scientific research and based on analysis and systematization of data on the various large cities around the globe, as well as a city of Kyiv and other large cities of Ukraine. The main emphasis of the work is on identifying and studying environmental and economic factors directly and indirectly related to the development of urban and suburban areas. The links between land use changes and urbanization processes associated with the city's development were investigated and outlined. The consequences of the work context, such as processes and their impacts on environmental change and the environmental situation, were also taken into account, both within the district and the region as a whole, as well as in a more global context.

As a result of the work, many scientific and scientific-practical international and domestic publications and other materials related to urbanization and related areas were analyzed, researched, and processed. In the course of the study, the author examines the experience of leading scientists from the EU, the USA, China, and Ukraine in the fields of urbanization, urbanization economics, ecology, and other related fields of scientific research. Key achievements in studying the causes and consequences of urbanization processes, their impact on the state of ecology, and the development of the city, region, and country's economy are considered and analyzed. To comprehensively assess the situation and model various options for developing urban and suburban areas, the author thoroughly studied the historical development of large cities in developing countries and the leading countries of the EU, the USA, and Asia. Cases of development of thriving towns and cities that have experienced economic decline or significant environmental problems are studied, analyzed, and researched. In the course of scientific research, the author analyzed the state, issues, and challenges associated with the increase in the level of urbanization of modern European, Ukrainian, and other cities of the world. At the same time, special attention was paid to the relationship of urbanization with different processes, such as

globalization, industrial revolution 4.0, climate change, and political challenges that affect the social and economic situation. The experience of leading world organizations, such as the UN, UNESCO, and FAO, in solving challenges related to urbanization and related processes has also been studied.

In the context of the study of urbanization processes on the territory of Ukraine, the author identified three main cities for the survey, Kyiv, Lviv, and Kharkiv, and considered and researched other large cities with more than 500 thousand people. To conduct the study, the author also chose the cities with the largest population on each continent and region: New York, Paris, Delhi, Tokyo, Rio de Janeiro, Shanghai, Lagos, and others. Also, individual cities were selected for their more detailed study: Kyiv, Malmö, San Francisco, Detroit, and Shanghai. For each of the above cities, the following data types were selected, processed, and grouped for the study - economic and social data, geographical data, and territorial structure; the real estate and land market was analyzed. The work of leading Ukrainian scientists in land use and environmental economics, including scientific schools in Kyiv, was considered when carrying out the study.

One of the primary steps in conducting the study was to identify the problems and highlight the main issues. Among the main existing problems that were considered, and as a result of the scientific work, a comprehensive assessment and search for methods for their solution was conducted. The following issues should be highlighted: lack of a clear definition and presentation of the urbanization process in the context of economic and environmental modeling; urbanization, as an independent area of research, is almost not represented in the domestic scientific literature and publications; there is no well-defined set of data, tools, and methods for the study of urbanization in economic and environmental directions; there is no formalized representation of cities as centers of social and economic development.

In outlining scientific research problems, the author set the following tasks for research to define the field of study better and understand how to solve problems. Namely:

- How to build a model of spatial development of territories taking into account environmental consequences and their cost in the process of changes in the land use of urban and suburban areas;
- how to determine the optimal location of industrial and commercial facilities at a given time and in the long term: economic assessment of land use;
- what are the options for the development of urban and suburban areas, taking into account the concepts of sustainable development, globalization, and change;
- what is the relationship between urbanization processes and the development of urban and adjacent territories with an emphasis on the use of land resources?

The expediency and need to improve the theoretical component of the description of the urbanization process as a global process that affects the level of economic development and is associated with environmental processes, both on a local, regional, and international scale, has been determined. The author presents his interpretation of the duality of urbanization - urbanization as a process and urbanization as a state. The above definition is based on economic factors, environmental factors, and components of land use, and it considers the legal and legal aspects of urbanization. The importance of conducting a study of the influence of environmental factors on the processes of urbanization and the inclusion of this component in the general context of urbanization research is highlighted separately. As a result of the work, the author has improved the mechanism for modeling and calculating environmental impact assessment based on current global and national climate agreements, costs for the restoration of natural resources, and resource losses (such as water, land, green spaces, air, and waste disposal, etc). State, regional, and city policies and regulations related to ecology and natural resources were considered when modeling the environmental assessment system.

The factors influencing land use in the context of the development of cities' suburban areas, considering their purpose, territorial zoning, and urban zoning, are

outlined. The key directions of economic development of territories, zoning, and placement of production facilities in the city zone and suburban areas are highlighted in the example of the city of Kyiv. Based on these data, economic assessment models are built when modeling various options for land use in city development with a forecast for the next 5 and 20 years. A system analysis was carried out based on the results obtained, and a land market model was created to study rational land use in the context of urbanization and modern challenges, such as globalization and its impact on the environment. Approaches to the analysis of changes in land use, how these changes affect the development of suburban areas, and the options for their economic development have been improved. The leading indicators of dependence and impact of the microeconomic situation in the city on the macroeconomic indicators of the development of adjacent territories, countries, and regions, as well as more global consequences in the context of the globalization economy, have been established.

The social context of urban development was considered to build a general model of urbanization, and various groups influencing its development were divided and grouped - residents, businesses, state/regional bodies, and international organizations. In addition, data on the location and characteristics of workplaces and industrial facilities in the city and region were analyzed. A conceptual scheme based on the current territorial division of the town and adjacent territories has been developed, the impact of the development of the city center and its districts on suburban areas, districts, and the region as a whole has been studied, the expediency of further exploring the level and volumes of the global impact of the city's economic development has been indicated.

An essential component of the model of urbanization processes and their state is the unification of concepts - the city, urbanization processes, and land use- from both an economic point of view, social aspects, and available natural resources. As a result of the modeling, data were obtained, and a financial and environmental assessment of land use development in the city and suburban areas was calculated. In

addition, a scheme for planning the development of territories and facilities has been built, and a forecast of their environmental consequences has been made. It is worth noting that the forecasting was carried out both short-term and long-term. As a result, a complex multidisciplinary scientific and practical model of development was further developed, which included the following components: the current social and economic state of the city, the models "green city" and "smart city," "transition city" and the hybrid (combined non-linear) process of city development was allocated. Further, the author draws attention to the importance of continuing the study, taking into account the following data: infrastructure and waste management, ATCs, territorial structure and land structure, the official definition of urbanization at the city and national levels, transparent distribution and zoning of urban areas and suburban areas.

The paper proposes a methodology for assessing options for developing territories and the city's economy cost-effective land use considering environmental factors. The developed method made it possible to form the main options for the development of territories, namely options for the development of urbanization in Ukraine and the world. For a more detailed and objective forecasting of possibilities for the development of urbanization as a state, a model for calculating the economic assessment of the use of land resources in the context of resource-efficient city management was substantiated and proposed. The system model of methodological analysis and characteristics of land use in the context of city management and the study of its development includes the following factors: types of objects, spatial location, visualization (map), a form of ownership, land, and its price/characteristics, prospects for the development of land or territory, economic reporting and forecasting. Visualization was used to view and use the modeling process results, namely a visual representation of the city with basic financial data, objects, and environmental indicators (in the format of a two-dimensional color map).

Urbanization is a relatively new term that researchers actively used in the second half of the twentieth century. However, cities and towns, as places of

settlement for people, are not new and have existed for as long as humanity has. Scientific research on urbanization in the context of environmental sciences and economics is a relevant and contemporary topic of scientific research worldwide. In recent decades, a subfield of economic research has appeared - the economics of urbanization, which scientists from the United States and China actively study. As a rule, researchers in the field of urbanization economics investigate only some aspects of this process. For example, the real estate market, land prices in the city and suburban areas, production facilities in the urban area, the optimal location of residential and office areas in cities, and the economic feasibility of expanding the city limits. In recent years, research on the environmental aspect of urbanization has taken on new importance in global environmental change, adopting new ecological agreements, memorandums, and readings.

Taking into account the above-mentioned areas and areas of urbanization research, the analysis of a significant number of scientific sources of information, based on the results of his study, the author of the scientific work wants to note the need for further development and research of urbanization processes in a broad scientific context. It should be noted that at this point, there is not a significant number of scientific works that would focus on the study of the impact of urban development on the activities and lives of people from a socio-economic point of view. A broad and generalized scientific model that considers the main economic factors that have influenced the process and state of development of cities and suburban areas. Only very generalized information on the development of urbanization has not been presented in general scientific access, and only individual-specific cases have been studied.

Therefore, in the future, it is advisable to develop a system of classification of cities and forecasting their development, taking into account adjacent territories, as well as zones that are directly and/or indirectly influenced by the development of urban areas. Modern scientific and practical tools, such as modern information systems and visual modeling, enable in-depth and comprehensive research on

urbanization processes. Thanks to such tools, it is possible to develop models that will make it possible to present options for the development of cities - from experimental ideas (a green city or a highly polluted industrial city of skyscrapers) to typical formats for the development of large cities. It should be noted that specific options for the development of a city depend on the region where it is located, the town's classification according to the main types of economic activity, its geographical conditions, and national or local federal policy. Using new approaches to the description and analysis of urbanization processes using modern information technologies will allow the future to more accurately predict environmental and economic changes and individual economic indicators in the context of urban development. First, conducting preliminary system modeling situational analysis and collecting and processing all relevant data for research is advisable. The author notes that before collecting and analyzing data, it is advisable to highlight more general scientific and theoretical aspects to describe urbanization as a whole as a multidisciplinary study.

One of the issues that is actively researched in the world is the future of cities and the development of the economy in the context of globalization environmental changes, namely: what will be the future of the resettlement of people, what will affect it, whether the majority of people will live and work in large metropolitan areas, whether environmental or economic zoning of urban and suburban areas will be carried out. Scientists note the main economic parameters that directly determine how the city will develop - the level and volume of investments (in the period), the current state of the world-regional-national economy, regional conditions, and climate change. One of the advanced sub-branches in the field of economic thought is the analysis and separation of factors (financial, social, and environmental) that influence the settlement of people and their choice of areas to live within the urban and suburban zones, as well as how their level of happiness varies depending on their location. A topic that requires further study is the search for a connection and mutual

influence of the states of ecology and economy during the intensive development or decline of the city, with a view to the future and the study of past cases.

The author explores and presents a scientific model of how long and widely a city can develop at the expense of suburban areas and what levers of influence on this development are used or can be developed in the future. For researchers of the economics of urbanization, an important question arises: what role will the state play, and how will its constituent institutions change with the rapid development and transfer of spheres of influence to megacities? After all, the data of the latest available scientific studies show that the world is becoming increasingly urbanized, and people are increasingly moving to live and work in some large cities. The available statistics apply to all regions, even with a high current percentage of urbanization, due to the high mobility of the population and the political or environmental situations in the world or region. To better understand how cities develop or what mistakes should be avoided, some researchers analyze and build models of how cities developed in the past, considering the main social, environmental, and economic factors that influenced this.

The author used well-known theoretical sources and the works of leading scientists. According to the results of this analysis, it should be noted that an essential criterion for understanding the urbanization factor is the formation and change of real estate prices and the real estate market in the city and suburban areas. In addition to economic and financial factors, in the 21st century, environmental factors have acquired a significant influence, the main criterion of which is environmental pollution, harmful emissions of the environment (such as CO₂ and others), and a general increase in the temperature of the earth's crust. To understand and review the environmental situation associated with urbanization, let's consider the most common research criterion - CO₂ emissions into the atmosphere. After conducting a detailed analysis of the sources of information in the literature, the authors concluded that in their research, it is worth considering the experience of European, American, and Chinese researchers, using their analysis and developed models. However, the

primary focus should be on more global systems of microeconomic indicators and the interrelations of urbanization processes at the macroeconomic level as an essential factor that has not yet been thoroughly studied. Few scientific works today are devoted to constructing complex descriptive models of urbanization processes, and existing works have only a more general theoretical description. It should be noted that in Ukraine the principal scientists who studied these issues are Martyn A.G., Yevsiukov T.O., Tretyak A.M., Dorosh O.S., Ibatullin SH.I., G.M. Lappo, E.N. Pertsyk, V.I. Nudelman, I.Y. Kontorovych, A.B. Ryvkin, Y.L. Pivovarov, M.G. Stupenya, I.O. Novakovska, O.M. Tsvyakha and others. Many well-known economists have studied modern problems and issues related to using urban land and planning forecasts for the future, including B. Cohen and J. S. Smith. Harvey, E. Glaesir, B. Ward, R. Grundman and others.

1. THEORETICAL FOUNDATIONS OF URBANIZATION RESEARCH

1.1 Defining Urbanization: Settlements, Community and Cities

The XXI century can be confidently called the culminating phase of urbanization in the world and the transfer of economic centers to individual cities - urban centers. Over the past ten years, the boundaries of cities have expanded very much in almost all countries. The urbanization process has undergone significant changes with industrialization.

The third and fourth industrial revolutions, the industrialization of the world's countries, have moved and continue to push the centers of human life from rural areas to cities. The automation and robotization of many processes make this possible in those economic zones and regions with a high concentration of new enterprises' technical and technological centers. Now, urbanization is rapidly moving from west to east, and over the past 10 years, it has grown into the creation of full-fledged functional units - cities.

Cities are new determinants of national and regional economic growth; they significantly contribute to changing the world's environmental situation. The modern world is globalized, where large cities form regional centers of influence. In this work, we study the state of land use, considering the urbanization process around the world; therefore, for such a study, the large cities of the world representing their local geographical region or continent have been chosen. To help us outline the basic economic principles of urbanization, we used the following economic parameters: the size of cities and suburban areas, the development of transport and infrastructure, data on companies and land prices, real estate (housing and offices), as well as data on the environmental situation. It is worth noting that the definition of "city" is an essential and determining factor of any scientific work carried out in this field of study. Each country or nation defines what a "city" is. Although large world

organizations, such as the UN, have definitions, they do not classify all cities according to the same criteria [23]. Cities can be classified according to the size of the city area and the total population or based on the decisions of local government structures.

The scientific research is devoted to the development of an ecological and economic model of changes in prices and land use options as a result of urbanization processes and changes in the environmental situation in the context of modern rapid processes and challenges under the influence of globalization, as well as the construction of an appropriate computer information system.

Taking the above as a basis, the author of this scientific work set and solved the following tasks:

- to combine different areas of scientific research in the context of the study of urbanization and related processes.
- to investigate the limits of the impact of urbanization processes on suburban areas and the region as a whole.
- to determine the models of development of territories depending on changes in the environmental situation and the adoption of relevant acts and international treaties;
- to propose a new approach to the economic valuation of land within the city and on its outskirts;
- to develop options for the cost-effective use of land resources, taking into account the further development of territories, ATCs, and economic costs related to the environment;
- build future urban development models, and develop a system for effective research of urbanization processes by creating appropriate urbanization profiles.

The paper examines the process of development of territories and the use of land resources within cities and suburban areas in the context of sustainable development as a consequence of urbanization. The subject of the study is the

ecological and economic modeling of rational use of land resources under the influence of processes related to urbanization and situational forecasting of land use objects for the future, taking into account changes and modeling of rational land use.

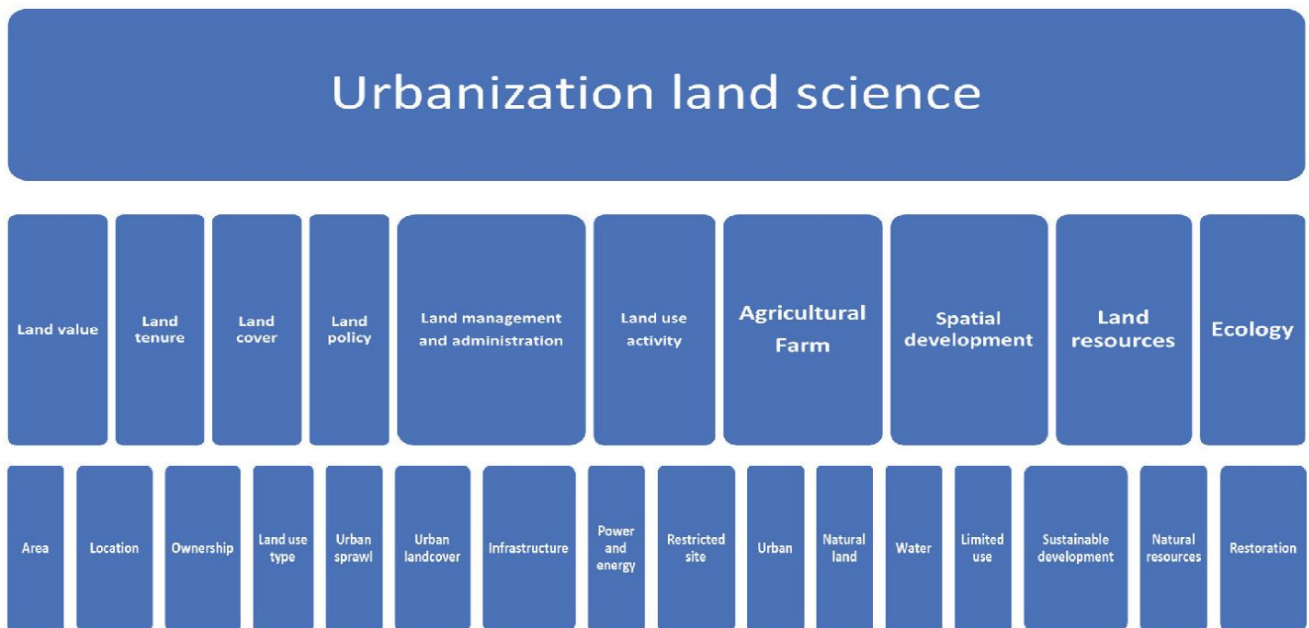


Fig. 1.1. Processes study components related to urbanization in the context of land use [1-3]

Land use (Fig. 1.1) is essential to urbanization because cities are built and developed using land resources (territories) and form the land and real estate market. Land resources have international and national classifications following legislative acts and norms, and such a classification, as a rule, outlines the form of ownership, possible uses, rent, and, in some cases, price. In this context, real estate is defined as a general type of land resource and, in some cases, as an object of ownership by type. The market, the boundaries of power (mainly through regulations), and society form regional characteristics and options for using land resources in the city and suburban areas. Natural and manufactured landscapes, climatic zones, and weather conditions form the basis of ecological impact on the development of territories, excluding anthropogenic factors and factors indirectly related to human activities. The land and real estate markets are integral parts of economic forecasting.

With the beginning of the Industrial Revolution in the 18th century, the first industrial centers began to form, which later defined the economically prosperous countries of the world. Key factors that have shaped several such countries are the transfer, expansion, and formation of centers around new industrial complexes. The increase in industrial enterprises, plants, factories, and other industrial objects led to rapid population growth in these regions. In our opinion, these have become the key factors that determined the development of urbanization and continue to impact it significantly. The end of the 20th and the beginning of the 21st centuries can be confidently called a new period of urbanization development in the world. However, in the next period of human development, new attributes appeared, such as ecology, the concept of human well-being, and the development of high technologies. In the modern world, economic regions located within specific urban centers in the United States, China, Europe, and Asia are gaining more and more importance.

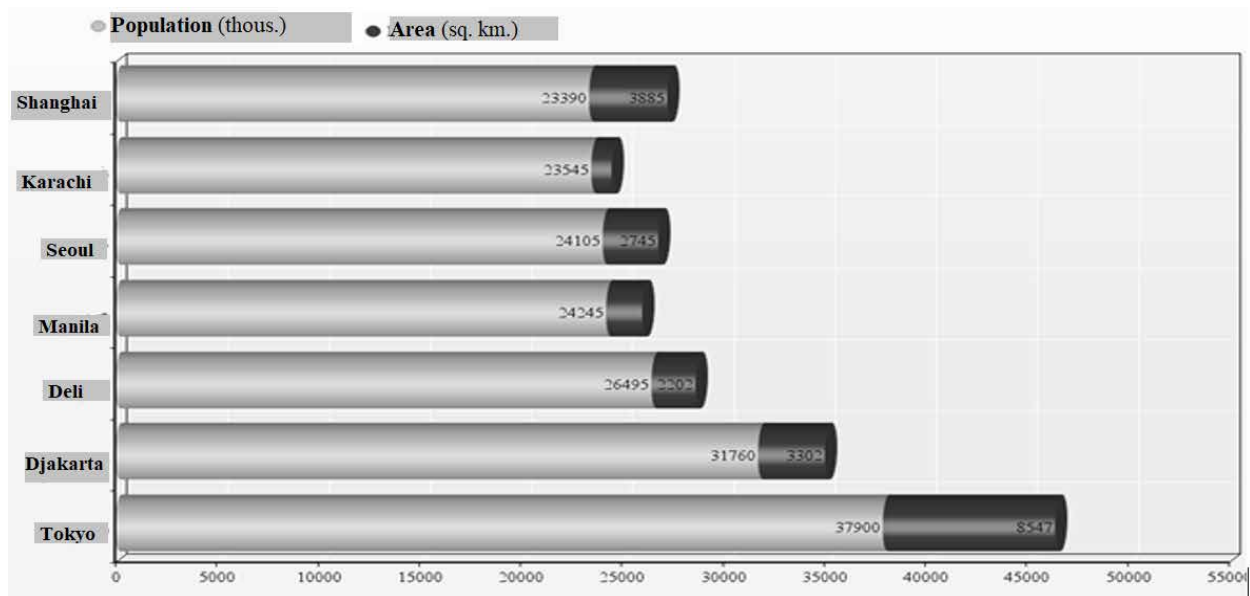


Fig. 1. 2. The increase the area of cities and their population diagram over the past decades, grown urbanization into creating full-fledged functional units - new cities

What do we mean by the process of urbanization today? Urbanization is developing the urban area and areas adjacent to cities - infrastructure. The urbanization process itself is not new. It accompanies the entire history of humankind

and began with the development of the settlements of the Mayan tribe, the territory of the Middle East, and the heyday of the Chinese Empire. This process was also observed in Ukraine, as evidenced by the Trypillia culture. However, there is no global consensus on how to define the urbanization process and when it is possible to classify cities as urban centers [4].

A significant part of the population today lives in cities. According to a UN report, in 2016, there were 512 cities in the world with a population of at least 1 million [5]. The share of city dwellers continues to increase, with cities such as Singapore, Macau, and Hong Kong currently leading the way. There is no denying that society is influencing urbanization now more than ever. During the initial phase of the research, we found that the concept of modern urbanization and its impact on the economy and the environment has not been thoroughly investigated. Some studies have been carried out that relate to specific cities or areas; this is especially true for developing countries. As for the nations of Europe and the United States, urbanization studies were mainly carried out at the end of the 20th century.

We believe in looking at urbanization as a modern process from a new perspective, using new modern tools, methodology, and research technologies. In this scientific necessary work, we study how large cities affect the economic state of states, the pace of their development, how they respond to financial crises, etc. In addition, we will study how population changes in urban centers change the environment in and around cities, how urban infrastructure develops as the population increases, and how new industrial complexes are built around such centers. Since much research has been carried out in industries close to urbanization, urbanization is still a little-researched area. Many works in this field are descriptive and have been carried out by civil society organizations such as the UN and government organizations in certain countries. Our goal as researchers is to present the terminology and overview of urbanization as a contemporary process that not only outlines its main points but also those that help us and other scholars to

understand the definition of urbanization as a continuous process with a significant impact on world processes and the development of society.

Over the past hundred years, the boundaries of most cities have greatly expanded in almost all countries, starting with Europe and continuing to India, Japan, and Latin America. Cities and urban centers greatly influence and shape the modern economy of states. Due to the rapid industrial development and industrialization of the countries of the world, namely, the third and fourth industrial revolutions, the centers of human life have been transferred from rural areas to small and large cities. Automation and robotization of most industrial and production processes, as well as a significant part of daily work in human life, makes this possible in those economic zones and regions where there is a high concentration of new enterprises, technical and technological centers, such as San Francisco (USA), London (England), New York (USA), Seoul (Korea), Taipei (Taiwan) and others [6].

A critical issue inextricably linked with urbanization is the development of the economy of cities and adjacent territories, so one of the crucial tasks in the future is the need to determine the relationship between investments, the level of economic development of the city, and its growth or decline. To achieve such a result, it is necessary to investigate the definition of urbanization in different countries and by international organizations. Interesting examples are China and European countries. If the nations of Europe developed rapidly economically and urbanistically in the 20th century, then China would continue such development in the 21st century. According to many researchers, the main factors of such trends are investments and rapid industrial growth, which, together with a large amount of labor and material resources, led to the formation of China as a new urban region. At the same time, European countries do not show high rates of economic growth and changes in urbanization.

Today, the number of large urban centers worldwide is more significant than what official statistics show. This is because states and regional bodies can change the boundaries of cities and adjacent settlements while all belonging to the same

urban center. We will use modern means to analyze such facts, such as computer vision and analysis, satellite images of cities for different periods, etc. Undoubtedly, in our research, special attention should be paid to the economic and social components of the urbanization process and environmental factors. The pace of urbanization development is due to the state of the world and the state's regional economy, as well as innovations and the results of the fourth industrial revolution. The world is changing, and some cities are constantly growing while others have achieved growth in the current cycle. The economy of the 21st century directly depends on the development of towns, especially in urban centers. Thus, the development of the economy of a particular region gives a strong impetus to the migration of labor resources and population growth. Significant investments in such areas stimulate the opening of new enterprises, which in turn leads to the development of cities and regions.

Examples can be given of a certain number of large cities whose actual area and size are more significant than officially stated. In this context, it is essential to understand how urban areas are defined today in terms of their official classification and terminology. The authors have analyzed the factors that represent the current definition of an urban center or a city. On this basis, we have built key databases that will help us classify urban areas.

One of the main determining factors of the modern definition of a city is the urban population, its density, and the boundaries of the metropolitan area. It should be noted that there are many ways to designate a particular settlement as an urban area. Still, the general concept of defining the boundaries of cities is rather vaguely defined. If we look at such definitions in the United States of America, urban areas and cities have similar terms, while agglomerates are described as different types of settlements. The city's central business district, the center of the leading active business city, high real estate prices, and transport issues are determined. Although, according to various economic theories, a city may have not one but several business centers, many of them were founded during industrial development, when large

enterprises dominated. Many financial and labor activities are unrelated to extensive industrial facilities or territorial zoning.

Urbanization is the quality or condition of urbanization or the process of urbanization. Urbanization is the process by which more and more people leave the countryside to move to cities. The most urbanized areas are Western countries, according to the UN (2014). Most people live in metropolitan areas – in most countries, most of the urban population lives in relatively small towns and villages. As the study showed, no standard international definition of an "urban" area or an "urban" population exists. Each country has its meaning and data based on the collected data. Statistical information that 50% of the world's urban population is determined simply by compiling these incomparable and sometimes contradictory definitions [1, 6].

A comprehensive list compiled by the United Nations Population Division collects the definition of "urban" population, used in censuses in 232 countries worldwide. The criteria countries use to define a place as "urban" include population size, population density, type of economic activity, physical characteristics, level of infrastructure, or a combination of specific criteria. Some simply list their urban areas by name. One hundred one countries of the world use minimum population thresholds to define settlements as "urban," or as a single criterion, or together with others. The most commonly used thresholds are 2000 inhabitants (used in 23 countries worldwide) and 5000 inhabitants (used in 21 countries). Only nine countries in the world use minimum population density thresholds; of these, only Germany uses it as the only criterion for determining urban areas. The lowest density threshold used is 150 people per square kilometer (Germany), and the highest is 1500 (China and Seychelles) [3].

Before the 2000 census and the delimitation of settlements, the degree of urbanization was calculated by the proportions of the population living in settlements to the municipality's total population, which also included persons without a fixed place of residence (e.g., homeless and nomadic populations). After the 2000 census,

the population that constantly moved and changed its residence (nomadic) lived in settlements if the institution belonged to a settlement or formed a settlement independently [3]. Currently, there is no single and commonly used (recognized by all) definition of urbanization and its associated processes and factors. Some scientists offer an alternative definition to the UN methodology, taking into account the concentration of cities, which is called the "agglomeration index (AI)" [12]. It is based on three leading indicators: population density, population size in a "large" urban center, and travel time to that urban center [3]. Therefore, the problem is how we classify an urban center, what properties it should have, and what areas to include/exclude. In different countries, different groups of scientists or specialists (sociologists, urbanists, developers) define the term urbanization differently. The structure of the state national agency in the United States, NCES, classifies and divides the entire U.S. territory into four types of areas (territories): city, suburban area, metropolitan area, and rural area. Each such territory is divided into three subtypes depending on population size (in the case of urban and suburban areas) and proximity to urban areas (in the case of metropolitan and rural areas) [99]. Given the all-encompassing 2020 census, the IBGE proposes a new typology to characterize urban and rural areas. Using this methodology, the urban population of Brazil decreases from 84.4% to 76% [100].

However, there is no single model that describes what urbanization is, the factors that contribute to why some cities are built and developed faster than others, and the determining factors that influence it. The initial assumption may be that convenient and developed transport networks, communications, and ecological ecosystems must facilitate this. Therefore, to continue the study of this issue, we propose a new model called "Axis of Urbanization" in our work.

It should be noted that Ukraine does not stand aside from the global challenges of the time related to globalization and urbanization but is an active participant in this process. This is confirmed by such indicators as significant labor migration, outdated land legislation, and inefficient use of land resources. Therefore, the study's author

analyzed the social, environmental, and economic factors affecting the development of the economy of individual amalgamated territorial communities of Ukraine, emphasizing the development of its capital - the city of Kyiv. The main reason for the concentration of research work in the capital of Ukraine is the general availability of statistical information and economic data from the 2000s.

It is crucial for effective research to find and establish links between the rapid process of urbanization and the change in agricultural land use from an economic point of view. The conducted research is an essential component of economic modeling based on data on Ukraine. Next, it will be necessary to demonstrate changes in the income of agricultural enterprises in the event of population migration to large urban centers. In addition, we will study cases of effective land management, analyzing whether it is more profitable for companies to create a new enterprise closer to or within urban areas than agricultural regions. This study highlighted the main economic differences in a company's start-up costs and operating activities based on the available transportation network, land resources, and local agricultural specialization. The results of the simulations should provide possible results for small- and medium-sized companies, as well as separate those that are part of the international corporate structure and local businesses.

1.2 Urbanization as a State and Process: Characteristics and Dynamics

It should be noted that despite the modernity and relevance of these issues, the topic of urbanization has been little studied. Much attention is paid to the problem of forecasting the cost of housing in a particular city or district based on market pricing or its geographical location [17]. At the same time, the author does not consider the factors of urbanization as a phenomenon that directly impacts the formation of demand for new housing. Other popular topics for scholars are studies of the post-effects of urbanization, such as heart disease in urban populations [18] or population decline in certain fish species [19]. We believe that such developments are worth

considering in further research. Still, the primary focus should be on more global systems and interconnections - the urbanization process is a dominant factor. In the course of preparing the study, the author considered existing and past theories, among which it was considered - the central places of Kristaller, the theory of the "economic landscape" of Lesh, the theory of "concentric rings" of Tyunin, various ideas of the past regarding urban development, the work of famous architects and urban planners, the theory of the development of the central part of cities and others.

A detailed analysis of literary and Internet sources showed that the study of scientific and journalistic literature and statistical data of various public and private organizations and institutions and the urbanization process is very complex and multi-vector. Therefore, its study, analysis, and forecasting process requires a comprehensive multidisciplinary approach that considers the mutual influence of many factors on each other and provides an opportunity for analyzing and processing a large amount of information.

Many well-known economists have studied modern problems and issues related to using urban land and planning forecasts for the future, including B. Cohen and J. S. Smith. Harvey, E. Glaesir, B. Ward, R. Grundman and others. They made a significant contribution to the expansion and replenishment of scientific knowledge, the development of an urbanization model, and the analysis of the state of the urban economy. Their work contributed to establishing the basic rules of urban land use and provided essential scientific foundations for the study. Many of the recent publications on such a study have focused on the study of a specific city or region within the country [24]. When studying particular factors of a city or urbanization, it is essential to establish initial economic models and forecasting tools in a broader context. Otherwise, a narrow viewpoint can prevent researchers from seeing patterns that make a financial model for future modeling incomplete, not to mention that such a model does not focus on sustainability. We can see cities as isolated territories without comparing them to other towns. Many new megacities in development are following in the footsteps of old cities and facing the same problems. Ecology is one

of the factors that must be widely used in the economic planning of cities. This study aims to outline and describe urban development patterns so that the data can be used for future planning.

A wide range of methods and tools designed to conduct scientific research is available to modern scientists. To choose the correct research method and set of tools, it is necessary to clearly outline the field of research, determine the object and subject of research, formulate the problem, set the right tasks for research, and formulate a goal. Economics (Fig. 1.3) and ecology are fundamental socio-behavioral sciences that have absorbed some sub-fields of knowledge and approaches to scientific research. The author of this scientific work explores the process and state of urbanization in the context of economic, ecological, land management, and social sciences. Simultaneously, the main emphasis is on financial and environmental modulation to predict further changes.



Fig. 1.3. Study Components of the processes related to urbanization: context of economic science [1-3]

Urbanization is a relatively new independent field of study closely related to environmental and economic sciences. For further implementation of scientific work, the author chose environmental and financial forecasting as the primary scientific

research methodology in the context of the research paper. Environmental and economic forecasting consists of two components - environmental and economic components. Both of these components are closely related to each other. They are integral to studying the main processes related to the development of cities, activities, and social aspects of people living in cities and suburban areas, spatial development of territories, and regional/local management. Economic changes and planning influence the development of cities; at the same time, this anthropogenic development affects changes in the environment, the climatic situation, and natural resources.



Fig. 1.4. City and urban services

It is essential to highlight the current definition of the urban development process and what scientists understand by the urbanization process (Fig. 1.4). When studying and researching it, it should be considered comprehensively. At the same time, it is necessary to consider such components as the city, land use, economic components of the city's life, and environmental issues. When considering matters related to the town, it is necessary to analyze the location of objects of economic activity and residential development and evaluate their densification and land use issues. When considering aspects of land use, it is necessary to consider territorial zoning, reduction of available territories (due to urbanization), and change of purpose

of land and infrastructure, without which the city cannot function. The economic component must consider all types of costs and profits from the activities of structures in the town, taxes, etc.

It should be noted that economic factors are dominant in the development and creation of new urban centers, as indicated in the studies [7]. A significant role in accelerating urbanization was increased investment in developing cities and suburban areas, the creation of interchanges and highways, and modern logistics centers. The above factors affect the urbanization process. As a result, current investments in the development of cities and suburban areas, where both the state and private structures are investors, are increasing. And in the future, it is increasingly likely that additional funds will be invested in such modern urban centers. However, it should be noted that at the present stage, such a process can take place very quickly, as we can observe in the example of China. But just as quickly, it can stop. A clear example of the opposite phenomenon is the city of Detroit, which, due to economic factors and new technological conditions, declined very quickly

It was evident that despite the importance and relevance of the research topic, little attention is paid to the issues and problems caused by urbanization, especially in the context of the development of events in the 21st century, both in scientific and journalistic literature and applied research. Much more attention is paid by various authors to the issue of forecasting the cost of dwellings and housing in a particular city or district based on market pricing or geographical location. However, it should be noted that the authors do not consider the factors of urbanization, which is a phenomenon that directly impacts the formation of demand for new housing. Other popular topics for modern scientists are the study of post-effects of urbanization, for example, heart disease in urban populations [8], population decline in certain fish species [9], or other animal or insect populations.

Based on the results of the studies carried out, we consider it appropriate to present a new definition of urbanization based on studies and hypotheses and focus on economic factors. Having conducted a detailed analysis of the sources of

information in the literature (Table 1.1; Figures 1.4 and 1.5), the authors believe it is worth considering such developments in their further research. However, the primary focus should be on global systems and the interconnections of urbanization processes as dominant factors.

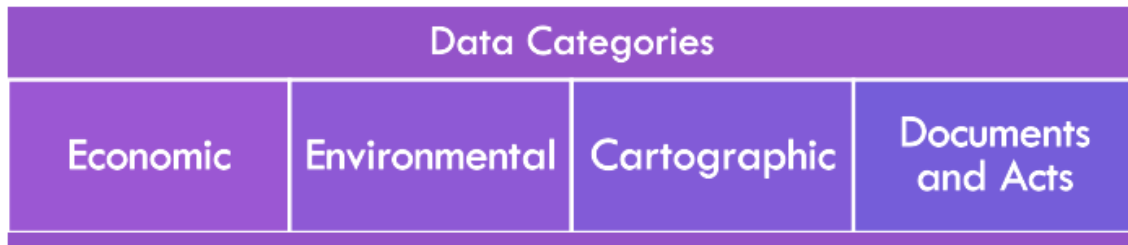


Fig. 1.5. Categories Data of urbanization study

Table 1.2 collects and groups the main problems facing scientists studying urbanization, the components of each of them, and the first proposals for solving such problems. The main issues are that the process of urbanization today is not sufficiently studied thoroughly, there is no economic modeling of nature management in the context of city research, there is no clear, unambiguous definition of urbanization, there is not enough information about the factors of direct and indirect impact on environmental and economic forecasting.

Table 1.1

Main Fields of Urbanization and Related Processes: Context of Selected Sciences*

Economics	Ecology	Land management	City Planning and Urban Planning
Influence and changes in real estate prices under the influence of various factors (separate study of influencing factors)	Programs and regulation of sustainable urban development	Land market, legal status and types of use	Spatial planning, zoning and design
Economic boundaries of cities	Ecosystem and its territorial zoning within and on the outskirts of cities	Real, actual boundaries of cities by type of plots	Urban boundaries and zoning

End of table 1.1.

Influence of the state of ecology on the economic development of the city	The impact of cities on the environment	Economic valuation of plots	Urban Development Models and Urbanization Economics
The general term "urbanization" and its definition in the context of various sciences			
The role of the state, regional and local authorities in the economic development of the city	City and suburban areas: coexistence and mutual impact on biodiversity, state of natural resources	Economically feasible options for the development of cities and infrastructure	The role of the state, regional and local authorities in the economic development of the city

* Prepared based on personal research data and from sources [1-12]

A multidisciplinary approach should encompass research related to land use, economics, ecology, law, urban planning, spatial development, social issues, etc. The research conducted and analysis made it possible to formulate preliminary proposals for solving such issues (Table 1.2.).

Table 1.2

Problems and Directions of Urbanization Research

Problem	Components	Solution suggestions
Economic modeling of nature management in the context of urban research is poorly represented	Land Economics Ecology	Identify the main economic data, factors and parameters in the context of urbanization
There is no clear definition of the concept of urbanization	Right City Planning	To propose, on the basis of the available definitions, a comprehensive study taking into account empirical research data
Study of the city as a separate functional unit	Economics	To develop a comprehensive model of the city as an integral element of economic research
Options for the development of the city in the future	Economics Spatial development Ecology	Create a model that takes into account a multidisciplinary approach and presents multi-component forecast models

Factors of direct and indirect influence on environmental and economic forecasting	Economics Spatial development Ecology Land Sociology	Identify factors from different disciplines based on and combine them with a single representation
The role of the state, regional and local self-government bodies in the economic development of the city	Right Economics	To study examples of the definition of urbanization and cities in the documents of different countries, to conduct a comparative analysis with the actual socio-economic indicators and city boundaries
Expansion and territorial expansion of the city - due to which this can happen	Economics Spatial development Right Land	Identify the main drivers, taking into account the territorial distribution and adjacent territories
Changing the purpose of territories, the price of formation and the impact of ecology on the cost - how to conduct a comprehensive economic assessment	Economics Land	To present a model of economic assessment of environmental processes in urbanization
What technical, computer and mathematical tools need to be developed for environmental and economic forecasting	Mathematics Economics Computer Science	Conduct thorough research and develop a methodology for growing funds for conducting research

If we detail the components and directions of the study, then a significant number of questions are asked that need to be solved:

- how urbanization affects the price of land formation and use, rent;
- the ratio of lands for different purposes (not urban areas);

- due to which the city can increase the size of its territory.
- what is the need of urbanized areas for the production of rural products;
- economic, social and environmental impacts of urbanization processes;
- models of the urbanization development process and the main factors of influence;
- expansion of the city boundaries and the impact of this on the change in the value of land within the city and surrounding areas;
- time intervals of changes in prices and pricing in the real estate market at different rates of urbanization development;
- what role does legislation and legal regulation play in the development or slowdown of urbanization processes;
- real boundaries of the urban area (actual) and defined in regulatory legal documents;
- what are the models and tools of system modeling and data analysis in the context of urbanization research.

The conducted research and analysis of information sources showed the need to develop a modern system of classification of cities, considering all aspects of their historical and economic development. It is necessary to consider the further development of cities into urban centers, which will allow the future to predict their development and adjacent territories and plan their future. There are many economic, spatial, and architectural theories about how the city should develop in the future. Some of them studied the past or built a complex model based on the evaluation of predicted data. It should be noted that global theories of urbanization have found little place in practical implementation. Some postulates and models have been used to construct new cities in the 20th and 21st centuries but are not used globally. After all, cities were formed in their time's historical conditions and realities under the economic and social situation that existed then. In the 21st century, new challenges have arisen associated with the rapid increase in population and the development of territories. Development of economies in different parts of the world.

Ukraine is a young state, but even under these circumstances, some factors of urbanization began to develop in the 20th century and continue to influence in the 21st. In Ukraine, the most significant urban centers are located in its capital, the city of Kyiv, the eastern industrial regions, and the south due to seaports, large terminals, deposits of natural resources, etc. More than 68% of the population of Ukraine lives in cities, and every year, this number continues to grow. In 2013, according to statistics, in four regions of our country, the percentage of urban residents exceeded 80% of the total population [22]. There is a problem of inconsistency between Ukraine's existing norms and regulations on rational and practical land use and land planning, especially for local authorities and commercial organizations. The author substantiates why the economy in the context of urbanization needs a new look. The work uses the layout of the city of Kyiv. This is a suitable example of the town's development, so the proposed model can be developed based on economic growth and land use data. This research can help solve the existing urbanization problems in Ukraine and positively impact the economic development of the city and the region.

The new period of urban development requires new theories and qualitatively new research. What is indisputable is that urbanization is a process that will continue. Its pace will be determined by the state of the world and the state's regional economy, as well as innovations and the results of the fourth industrial revolution. In our future research, special attention will need to be paid to the economic and social components of the urbanization process and environmental factors. Problems related to ecology are one of the main ones in the process of urbanization, as there is a rapid development of infrastructure, the development of cities and adjacent territories, a very rapid uncontrolled increase in the population, an increase in the number of personnel transport and the development of new enterprises. All these factors negatively affect the quality of life in cities and can lead to a decrease in the attractiveness of real estate. As a result, people do not move to such centers but begin to build others.

Urbanization is a relatively new branch of the research field. Most existing research is multidisciplinary and cross-sectional, with economics, sociology, and

ecology being the main fields for conducting such research. However, most modern scientific papers have a narrow interest in this field of study and analyze only topics such as GIS, spatial development, city management, or real estate market analysis. The author notes the lack of comprehensive, high-quality, detailed information that provides a deep study and presentation of urbanization as an independent scientific field, which it undoubtedly is. The author notes that modern scientific discoveries and significant advances in computer science should be used for urbanization research. Computer science can serve as a fundamental scientific tool for modern urbanism. Undoubtedly, tools such as computer vision allow us to efficiently analyze and classify spatial data or use modern advances in machine learning, which will enable us to create reliable real estate forecasting models or accurate city models built using 3D modeling platforms, which provide a strong argument for their use by researchers of the urbanization process and cities [36].

Table 1.3 provides an overview of the fourteen main fields of study of the urbanization process. They are grouped according to the main fields of scientific research, such as ecology, sociology, economics, urban planning, computing and information systems, legislation, and regulations. The structure of the research field indicates the main directions of potential research work. It should be noted that some areas of activity should consider structures such as land use and resource management. The above fields of research represent a list of methods of scientific research that can be used to study a specific direction.

Any thorough scientific research relies on knowledge and use of terminology, methodology, and various scientific data in the field of research. Urbanization research is one area where there is currently a lack of definitions of key terms, components of this process, and key data indicators for their research and study. International organizations, official government agencies, and research institutions of different forms of ownership have different views on the urbanization process and rely on and use various research methods, statistics, and data classification.

Table 1.3

Overview of Urbanization Research Areas*

№	Industry	Field of scientific research	Structure	Methods
1	Ecology of urbanization	Ecology	Regulation Resources System Results	Analysis and hypothesis Legal research
2	Green City	Ecology	Buildings Energy Environment Land Use Waste Management	Analysis and hypothesis Legal research Qualitative Quantitative System modeling
3	Population, dynamics and health	Ecology Sociology	-	Qualitative quantitative system modeling
4	Growth and development of the city	Economics	Development of urban areas	Analysis and Hypothesis Quantitative System Modeling
5	Patterns of urbanization development	Economy City Planning	-	Qualitative quantitative system modeling
6	Spatial planning and placement	Ecology Economy City Planning	Land cover	Qualitative quantitative system modeling
7	Real estate market	Economy City Planning Laws and Regulations	Market Analysis Pricing Modeling Supply and Demand Forecast	Quantitative System Modeling
8	Urban planning and monitoring	City Planning Laws and Regulations	-	Legal Research Qualitative

End of table 1.3.

9	Smart City	City Planning Laws and Regulations Computing and Information Systems	City Management Urban Data Modeling Predictive Modeling	Legal Research Qualitative Quantitative System Modeling
10	Urban modeling	City Planning Laws and Regulations Computing and Information Systems	-	Qualitative quantitative system modeling
11	Land development	City Planning Laws and Regulations	Visualization of the city Perspective development scenarios	Legal Research Qualitative System Modeling
12	Land use and infrastructure planning	City Planning	Land Use Norms GIS Data Modeling	Legal Research Qualitative System Modeling
13	Environmental monitoring and regulations	Ecology Laws and regulations	-	Legal Research Quantitative System Modeling
14	Laws city planning	Laws and regulations	-	Analysis and hypothesis Legal research Qualitative

* Prepared based on personal research data, reports of the UN, Britannica and the Statista service [37-40]

We strive to answer the following questions in our work: what is the correct definition of a city; how do modern cities differ from old ones; how can urban, suburban, and rural areas be differentiated? Many factors make the difference in definitions and indicators incomprehensible, including social, political, and economic

factors and legislative regulations. It is imperative to classify the main factors that made urbanization possible in the previous time and what acts as a catalyst for the expansion of urbanization now. To classify cities and the urbanization process, we need to understand why settlements were built in certain specific locations and the modern determining factors for expanding the boundaries of existing ones and creating new settlements.

One of the hypotheses about why the urbanization process occurs is the movement of the population towards large urban centers and megacities. In recent decades, this migration rate has increased, and such a change will be enormous in the future. This is already happening in some countries, and it is inevitable, while other countries will show a massive leap in this direction in the next ten to fifteen years. However, no single model describes what urbanization is, the factors that contribute to it, and why some cities are built and grow more than others, which are the main determinants of this process.

Studying the experience of the member countries of the Organization for Economic Cooperation and Development, primarily Finland, Japan, Canada, and Germany, the author argues that Ukraine does not have an integrated approach to the rational use, conservation, and restoration of forest resources [110].

Therefore, to resolve these issues, economic levers, regulatory frameworks at the national level, and a modern legislative framework for ATCs and large cities are needed. Judicial reform and amendments to the Land Code are also significant in this context. The author considers it appropriate to create national and local open registers of land use in the context of natural resources and general-purpose lands. Such a system should contain information about the owners of plots, communities, or individuals and data on the quality of green spaces, their age, area, etc. Also necessary are plans for the restoration of natural resources, namely forest plantations, and distribution according to possible options for their use in the future.

Suburban areas are critical objects for such a system. As mentioned above, cities develop at the expense of adjacent areas, including agricultural land or forest

areas. The impact on suburban areas and forest plantations may not be direct (not due to development or change in the option of their use) but indirect. Such factors include environmental impact (landfills, polluted water streams or harmful emissions, noise, and radiation) and illegal use of territories.

1.3 Sustainable Urbanization Frameworks

Environmental problems are one of the main ones in the process of urbanization, as there is a rapid development of infrastructure, the development of cities and adjacent territories, an uncontrolled, very rapid increase in the population, an increase in the number of personal transport and the development of new enterprises. All these factors negatively affect the quality of life in cities and can lead to a decrease in the attractiveness of real estate. As a result, people do not move to such centers but begin to develop others.

The authors investigated the factors that harm urbanization in cities, from small suburbs to large industrial metropolises. The main focus of the scientific work has been the study of the current state of urban research, emphasizing the different contexts of their use, ranging from economic to environmental and social. It cannot be denied that the scale of the territories affected by urbanization is immense. As cities develop and populations move from remote regions to single urban centers, urbanization has the most significant impact and its specific consequences. In the future, we aim to study how these processes affect the environment and answer whether this impact can be suspended.

Modern cities are one of the main drivers of states' economic growth and prosperity. At the same time, they present many challenges and generate many problems. Urbanization is a process that directly results from cities' growth and development. New financial, human, and land resources are needed for the city to develop and for urbanization to continue. New urban construction projects generally capture or directly exploit neighboring land plots. In addition, for the city to supply

itself with electricity and food, the areas adjacent to the city are used for power plants, farmland, and landfills. The above process leads to significant short-term (1-5 years) and long-term (20+ years) environmental consequences. Figure 1.6 presents a model of potential direct and indirect environmental consequences due to the urbanization process. The consequences can be divided into two categories: those directly affecting the city and the occupation of land and areas adjacent to the city. Among the main environmental consequences of the rapid and widespread urbanization process are deforestation, soil and water pollution, carbon and greenhouse gas emissions, and a decrease in the overall level of public health [11-15].

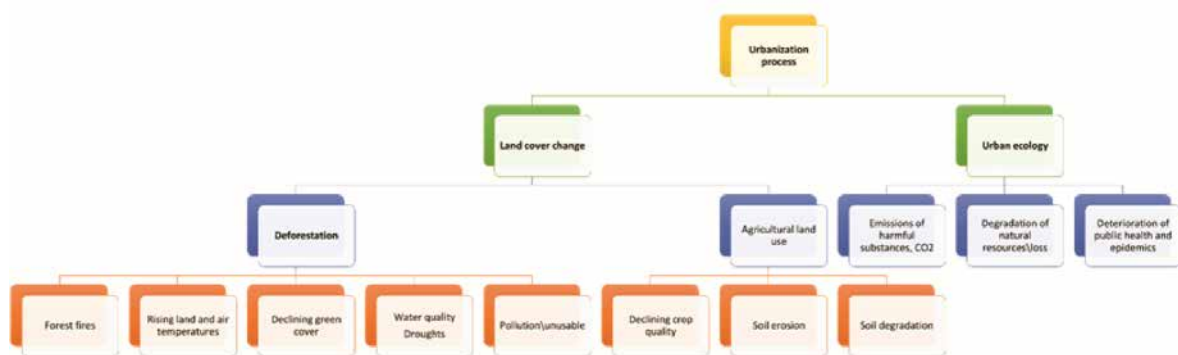


Fig. 1.6. Consequences of the urbanization impact on the environmental situation and land resources

Environmental consequences can lead to or even directly affect both the city's development level and the national economic growth and GDP growth rate. Table 1.4 presents a classification of the main parameters of total economic costs resulting from the development of environmental processes. The author has classified and outlined five main ecological processes directly affected by urbanization. However, it should be noted that they are all directly related and can influence each other. Urban expansion, waste disposal, heavy and light industry, power generation (especially nuclear power and coal industry), and transportation are significant catalysts for deforestation, reduce water quality, and increased carbon emissions. According to the Paris Agreement, many countries now spend most of their GDP on combating the environmental consequences of urbanization. Such countries must pay a considerable

price to reduce the harmful effects of impacts on public health and the environment [15].

Table 1.4

Ecological Processes Classification Affected by Urbanization *

Process	Options	The process affects:	Affect the process:
Deforestation	Volumes, km ² /year Deforestation, ha Cross-border deforestation index, points Volume of forest renewal, km ² /year Social value of ecosystem, \$/ha	Carbon emissions Soil erosion Flood/drought Changes in the water cycle Damage to the ecosystem and natural habitat	City expansion/construction Land use of agricultural land Woodworking industry
Reduced water quality	Demand-to-supply ratio, % Drought intensity index, points Water pollution, tones/cubic m Drinking water quality index, points	Drinking water supply for the population and livestock Crop Cultivation and Soil Use Overall level of fresh water supply and health care	Use of agricultural groundwater Energy Facility Consumption Industrial, Personal Non-Consumed Use
Carbon emissions	Emissions, per capita/per km ² cubic tons per year Cost per emission time, \$ per ton Reduction costs, \$ per ton, % of GDP	General health of the population Increase in air and ground temperature Reduced water and soil quality	Public and personal transport Agricultural livestock Waste storage Power generation Industry
Waste	Transportation, \$ per ton (m ³) Waste, kg per capita Waste storage cost at landfill, \$ per ton Waste recycling costs, per ton	Soil contamination Air pollution Pollution of fresh and marine water bodies Greenhouse gas emissions Public health	Industry Trade General Public Agriculture

Public health	National/municipal health expenditure, \$ per capita, % of GDP Sustainable development, \$ investment, % of GDP	City budget expenditures Personal health and well-being Social situation and demography Economic growth rates	Carbon emissions Water and air pollution Food contamination Viruses and pandemics
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* Prepared based on personal research data, reports of the UN, the World Bank and the Statista service [10-15]

An important task for the future will be to study the relationship between the sizes of these cities in the context of their historical development, how they developed, grew, expanded boundaries and suburban areas, etc. Eight of the thirteen cities for which we studied are located on the shores of the sea or ocean [31]. With a possible rising sea level shortly or in the future, many inhabitants will have to adapt to the new environmental situation. It is important that the necessary steps are taken shortly and that the economies of the city and the nation are ready for future challenges.

Based on the results of our study, we determined that, on average, cities spend about 3% of their budget on ecology and only plan to increase these indicators in the future. In this study, we did not investigate the direct environmental impacts and economic consequences they would have on land prices, the urban economy, the development of technologies, and the use of alternative energy. However, what we can already talk about now is the fact that governments need new policies and approaches to the environmental aspects of land use and urban economy planning since they are all part of the development of cities and states.

Based on the results of previous studies, the development of some urban agglomerations, especially in Africa and Asia, leads to increased air pollution with CO₂ emissions, drainage of water bodies, flooding of fields, and deforestation. It is undeniable that the authorities of certain countries understand this problem and take

specific steps to solve it. Some researchers cite data indicating the profound impact of cities on cardiovascular diseases and obesity of people, as well as the disappearance of populations of plants, fish, birds, and animals from their habitats. Such data require further processing and analysis, primarily based on official statistics of international organizations, considering the level of urban development and the level of pollution of territories. To improve such an analysis, it is necessary to find data on urban pollution and its impact on public health before and after urbanization.

Conclusions for Chapter 1

To summarize the examples above, settlements can be classified as district, city, suburban area, city, and rural area. At the same time, each such territory is divided and determined based on the population, settlements, and proximity to large, densely populated areas. Meanwhile, a common denominator exists in the official international definition of cities. If we analyze them, we can divide settlements into two broader categories - urban and rural areas. What distinguishes the different definitions is the official city boundaries marked on the map as the border of the city limits. The next step will be to investigate how cities were formed to study their history from several angles, including cases in which two or more cities were merged or when several industrial regions were incorporated into forming a production cluster that later evolved into a municipality. However, such research work is beyond the scope of our current research and could potentially be explored in the future.

In the course of the work, the expediency of using an integrated approach for environmental and economic forecasting in the study of urbanization as a sub-branch of science based on the knowledge and postulates of economic science, analysis of changes and factors influencing the environment, research of the land market and economic data on land use in cities has been proved. Moreover, the feasibility of including suburban and surrounding areas for more effective modeling and forecasting of land-use changes has been proved. During the study, an analysis of the current state of urbanization in the world and Ukraine is carried out, and the

processes that influenced the historical development of cities and economic factors are investigated. This allowed large cities to become megacities, to form and reach the current peak state of their economic development, increasing the area and population, both due to the annexation of adjacent territories and due to new approaches to construction and concentration of economic, political and financial activities in separate areas of the city - Business Districts, as well as the formation of the Central Business District of the city.

The need to conduct multidisciplinary studies of the economics of urbanization, which would consider previous experience and propose a qualitatively new ecological and economic model for forecasting future changes in the development of cities and surrounding areas, was identified. All of the above is based on the results of studying and taking into account the data of scientific research, the opinions of prominent Ukrainian scientists-researchers in the field of environmental economics, urbanization, and land use processes, as well as the analysis of current trends in world scientific works and developed acts and regulations related to environmental and economic factors of urbanization. The expediency of considering many variable situations associated with the rapid development of cities in developing countries and individual megacities of developed countries due to many influence factors has been proved. Let us note the main ones: the real estate market, the foreign exchange market, the land market, environmental disasters, climate change, the spread of infections, and the development of epidemics in these cities. It has been established that the above factors have not only a direct impact on cities but also due to changes in the economic and environmental conditions in cities and lead to macroeconomic fluctuations in regions and, in some cases, in the world.

DATA AND METHODOLOGIES FOR MEASURING URBANIZATION

2.1 Spatial and Urban Data: Collection and Analysis

In the modern world, the decision-making process for the development of the city in the context of its economic development is carried out by the governments of countries, local authorities, international organizations or private institutions, as well as officials, based on a large amount of information, analytical data, and scientific developments and assumptions. According to the author, the main challenge in planning and making adjustments to existing documents, for example, such as the city development plan. There is a lack of a holistic picture and general theoretical models that could be put into practice by the aforementioned institutions and officials. Figure 2.1 shows a spatial diagram of the urban area. In this scientific work, we are only taking the first steps towards building such a model. That is why it is advisable to start analyzing existing data and models to have a clear idea of the state of affairs and develop further steps towards creating a standard model of urbanization, taking into account environmental, artificial, and other modern challenges. It is important not to repeat the mistakes made in existing models and systems but to focus on the practical implementation of such a model and future research direction.

Urbanization is an important factor in the development of the city's economy and the state as a whole, which does not directly dictate the path of development of micro- and macroeconomics of regions, which in the context of globalization can play a significant role. The development of suburban areas, industrialization, post-industrialization, environmental problems, and the further existence and development of agricultural regions bordering urban centers (urban agglomerations) cannot be excluded from the field of view.

The study of urbanization processes requires a detailed study of the spatial development of territories. Fig. 2.1 schematically depicts spatial development and

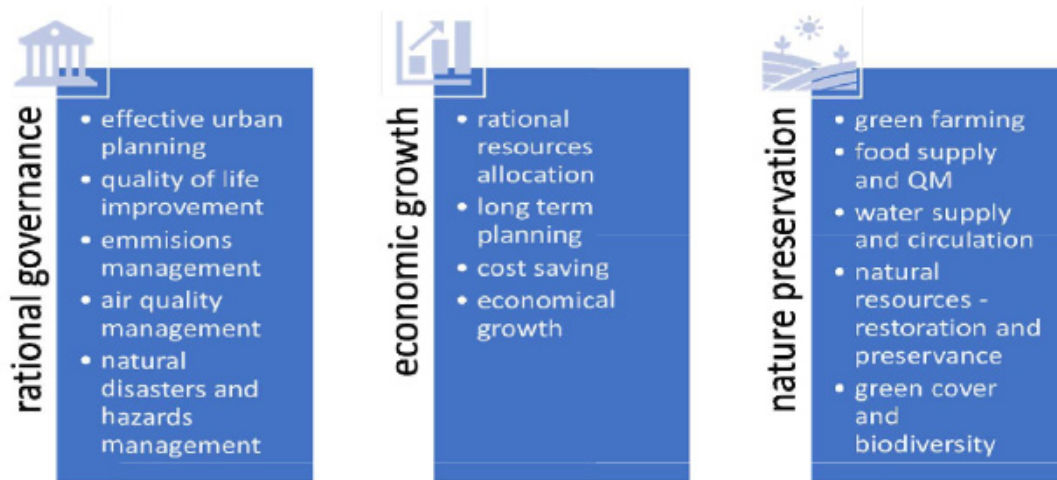


Fig. 2. 1. Rational urban development

urbanization. The basis of the city's spatial development consists of the city's territory with its urban development, industrial, industrial, and other infrastructure facilities of cities, roads, networks of surface and underground communications, as well as forest park zones, squares, and other natural landscapes. Around the cities are agricultural lands, protected and protected areas, etc. With the development of urbanization, changes in the location of such objects and the spatial development of territories inevitably occur. Cities fail people, as they are home to primary production and other facilities that constantly need workers. New workers need housing, the development of new transport infrastructure, and much more.

When studying the process of urbanization, it is worth paying attention to the development of the real estate market because urbanization is associated with an increase in the population and the resettlement of people from the periphery to the urban center - cities and suburban areas. In addition, new enterprises are created and developed, which increases the need for the organization of the service sector. All of this attracts people from different regions of the country and from other countries and even continents to such centers (Table 2.1).

An artificial increase in population growth in such centers requires a proportional number of housings for people and the development of new housing complexes and infrastructure around them in the future. With high demand and low supply, which can be both in the early stages of the urbanization process and the later

Table 2.1

World Top Countries and Individual Territorial Units with the Urbanization Highest Level of the Population (% of the total population, with a population of more than 1 million people) *

Country	%, 1960	%, 2020	Urban population, Million. Persons
Hong Kong	85	100	7.482
Singapore	100	100	5.686
Belgium	92.4	98	11.263
Kuwait	74.89	98	4.270
Uruguay	80.2	96.1	3.473
Japan	63	94	115.782
Puerto Rico	44.5	93.6	2.989
Israel	76.85	92.6	8.533
Argentina	73.61	92.11	41.796
Netherlands	59.75	92.24	16.087
Chile	67.84	87.73	16.770
Australia	81.53	86.24	22.152
...
Brazil	46.14	87.07	185.081
USA	70	82.66	272.364
France	61.88	80.97	54.570
Mexico	50.75	80.7	104.088
Türkiye	31.52	76.1	64.186
Ukraine	46.79	69.61	30.72
China	16.2	61.43	861.289
Nigeria	15.41	51.96	107.106
Republic of the Philippines	30.30	47.41	51.950
Egypt	37.86	42.78	43.781
India	17.92	34.93	481.980

* Prepared based on personal research data and data of the World Bank [1-23]

stages, the prices of existing real estate increase significantly. This happens when the rapidly developing urban region needs new labor, and workers cannot afford to buy expensive housing. This leads to the development of agglomerations adjacent to the center and new transport routes or the collapse of the real estate market [16].

The rapid increase in population growth in cities, as centers of urbanization, leads to the need to build a significant amount of new housing for people and create new infrastructure around new housing development, shops, schools, kindergartens, shopping and entertainment complexes, etc., shortly. The high demand for housing and the small supply for it leads to a significant increase in housing prices. The urban region is developing rapidly and constantly needs to replenish the workforce. However, migrants from rural areas or other peripheral regions do not have the funds to purchase such housing. Therefore, such spatial development entails the rapid development of territories adjacent to cities, where housing and food prices for people are much lower. Following this, developing and renewing infrastructure and transport routes gained new momentum [21].

While studying and processing a significant number of scientific papers and sources of information, the authors concluded that it is necessary to develop a system of classification of cities - from the beginning of their foundation to the development into an urban center. A further important area of research is the forecasting of urban development to understand such development's pessimistic and optimistic scenarios. Based on the research results and the created new model, we will be able to predict how long a city can develop, whether there are factors and drivers of such development, and, as a result, the construction of a new economy around urban centers. Since the city is an integral unit of any state, it is necessary to understand what role the state will play in this process. How will it affect the economy with the rapid development and transfer of spheres of influence on cities from the regions, and when it is necessary to form new administrative-territorial units?

While China is an example of high-speed growth rates in both urbanization and economy, Ukraine lags far behind in the above indicators. Kyiv is the dominant city

in terms of population and investment in Ukraine; at the same time, the small amount of data, their low quality, and their reliability do not allow us to fully understand the real picture of the urbanization of Kyiv and the surrounding areas.

To conduct the study, we selected and grouped the most significant cities on the continents and placed them according to the city's total population. The geographical location of the selected cities is shown in Fig. 2.3. Table 2.2 contains information on the population of cities and their area, which is divided into three groups: general, urban, and suburban (metropolitan area).



Fig. 2.2. Urban Centers Map: Region and Type of Land Use [26]

The following cities were selected for the study (Fig. 2.2 and Table 2.1) - Tokyo, New Delhi, Shanghai, São Paulo, Mexico City, Cairo, New York, Istanbul, Manila, Lagos, and Paris. We have added Kyiv as Ukraine's capital and largest urban center to the list of cities for research. We compared the rapidly developing city of Kyiv with larger metropolitan areas and noted the differences between large cities and relatively new urban centers.

Table 2.2

The Largest Cities - Region Urbanization Centers*

№	Name of the city	Country Continent	Total area, sq. m. Km.	Urban population	Suburban area, quarter. m.	Suburban population
1	Tokyo	Japan/Asia	8,230	13,515,271	6,039	23,884,797
2	Delhi	India/Asia	3,483	16,753,235	1,251	12,863,765
3	Shanghai	China/Asia	6,341	24,281,400	2,341	9,718,600
4	San Paolo	Brazil/South America	11,698	12,252,023	8,582	9,793,977
5	Mexico City	Mexico/North America	7,947	8,918,653	4,831	12,077,347
6	Cairo	Egypt/Africa	3,085	9,500,000	1,075	10,576,000
7	New York	USA/North America	11,667	8,398,748	10,881	14,281,200
8	Istanbul	Turkey/Asia	5,196	15,519,267	2,620	365,267
9	Manila	Philippines/Asia	1,873	1,780,148	1,830	21,307,852
10	Lagos	Nigeria/Africa	1,965	13,463,000	1,058	7,874,435
11	Paris	France/Europe	2,509	2,148,271	2,404	10,096,536
12	Kiev	Ukraine/Europe	1407	2,967,360	12,695	407,640

* Prepared based on personal data of research, reports of the UN, the World Bank and the Statista service [27-30]

Figure 2.2 shows the types of land use, divided into the following groups: large areas of agricultural land are indicated in white, light gray areas are uncultivated lands, dark gray areas are semi-developed lands, and neutral gray are of mixed type. In the study context, land plots are identified by the types of their use for visualization and communication between urban centers and neighboring land plots. For example, a significant amount of land is used for agricultural purposes (farmland) in Europe and central North America. They serve to provide food to densely populated areas and large cities of the region. Although most of India's territory and the eastern regions of China are densely populated, it was challenging to determine land use in these areas. In Figure 2.2, large metropolises are located mainly in territory related to agricultural land or other land plots. Nine cities from the selected

group for the study are located on the coast of the oceans due to the availability of convenient transport routes, the historical development of events, and the favorable geographical location of such cities.

Information was collected on the total volumes of land plots used for urbanization to conduct a comparative analysis of the largest cities in all countries. Such data collected and analyzed represent the total amount of land used. The information proved helpful in benchmarking to determine the proportion of the total urban land area used by the country's largest city. Data on the area are presented in sq. m. km., and the cost of urban land is in US dollars. The total area of urbanized territories in selected countries:

1. USA - 80203 sq. m. Km. (9147420 sq. km. total area of land),
2. Mexico - 102418 sq. m. Km. (1943950 sq. km. total area of land),
3. China - 380679 sq. m. Km. (9388211 sq. km. total area of land),
4. Ukraine - 32600 sq. m. Km. (579320 sq. km. total area of land),
5. France - 86463 sq. m. Km. (547556 sq. km. total area of land),
6. Japan - 108678 sq. km. Km. (364550 sq. km. total area of land),
7. Brazil - 134981 sq. m. Km. (8358358000140 sq. km. total area of land),
8. India - 222,688 sq. m. Km. (2973190 sq. km. total area of land),
9. Egypt - 24270 sq. m. Km. (995450 sq. km. total area of land),
10. Turkey - 44090 sq. m. Km. (769630 sq. km. total land area),
11. Philippines - 10817 sq. m. Km. (298170 sq. km. total area of land),
12. Nigeria - 17196 sq. m. Km. (910770 sq. km. total area of land).

However, it should be noted that it is difficult to establish a direct correlation between the size of megacities and the countries in which they are located. So, for example, the area of the largest cities in the world as a percentage of the total area of urban land use of the country is:

1. Tokyo - 7% of Japan's total urban land use area,
2. São Paulo - 8% of the total urban land use area in Brazil,
3. Manila - 17% of the total urban land use area of the Philippines,

4. New York - 14.5% of the total urban land use area of the United States of America.

The city of Kyiv is an exception, and its area is 4% of the total area of urban land use in Ukraine. However, a simple analysis of the map shows that most of the official part of the area of Kyiv is occupied by green spaces without any buildings.

It should be noted that the data in Table 2.2 are the area of cities and suburban areas, as well as the population in the city and the surrounding area. The data represent the capital region, defined separately in each country. The data in Table 2.2 are arranged by the population size of large cities (megacities). Cities are divided by country and continent to understand better the regional characteristics of the world's major cities. Most cities have a densely populated and small central part and a disproportionately large suburban area, where many people usually live. However, some exceptions exist, such as Kyiv, and Istanbul. At this stage, the reason for this may be the historical features of the development of cities and their economic development, as well as various factors of land use and territorial development.

To date, there is no single definition of urbanization or the process of urbanization at the state level. Therefore, one of the tasks of our study is to determine the main components of urbanization and provide a classification of economic indicators and aspects of land use in this area of research. We looked at how urbanization is defined by international organizations such as FAO, UN, and UNESCO and also reviewed how cities are defined in some highly urbanized countries.

The problem is how we classify an urban center, its characteristics, and which areas to include or exclude in its composition. Urbanization in a broader context can be defined as the city's official boundaries, the location and size of industrial and agricultural businesses, and the number and density of the population. International organizations provide broader concepts of city classification, emphasizing economic, social, and land aspects.

The city's development is based on spatial development, transport infrastructure, road surface quality, natural and food resource centers, clusters of

local communities, etc. Some cities may not be classified as national but as international cities. These include, for example, large metropolises in the European Union, such as Paris or Berlin, London in the UK or Hong Kong. Particular attention should be paid to how we classify future cities and newly formed urban clusters, for example, in Africa or Latin America, because they have their own rules and a particular development context.

Figures 2.3. Moreover, in 2.4, the author presents the studied data on the classification of urbanization at the international (Figure 2.3.) and national levels (Figure 2.4). The primary data collected, processed, and used in this study are shown in Table 2.3. Table 2.3 provides structured information on the terminology of urbanization and its components that a particular organization and country order, the key components of this definition, as well as the research areas and subsectors based on which this definition is based.

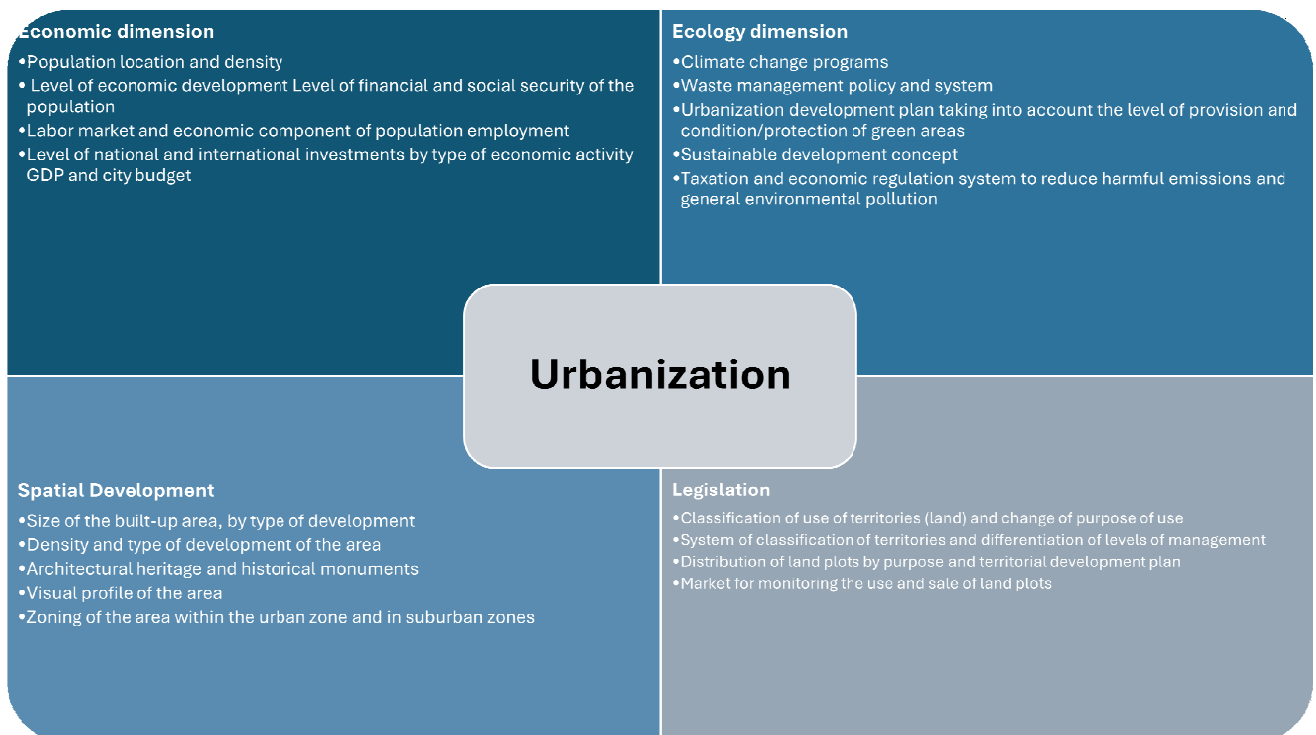


Fig. 2.3. International Level of Urbanization



Fig. 2.4. National level of Urbanization

Table 2.3

Urbanization: Terminology, Definition, Components*

Definition**	Fields of science Fields of study	Organization Country	Description Key components
Urbanization Urbanization	Economic and sociological data	UN	Size of cities and population dynamics Urban growth and city limits Environmental consequences
Sustainable Urbanization Sustainable urbanization	Ecology Sustainability Environment	UN	Economic, Financial and Social Aspects of Sustainable Urban Development
Sustainable cities Sustainable cities	Ecology Sustainability Architecture	UNESCO	Smart City Architectural heritage and historical monuments Sustainable Development Plan
Impact of Urbanization Impact of urbanization	Agricultural sector Politics and management Green City	FAO	Planning and policy of economic development of rural areas Food and social consequences

			of urbanization Green City Planning and Concept
Cities and urbanization Cities and urbanization	Management Legislation Climate and natural resource management	World Economic Forum	Socio-political aspects of city management Urban management and economic planning Financial, investment and environmental economic planning and policy
Urban development Urban development	Economic growth Sustainability Spatial development	World Bank	Urban population and dynamics Urban Sustainable Development Planning Urban Economy, City Development and Urban Planning
Urban Agriculture Urban agriculture	Agriculture Land Politics and management	American Planning Association, USA	Green space Economic development of suburban and rural areas Local politics and governance Planning of agriculture in the city area and its provision of food
Urbanization Urbanization	Sociology Economic development	Britannica, USA	Classification of calculations Definition of urban economy Size of the city square
Urbanization Urbanization	Definition of terms	Merriam-Webster, USA	History of urbanization Determination of the state of urbanization
Urban land area Urban area	Land use and development Geography	Our World in Data, United Kingdom	Size and dynamics of urban land area Population density and statistics Urban and rural population mapping
Urban definition Definition of urbanization	Population and social research Definition of terms	Bureau of Population Research, USA	Regional and international classification of settlements Statistics and Population Growth Prospects

Urbanization Urbanization	Economic and social development	Institute for Policy Studies of the Ministry of Finance, Japan	Population growth and dynamics Centralization of cities and decentralization GDP and employment statistics, planning
Urban living Urban housing	Population and social research Management	Deutschland.de, Germany	Urban and rural statistics Living conditions and economic equality
The Urban Informal Economy Soft informal economy	Sociology Economic development Planning	Urbane, Germany	Planning Allocation of land plots Economic Plan for Small Business Waste Management Future planning and policy
Big city	Economic and sociological data Political studies	National Institute for Strategic Studies, Ukraine	Political, economic and social aspects of the development of the city, definitions and statements. Infrastructure development and long-term planning of the city
General Scheme of Planning of the Territory of Ukraine	Spatial development Planning Real Estate Economics	City 2030, Ukraine	Dynamics and planning of the housing stock Mortgage policies and regulations Financial Real Estate Statistics
Agglomeration process	Definition of terms Politics and management	Government website on decentralization, Ukraine	Definition of metropolitan agglomeration and legal regulations State policy of centralization and decentralization in the context of the city Administrative division of settlements

* Prepared based on personal data of research from additional sources [1, 3, 4, 46, 58, 59]

** Terms and definitions are presented in the original language

It should be noted that the peculiarity of Ukraine, as a young state, is the very intensive development of specific administrative-territorial units, particularly its capital, Kyiv. In practice, there is a big difference between what is planned by the government or local authorities and the actual land use situation. Many authors note in their works the existing problems with outdated regulatory documents and conclude that it is expedient to develop new microeconomic models based on urbanization. However, in their research, they do not consider or do not consider and do not use comprehensively all the completeness of information and the interconnection of various factors related to the city's development. In our work, we try to comprehensively analyze the main factors that have an impact on the economy and urbanization, such as urban planning and design, environmental situation in and around the city, strategic planning, economic and financial planning, as well as the use of land resources and essential factors for the formation of real estate prices in Ukraine, primarily based on data and research on the development of the city of Kyiv.

It is important to note that in Ukraine, there is a significant discrepancy between actual data on development, economic and environmental indicators, master plans, legislative acts, regulations, and state standards and norms. The authors note that the existing system of legislation does not fully disclose or provide them.

The above information was considered, analyzed, and considered; a significant number of publications, information and documentation, data of the state register, statistics, and regulations were processed. We will not give their assessment or offer our statement. First, we want to substantiate and build a general economic model of urbanization for Ukraine. First, let us focus on studying the city of Kyiv and comparing it with other cities in Ukraine and the world. Moreover, the developed model should consider the existing developments and information and present them in the modern development of urbanization and the city's economy as a whole. After conducting a detailed analysis of the sources of information in the literature, the authors concluded that in their research, it is worth considering the experience of European, American, and Chinese researchers, using their analysis and developed

models. However, the primary focus should be on more global microeconomics systems and the interrelations of urbanization processes at the macroeconomic level as an important factor that has not yet been thoroughly investigated. It should be noted that the prominent scientists who studied these issues in Ukraine are Tretiak A.M., Dorosh O.S., Ibatullin Sh.I., and others.

Large and medium-sized cities and their suburbs and surrounding villages form urban clusters or conglomerates. Such clusters are undoubtedly a key factor influencing regions' regional and local economic development and growth [15]. Urbanization is an ongoing process at the forefront of regional transformations and can affect a country's economic growth rate. It can also play an important role on an international scale, affecting neighboring countries somehow. Urbanization is an important factor in the development of the economy of both the city and its neighboring suburban areas.

As the central cluster of the city develops, it can attract resources from neighboring regions and have a negative long- and medium-term impact on their development, slowing down or even regressing their growth. At the same time, suburban areas directly related to the city may become part of the city and affect its economic development. Such impacts are observed at the level of both individual households and businesses. From the point of view of city and regional management, such urban centers are a challenge for suburban areas. In general, forming such centers requires that the economic development plans of cities be changed and new decisions be made with a long-term vision and planning. This requires a new approach to how we see the distribution of the city in the context of our proposed division into the Central Business District (CBR), the Central Urban Area (Zone 1), and the neighboring suburban areas (Zone 2 and Zone 3).

With this work, the author lays the foundation for building a reliable economic model of relations within cities between the CBR and suburban areas in the future. Kyiv was chosen as the object for such scientific work. Kyiv and its suburban areas are an example of new urban planning. The urban agglomeration is one of the

region's largest and fastest growing in Ukraine in terms of economic development [60]. The author acknowledges that the data analysis is limited in scope and does not consider the development of some cities in the suburbs of the capital or how this growth has occurred in the last decade. In addition, one of the key factors in studying the growth of a city is an open market for land and prices, but Ukraine is currently at the stage of transition to such a market so that this case will be considered in future studies [61].

The Kyiv City CBR and the three main suburban zones, Zone 1, Zone 2, and Zone 3, are shown in Figure 2.5.

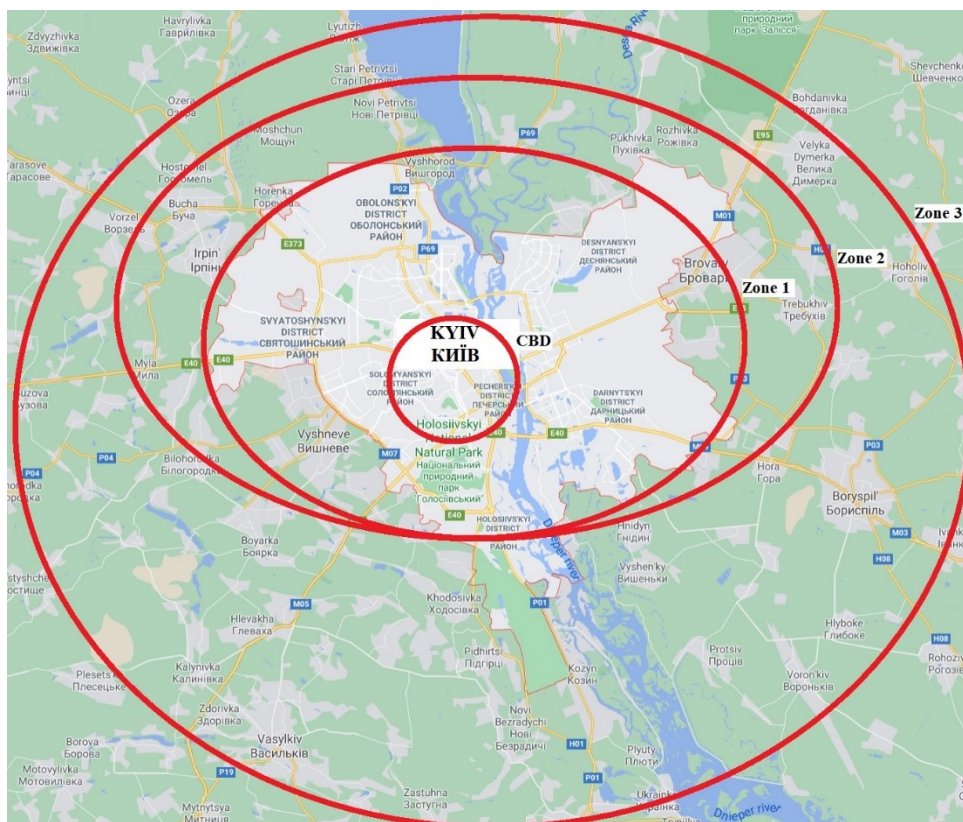


Fig. 2.5. Kyiv: Urban and Suburban Zones

The zones were determined based on the activity of business structures, residential areas, the official administrative division of districts, and transport infrastructure development. The CBR covers a significant part of the Pechersk district and parts of the Holiivskyi, Podilskyi, and Shevchenkivskyi districts of Kyiv. The city of Kyiv, except for the CBR, is presented as Zone 1. Zone 2 includes the most

extensive satellite cities of the capital, such as Brovary, Irpin, Bucha, and Vyshneve. Zone 3 consists of cities all within 50 km of the CBR.

It should be noted that prior to Russian invasion and war in 2022, there were eight large cities in Ukraine with a population of more than 500 thousand people [104]. Among such cities, more than one million people live in three, these are:

- Kyiv (2.9 million people),
- Kharkiv (1.4 million people),
- Odesa (1 million people).

While just under a million people live in cities such as:

- Dnipro (990 thousand),
- Donetsk (900 thousand),
- Zaporizhzhia (731 thousand),
- Lviv (724 thousand),
- Kryvyi Rih (619 thousand).

In terms of total area, the city: Kyiv (847 km²) is the whitest city in Ukraine, followed by Kryvyi Rih (430 km²), Dnipro (409 km²), Kharkiv (370 km²), Donetsk (358 km²), Zaporizhzhia (331 km²), Odesa (162 km²) and Lviv (149 km²) [104].

Such a discrepancy between the population and the area of cities is because Kryvyi Rih, Donetsk, Dnipro, and Zaporizhzhia have extensive industrial facilities located within the cities and occupy a large city territory. Large cities are developed mainly by annexing nearby settlements and changing the options for using the territories of suburban areas: forests, agricultural land, and general land. It should be noted that in the context of new reforms, formation, and development of ATCs, the use of land territories has undergone significant changes, primarily in terms of regulations and changes in their subordination.

2.2 Economic and Ecologic Indicators

In the modern world, urbanization is becoming increasingly developed and rapidly spreading from west to east. It was expected that by 2020, the population in urban areas would increase, for example, in Asia by 1.2 billion and in Africa by 0.9. China is the leader in economic development and population in urban agglomerations [32].

The development of high-tech enterprises has created modern, unique ecosystems, such as Silicon Valley. Such ecosystems contribute to the high growth of their investment attractiveness and an increase in investment volumes both in the short term and in the future. For example, in 2014, the total investment in the US economy was estimated at \$456 billion, while \$348 billion was invested in the Chinese economy. These data were obtained from a report by the UNESCO Institute for Statistics [33].

An interesting factor for the study, according to the authors, is the fact that, for example, the city of San Francisco, being the leader in terms of investment and economic growth, is not a leader among the urban centers of the region, according to 2010 data, it ranks 13th in the United States in terms of total urban population, and 6th in terms of the population of the agglomeration. The urban population growth here was about 1.03% in 2016, but this region has sharply increased real estate prices. This situation differs significantly in developing countries such as India, Africa, or Latin America [34]. In these countries, as a rule, economically successful areas and cities contribute to a high level of urbanization.

One of the hypotheses that we put forward is that the national level of urbanization directly depends on economic stability, level, and GDP growth. It is also necessary to consider that regional features and the general level of development of the country, including the number and density of population in urban agglomerations, affect the overall level of urbanization.

Throughout the scientific work, real-world economic and social indicators of urban development have been studied to help researchers formulate the concept of urbanization as a process deeply related to land use. We investigated the issue of land use, namely: What is the difference between different cities, and whether it directly depends on the economic data of the city's development? This information can be used in economic forecasting and land-use planning for Ukraine and other developing countries with new urban centers of regional influence. To achieve our goals, we selected the most considerable cities from different continents – Asia, South and North America, Europe, Africa, and the capital of Ukraine, Kyiv, which will serve as an example for comparison. The main economic, social and environmental indicators that have been analyzed and investigated to differentiate urbanization profiles are shown in Table 3.5. To build such urbanization profiles, data on the following indicators were studied and analyzed:

- national currency;
- GDP growth rate, %;
- annual GDP growth rate, %;
- unemployment rate, %;
- inflation rate, %;
- interest rate, %;
- trade balance, mln. UAH;
- Current state of the city budget, mln. UAH;
- national debt, mln. UAH;
- position in the ease of doing business ranking, position;
- expectations of enterprises regarding the prospects for the development of their business activity by types of economic activity, index;
- indicator of economic sentiment, index;
- Volume of investments by types of economic activity, mln. UAH;
- profit of companies by types of economic activity, mln. UAH;
- city budget and expenditures;

- participation in international, national and city programs for sustainable development and combating climate change;
- city waste management programs
- labor market and general social security of the population;
- social and economic of households;
- climate and weather monitoring data;
- and others.

When performing the work, data taken from the reports of the UN World Organization, the World Bank, and the Statista service were used, namely research, economic analysis, and numerical data. We analyzed spatial and global map data to determine cities' positions and provided a classification of land areas according to the category of their use. The main research methods are system analysis and data modeling; data tables were used to organize and present each city's relative economic and social data. Graphs and figures are used to present the practical results of the research and outline future states for sustainable development planning.

One of the new methods of research and forecasting for the further development of the economy is socio-economic forecasting (Table 2.5). It should be noted that this approach focuses on macroeconomic research and operates with data and objects at the level of national research and society. The author believes the above approaches cannot be directly used for qualitative assessment and modeling of urbanization development because cities are independent, separate, complex objects related to the national and regional economies and affect the environment.

To build a model of environmental and economic forecasting, it is necessary to take into account the prices per unit of area and the total cost of plots or real estate, options for the growth of the territory - rent, rent, sale, determination of economically feasible options for the use and purpose of land resources in the context of urbanization development. It should be noted that urban area and urbanization are distinct concepts; in his work, the author incorporates aspects related to the city into the concept of urbanization. In the future, macro- and microeconomic data should be

fully considered, especially those closely related to environmental forecasting and social development of territories, communities, society, and the state. In order to work out the above list of data in the chosen field of research, the author considers it appropriate to build a new ecological and economic research system, taking existing methods as a basis and using an innovative approach to system modeling.

Table 2.5

Research Methodology: Economics, Sociology and Ecology

Methodology	Field of study	Constituent parameters and data
Information Collection	Economics Ecology Sociology Earth Sciences	Data collection Data Processing Data cataloging Data analysis Data structuring
Description of the theoretical model and research framework	Economics Ecology Sociology Earth Sciences	Analysis of existing theories Development of the model concept Description and justification of the research framework Development of your own hypotheses
Econometrics	Economics	Statistical methods Quantitative data Regression modeling Preliminary hypothesis (initial)
Score	Economics	Economic assessment Social assessment Environmental and Economic Strategic Environmental Assessment
Modeling	Economics Ecology Sociology Earth Sciences	Economic modeling Socio-economic Ecosystem modeling Land Use Modeling
Prediction	Economics Ecology Sociology	Economics Socio-economic Ecological Environmental and economic



Fig. 2.6. Ecological and Economic Research Diagram in Urbanization

Figure 2.6 schematically presents the environmental and economic components of the environmental and economic forecasting study. An important ecological and economic study component is the economic assessment and quantitative data analysis for further forecasting situations. In the context of the study of the environmental component, it is worth highlighting such components as developing and implementing a plan for the sustainable development of territories and the city at the national and municipal levels. Based on the data presented in Table 2.5 and Figure 2.6, a scientific hypothesis has been formed, and a preliminary concept of the economic development model under the influence of economic and environmental factors of influence and emergency events (crises) has been developed. The given model represents the change in the level of GDP growth in three dimensions - the predicted (better) scenario, the scenario of the economic crisis, and the scenario of several environmental crises.

The modern economy is associated with industrialization, the development of cities, and new technologies. The new reality is that the gross domestic product (GDP) of individual cities, regions, or districts is more significant than its value for some developed countries, and the population density in such a region increases several times per year. All this forms a new economic situation: an economy associated with the city as an urban center. Therefore, in the future, it is worth focusing on studying the factors that define prosperous cities as constantly developing cities. It is also necessary to investigate which economic factors dominate the new centers instead of the classical approach. The authors consider it expedient to investigate a set of environmental factors, the presence of real estate in suburban areas, because they affect the increase or decrease in population growth and, in the future, can have a significant weight in developing the city into an urban center.

The main economic, social aspects, generalized factors and research data that were collected, processed and used to build the economic component of the forecasting model, namely: the main micro- and macroeconomic indicators of the study in the context of regional, national and municipal planning and development: consumer spending; exchange rate; gross domestic product; GDP per capita; gross national income; stock market; interest rate; public debt; inflation rate; Unemployment; trade balance; real estate prices; resettlement and resettlement of people (mobility of the population), development of urban infrastructure; investments in the development of the city and their forecasting; land resources (lease, purpose, use and consequences); human behavior and decision-making as a social context of urbanization; economic and financial crises - bilateral impact on the development of cities; urbanization as a general economic model; territorial zoning and planning with a forecast interval of 1, 5 and 20 years; ideal city model, pragmatic model, and realistic city model; population density; territorial zoning in the city, inflation rate, etc.; in addition, data on the number of available dwellings (vacant, rented and under construction); transport network; park areas/zones and infrastructure coverage.

Table 2.6

Main Economic Indicators of Urbanization Development*

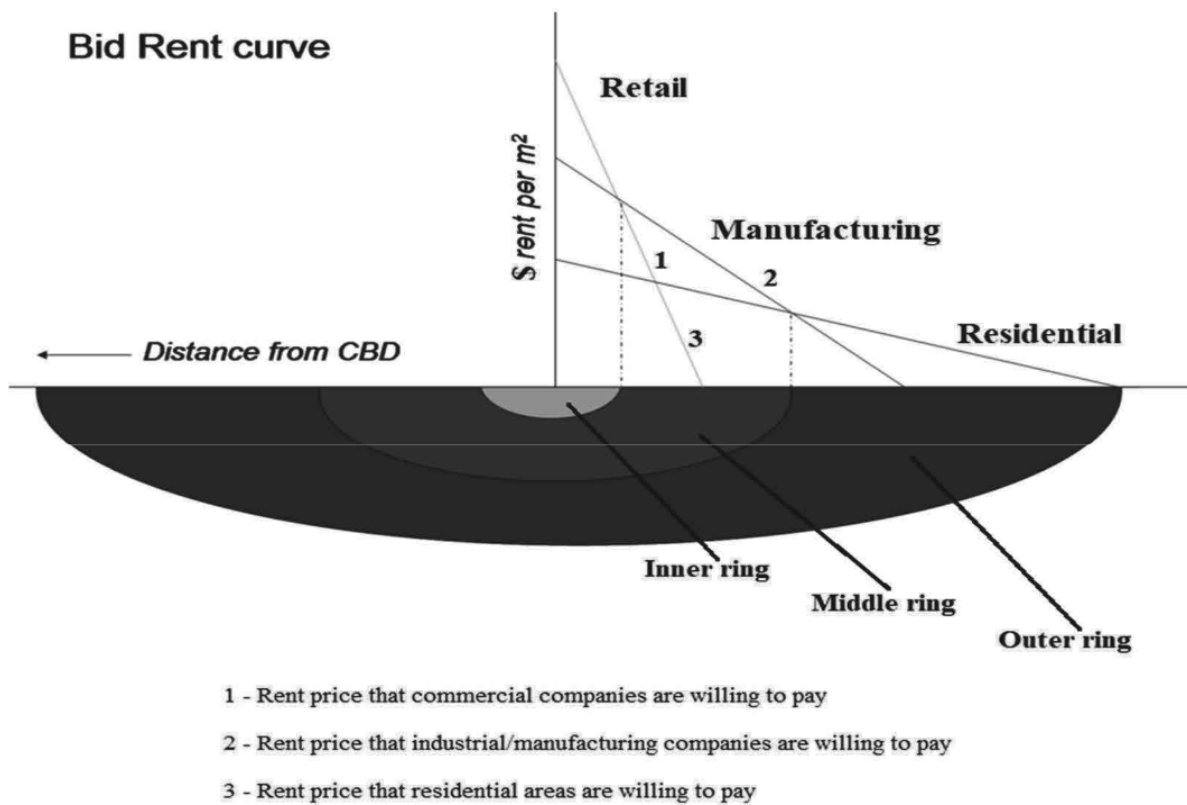
Economic indicator	Components	Influencing factors
State budget	GDP Inflation NBU rate Level of economic development	Direct
City budget	Expenditures Profits Tax rate Development and internal investments	Direct
Social Costs	Community projects Payments City services	Not straight
Construction and development of territories	Energy Engineering networks Roads and transport networks Waste Management Green areas, natural areas and parks	Direct
Employment	Unemployment Average monthly salary	Not straight
Investment	Internal; External Direct; Indirect By types of economic activity	Direct
Green economy	Environmental monitoring Green tax Alternative sources of energy Reclamation and restoration	Direct

For further research, we propose to determine the economic coefficient of urbanization based on the data in Table 2.6. It should be noted that real estate, land, and property are important elements for determining the given coefficient, so it is necessary to investigate each economic aspect of the impact on the level of

urbanization development. The leading economic indicators of the development of urbanization processes are state budget, city budget, social spending, construction and development of territories, employment, investments, green economy, and others, and their main components are given in Table 2.6, determined depending on their impact - direct or indirect, on the economic development of urbanization (urban areas).

The field of economic research is the central part of urban studies. Some many tools and techniques are available to a researcher working in the field of urban economics. One of the most commonly used and effective tools is the rental rate curve and gradient (Fig. 2.7) [46]:

- R_i = maximum rent or price that a particular user can pay for urban land at a specific point i , dollars/acre;
- D = density of land use in leased areas, sq.ft/acre (varies depending on the type of activity and depending on current regulation and zoning);



$$R_i = D * (r - c) - D * t * d_{ic}$$

Fig. 2.7. Rent Curve and Gradient of Economic Components Study [45, 46]

- r = income received from activities per unit area (depending on the types of activities);
- c = costs to generate this income, in US dollars/unit area (depending on the type of activity);
- t = transportation costs, in US dollars/unit area;
- d_{ic} = distance from the point in question to the point of maximum availability, in miles;
- $(r-c)$ the profit that will be generated per square foot of leased space: higher for a large department of the store and exclusive office space for the headquarters of the corporation; lower for low-cost housing or production that requires land;
- $D*(r - c)$ - the profit to be made per acre of land: it becomes quite high even for inexpensive housing, if the density is high enough;
- $D*t* d_{ic}$ - the cost of transporting people (and goods) that must get to (and from) the object every day: the denser the use of land and the greater the number of people using it per square unit of area, the more expensive the cost will be from the point of work/departure to the home and workplace of each person [46].

It is used to analyze the prices of renting land or real estate for various purposes (commercial, industrial, or residential) and to display points of market equilibrium. It also shows the optimal (finance-related) distance from the central business district to the planned new construction site. This model is divided into four main zones in the city: the central business district, which is also part of the central intra-city ring zone, the middle ring, and the outer ring zone. Computing and information system tools are used to construct similar curves. The quality of information is one of the keys determining factors in the construction of lease and gradient curves. Machine learning tools (software) can be used to conduct future research or work with extensive input data to build optimal rental models.

Land use and land management are an integral part of the economics of urbanization, which are investigated in research work. One of the key components of

land use within the framework of urbanization processes is determining the value of land use. Many social, economic, and market factors affect the calculation of potential costs. As part of the study of cities and urbanization processes, we focused on several key factors that play an important role in price modeling. For convenience, we have divided land use and land plots in cities and suburban areas into five total areas – domestic, farmer, industrial, public institutions, and green spaces. These five types of areas and their economic factors are presented in Figure 2.8. In addition to the general price of real estate, land use rules, property care, and environmental costs, other important factors can also affect these processes.

Table 2.7 contains the summary results of the primary socio-economic data for these four zones [62-63]. The key socio-economic parameters we study are the average distance from the Zone to the CBR, the average population of the Zone, the number of employed workers in the Zone, and the average monthly salary per employee.



Fig. 2.8. Direct and Indirect Economic Costs Factors of Land Use: cities context

[67-70]

Table 2.7

Kyiv Economic Data: Urban and Suburban Areas

Indicators	CBR	Zone 1	Zone 2	Zone 3
Total area, sq. m. Km.	33.66	805.34	1123.6	1545.7
Distance to CBR, km	0	45	31	36
Population, thousands of people	253.1 (11.5% of our population in Kyiv)	2656.4 (91.3% of us. Kyiv)	343.5 (8.5% of population in Kyiv)	436.1 (6.7% of Kyiv)
Median family income, \$ per family per month	1592.5	612.9	375.44	375.44
Number of employees, thousands of people	470.4	673.7	54.4	38.4
Average salary per person, \$ per month	744.15	480.44	494.35	411
The price of the land, \$100 per square meter.	69	35	30	38
Commercial real estate price, \$ per sq.m.	3085	1200	772	348
Housing price, \$ per sq.m.	2316	1641	760	480
Office rental price, \$ per sq.m.	65	31	23	23
Household monthly food costs, \$ per household	640.5	198.46	167.9	167.9
The price of gasoline, \$ per 1 liter.	1.05	1	1	0.9

* Data are prepared based on the results of the study [62, 65]

Another important factor for the study was land prices, commercial and residential real estate, and renting offices (per 1 square meter). To determine the expenses of residents of the capital for accommodation and transportation, we calculated the average monthly household income, food costs, and the price for 1 liter

of gasoline (A-95). On average, a household in the city consists of 2 adults, and these data coincide in Kyiv and the suburbs. The columns with data on the population include indicators in % according to calculations that were carried out based on data on the official population of Kyiv, which is 2909.5 thousand people [64].

Based on the data in Table 2.7, the CBR is the center of activity of business structures and the most expensive zone in the urban agglomeration. The average salary in this zone is 65% higher than in the rest of the city and 160% higher than in Zones 2 and 3. More and more people work in the CBR than live in the area, although its area is only 4% of the total area of Kyiv, which is only about 839 square kilometers. The average monthly food costs of people in zones 1, 2, and 3 are about the same, while in the CBR, they are three times higher.

To collect, systematize, and analyze environmental data, the author conducted a brief review of existing articles and materials. The ecological situation and the state of ecology in different cities are analyzed. It is determined that the state of the ecological situation depends on the size of cities; The more extensive the city, the more significant its impact on the environment.

A similar situation occurs with a significant concentration of city roads, enterprises, factories, and other life support facilities. Harmful emissions harm the environment and ecology, so their indicators and parameters require constant monitoring. It is necessary to consider that the situation in different areas can differ significantly in terms of CO₂, urban emissions, etc. In the future, an assessment and analysis of options for developing environmental situations with further forecasts will be carried out, and positive trends in environmental situations in large cities will be highlighted. Figure 2.9 schematically depicts an environmental monitoring system for studying the situation in cities and adjacent territories. Table 2.8 presents set of basic environmental data, which were subsequently used for analysis and economic assessment of the environmental situation in selected and studied cities.

In order to better outline the main economic, environmental, and other components and factors of influence and comprehensively describe urbanization, it is

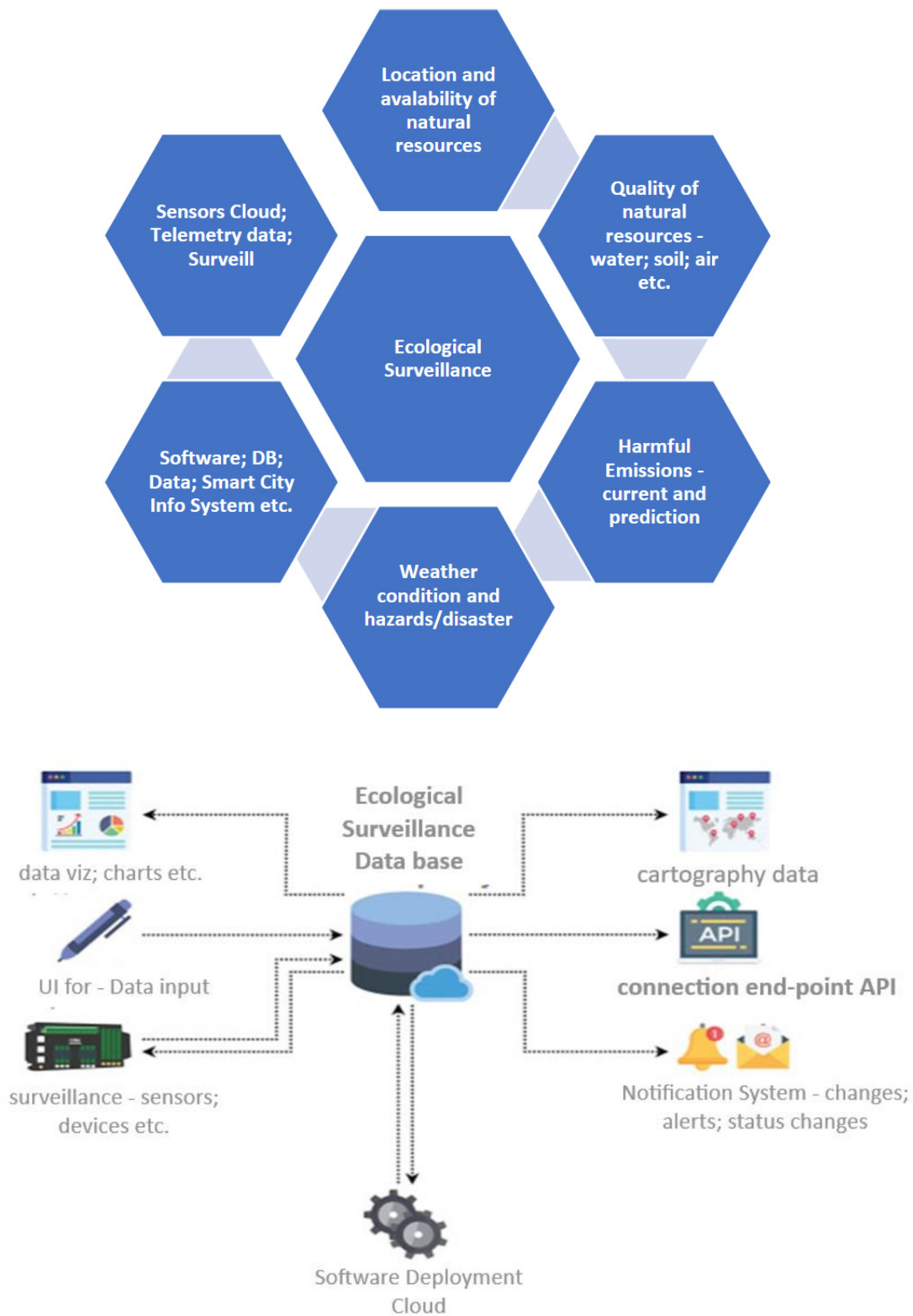


Fig. 2.9. Environmental and Weather City Monitoring System: Schematic Representation

proposed to present the concept of the ecological-economic coefficient of urbanization. Since the land-use component is key to representing and determining

the urbanization coefficient, and land and real estate are primarily the main elements of this component, it is necessary first to study them in detail, describe, understand, and investigate all the components.

Table 2.8

Urbanization Ecological Components*

Data	Category	Characteristics (application)
Climate agreements	Legal regulation	Plan for the sustainable development of territories or cities
Ecological fee Green tax	Financial data Legal regulation	Restoration of natural resources Improving the environment
Energy sources and their distribution, specifications The cost of introducing new technologies Tax on renewable sources	Financial data Legal regulation	Planning (incl. financial) of the introduction of renewable energy sources
Waste Management (Transportation and Storage)	Waste	Waste Policy and Legal Regulation Waste sorting
Recycling and disposal of waste	Waste	New technologies for garbage collection and recycling
CO2 emissions	Harmful emissions	Air condition monitoring Implementation of the new policy and fees and overcoming the consequences
Filling the air with harmful substances and their concentration	Harmful emissions	Air condition monitoring Inspection of territorial objects and various sources of pollution - making appropriate decisions to overcome the consequences and minimize damage

Water Purification and Transportation	Natural resources	Provision of the population and enterprises Economic analysis and planning of processing and supply
Quality and level of soil contamination	Natural resources	Monitoring and regulation Economic calculations for resource recovery
Area, density and specific gravity of forest and green areas	Natural resources	Quality of life of the population Monitoring and regulation
State of the biosystem and species	Ecosystem	Monitoring the state of biosystems Policy and regulation
Geographical location and territorial location (zoning)	Spatial data	-

* Prepared based on personal research data

The second important component of the urbanization coefficient is the economy and economic data, which are factors of influence. Among the main economic factors, the following are worth highlighting real estate prices are the main criteria for determination.

Thus, in this context, division and separate analysis of the formation of economic value and economic valuation of real estate are important based on options for its use, types of purpose, and the context of the territorial zoning system. The next economic factor that should be considered in the work is the coefficient of real estate pricing for a particular zone of the city and suburban areas, and they should conduct their comparative analysis. For the correct mathematical and numerical representation of the real estate pricing coefficient, it is advisable to single out only those factors that directly affect the formation of real estate prices.

In the future, to develop a system of mathematical modeling and forecasting of values, it is worth investigating how much the pricing coefficient in the city affects and depends on economic data on the development of suburban areas. What are the main environmental factors influencing it and other factors that indirectly affect it? In addition to the primary factors listed above in the formation of the economic component of the urbanization coefficient, there are several secondary factors and factors, among which are the country's GDP indicators, the taxation system (primarily real estate and the discount rate), the national currency and its exchange rate (exchange rate change) against the US dollar, the employment market and the leading socio-economic indicators of employment, the index of industrial growth and construction, the volume of investment by type of economic activity, etc.

Among the environmental factors that affect the urbanization coefficient, first of all, it is necessary to consider those that contain numerical data, based on which it is possible to conduct an environmental assessment of the level of their impact on urbanization. The importance of a clear definition and classification of territories in the city and its surroundings in the system of territorial zoning and the distribution of lands by their purpose should be noted. Such a system will allow one to describe and systematize the primary economic, social, and environmental data by type of urban area, zoning, and micro-zones of the city.

First at the state level, then at the local level, it is necessary to define and classify terms at the legislative level terms related to urbanization, delimitation of territories, determination of boundaries and boundaries of cities, consider legal, legal and property aspects to understand the actual state of affairs.

To understand and present a step-by-step system for defining urbanization, some basic terms related to this issue have been analyzed and grouped, namely: urbanization; development; city and its boundaries; suburban zone; village; associations (agglomerations, etc.); urban zones; land resources and types\types of classification; types of legal/legal activities in cities (urban areas). One of the tasks set in the work was to provide answers to several important questions: whether the

land and real estate market is directly related to economic issues related to urbanization, analyze the research presented in foreign scientific articles and works, and take them into account; whether there is an objective applied classification in addition to definitions, diagrams, graphs; whether urbanization affects the dynamics of changes in the value of land over time, etc.

In this scientific work, we have established a framework that defines urbanization as a state and process. This structure has four stages of consideration and is divided into two sections, which are presented in Figure 2.10.

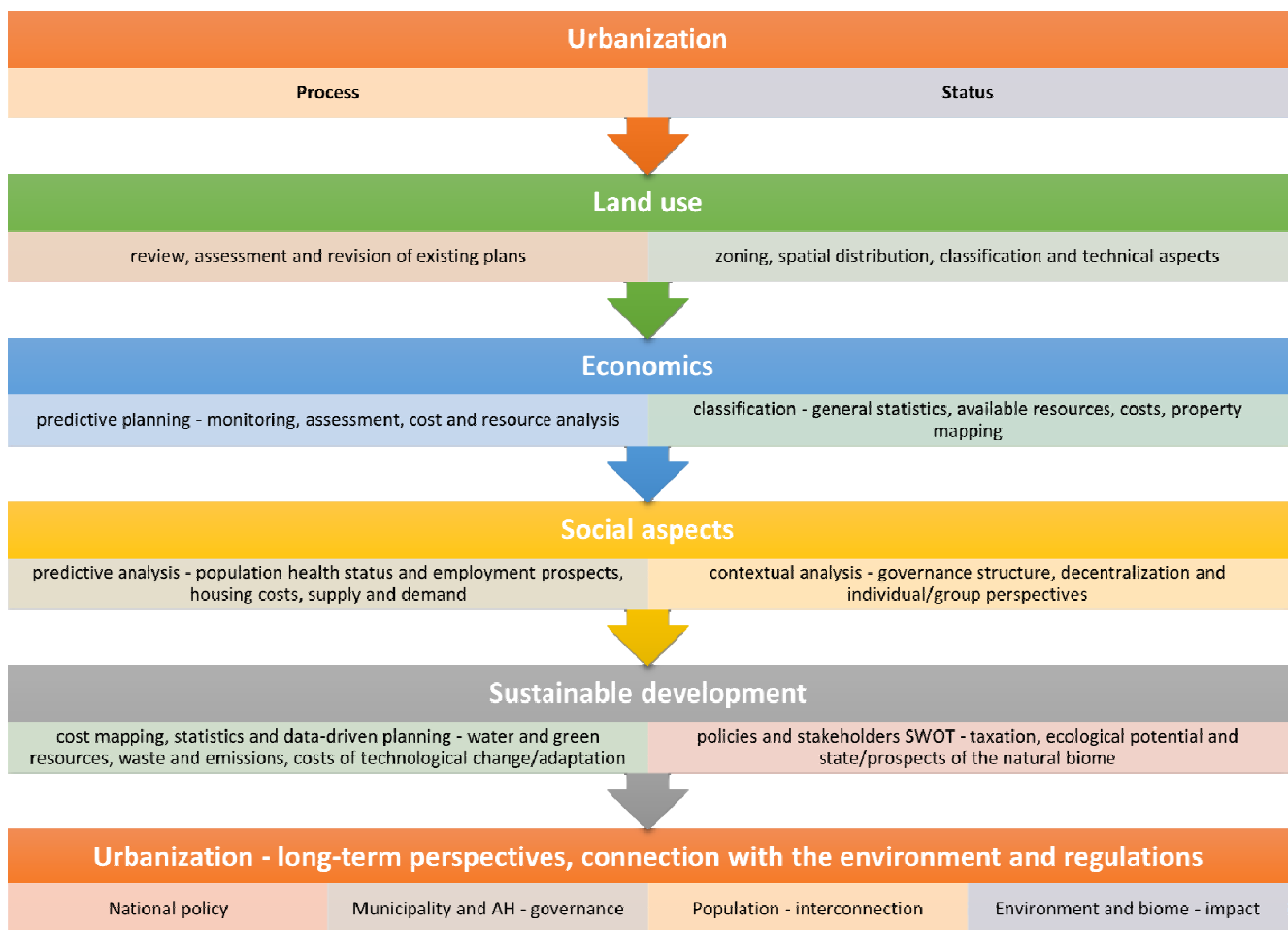


Fig. 2.10. Determining urbanization: Step-by-Step System

The author defines urbanization as the state and process at the intersection of many sciences and fields of study, the international context of its definition, and its legal status. Urbanization in a broader context refers to land use, economics, and social aspects that affect sustainable development planning and have significant

environmental impacts and consequences. This process should be considered not only at the local level but also at the national and international levels. We hope that the classification, definitions, and frameworks explored and presented in this paper will be helpful to scholars in economics and land management around the world, helping policymakers and nonprofit leaders. The author plans to continue studying the framework of urbanization in a broader context and issues related to urban planning, mapping, land use, and urban management.

2.3 Research tools and methodologies: Integrating Data for Comprehensive Evaluation

The study of the urbanization process using an integrated multidisciplinary approach is a new area of scientific research. We define multidisciplinary research as cross-cutting scientific research that fundamentally includes economics, sociology, information technology, land management, and ecology. At the same time, many modern scientific works focus only on specific subfields, such as GIS, spatial development, urban management, technological infrastructure, solving specific problems with computer technology, or real estate market analysis. The author notes the lack of comprehensive, high-quality, and reliable information that will allow for deep analysis and presentation of urbanization as a separate scientific field. Researching and studying an innovative city system without first defining the tools and scientific research methods related to this field is impossible. The author notes that significant progress in computer science has made it possible to carry out more detailed calculations, system modulation, and comprehensive research in this area.

Effective and practically valuable scientific work requires understanding the basic mechanism of all processes and the collected array of knowledge not only in the field of research but also in a set of tools that can be used to carry out such work. Studying urbanization and its components is a challenging task. Urban studies include, among many other areas, research on real estate, land use, public policies

and municipal government regulations, geographic information, and social studies [35]. In addition to sustainable development issues, many modern researchers have been attracted to the concept of green cities and effective planning for using natural resources over the past decade; now, these issues are at the center of their attention. Meanwhile, the current state of urbanization research has presented new challenges and scientific opportunities to work further. It became evident that to continue his research in this area, it was necessary to establish a modern set of tools and methods for their use.

Therefore, one of the tasks of the scientific work was the study and selection of data types, methods for their study, research, and possibilities of further forecasting, as well as tools for economic modeling and urbanization, presented in Fig. 2.11 [20].

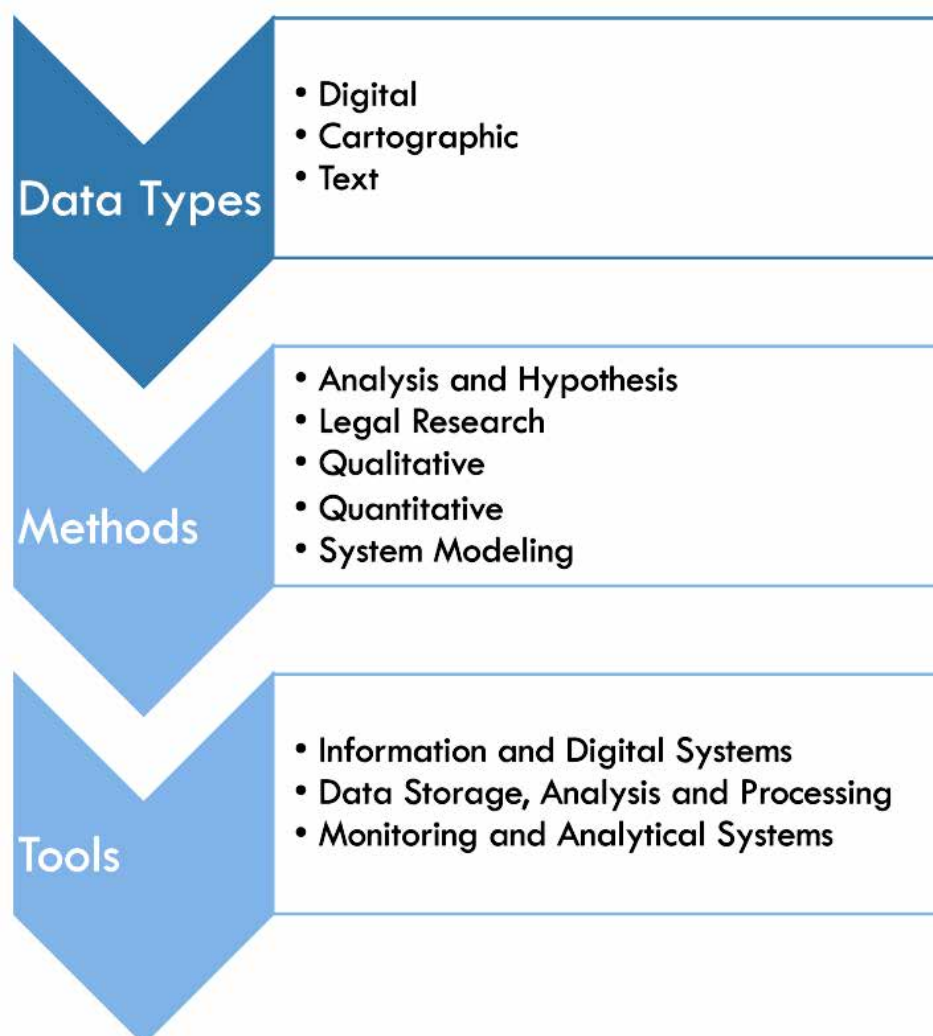


Fig. 2.11. Data types, methods and tools of economic modeling and urbanization studies [1-12]

The primary data types are digital, cartographic, and test to study urbanization. The optimal set of methods for their analysis and processing is determined as follows: analysis and elaboration of the hypothesis of further actions, study of the regulatory framework on this issue, use of various qualitative and quantitative methods, and further system modeling of processes. The tools for conducting such a study are information and digital systems, storage, analysis, and processing of large amounts of data, as well as monitoring and analytical systems. The systematization of data types, methods for their collection, research, and analysis, and selection of the necessary tools will allow a systematic approach to the further study urbanization problems.

The issue of urban planning forecasting in the context of urbanization is associated with using various modern means, including artificial neural networks. The forecasting stages include the following activities: research, project and software development, approbation, and refinement of the draft structure. In the future, in scientific work, scientists review and study relevant scientific sources, and if necessary, change the parameters of the scientific and technical system and develop a system for checking and monitoring the results of such a system.

Modern means and methods of research, modeling, and forecasting allow for solving many problems related to the study and modeling of urbanization processes and the state of urbanization of the territory. Such tools and methods allow you to solve the following problems:

- review, test and analyze existing solutions;
- determine the level of urbanization and development of the territory(s);
- determine the structure and characteristics of the development of territories(s);
- choose the best option for the development of territories (economic, social and/or environmental directions);
- to develop a concept and terms of reference for the development of new technologies that will allow to solve current issues or solve existing problems more effectively more effectively;
- automate the collection, analysis, processing and storage of model inputs;

- conduct short-term hypothesis testing and work out preliminary modeling results;
- analyze existing solutions, methodology and approaches and determine which issues they do not solve or give low accuracy of the results obtained;
- to forecast and monitor the results obtained, compare them with existing ones and conduct empirical research based on them;
- to create a comprehensive multi-layer information system for ecological-economic modulation and forecasting, considering spatial and economic components, land use data of territories and social and environmental characteristics of urbanization profiles.

For effective modeling, it is important to take into account the following factors when developing a model and choosing the optimal set of tools to solve the problem:

- Choose the optimal type of neural network to solve the current problem;
- to present the definition of urbanization and the constituent factors of its influence;
- choose appropriate economic, environmental and general urbanization profiles;
- determine the rate of urbanization (urban development) - provide definition, parameters and quantitative characteristics for calculation.

Modern information technologies can serve as a practical set of tools for a modern urban researcher. Without a doubt, tools such as computer vision and modern information technology will allow us to analyze and classify spatial data efficiently or widely apply advances in machine learning. The above methods and tools make it possible to build reliable models for forecasting the real estate market or accurate urban models using 3D modeling platforms, which provide a strong argument for their use by researchers of urbanization processes. The paper presented and used more than twelve indicators to study smart city data. They are grouped into significant areas of scientific research, such as urban planning, urban services, legislation, and technical infrastructure. The work outlines the main directions of

possible research work. Some fields are at the crossroads of sciences and can be combined to form core research areas, such as doing business, financial research and modeling, e-government, and land management. All of the above research methods can be used to study each specific problem related to the development of the city and the study of urbanization processes.

The author has developed the concept of the cycle of research of the urbanization process, which is presented in Figure 2.12. This concept is based on the method of scientific research and is the result of preliminary research robotics on the study of the urbanization process. This cycle consists of twelve stages, each of which is a separate research stage. Research work begins with defining the problem, outlining the research departments, and determining the scope of the research. The next step will be to search for information as part of the research work. The information for the study that has been collected must be studied, grouped, and analyzed in detail. Once the information was grouped and studied, an initial set of hypotheses was formed, based on which the scientific model was built.

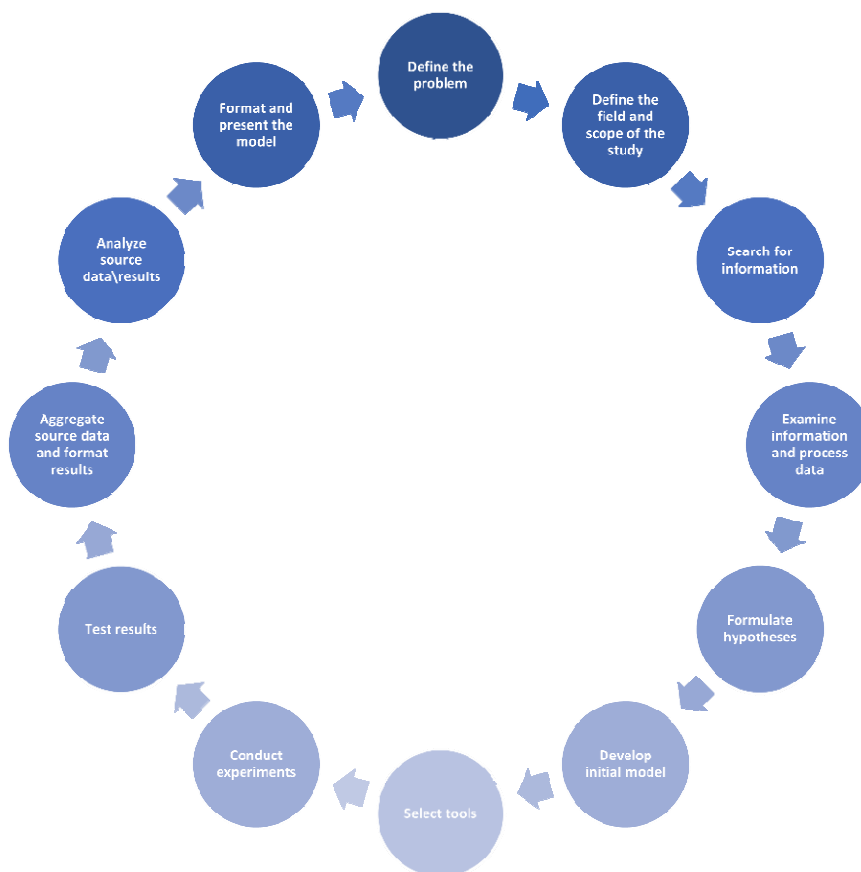


Fig. 2.12. The Urbanization Process Study Concept [25]

The presented scientific model is an iterative sub-cycle of four steps within the framework of the primary research cycle. It starts with the initial model; then, the researcher selects a toolkit to build that model using the selected toolkit. Then, he conducts one or more experiments using data, the output of information that was processed and grouped earlier. After the experiment, the scientist tests the results and compares them with his initial hypothesis, analyzing them based on the information received. If the results are at the hypothesis level, the scientific work's performance can proceed to the next step. Otherwise, the model cycle must be repeated with a new set of input parameters or another set of tools until the results are satisfactory. Once the hypothesis has been confirmed, the study model's initial data is collected, and the results are formatted, which will be presented to the research community. It is important to note the importance of the last two steps of the cycle – the initial analysis and presentation of the research model. They are the main result of the research work carried out and determine the materials to be presented to the scientific community later.

The author studied and analyzed many scientific papers and information on urbanization, land management, and information systems during the research. The author used qualitative research to create an innovative city system in the context of a broad study of complex processes. This method helped us outline a smart city management system's leading economic and financial parameter. Another key result of the research is the understanding of the importance of using the presented tools and methods to create a smart city model – these are land management services emphasizing the use of maps and ground surveillance, services for collecting, processing, analyzing, and providing statistical data. The author uses the method of scientific abstraction, system modeling, and theoretical generalization to build the concept of a smart city and develop requirements for the technical implementation of such a model. This list includes seven main tools and their classification: digital tools and technologies, technical tools, information systems, computing systems, control systems, and analytical and forecasting systems. The information system was divided

into five substantive sections. Three important components that need to be noted were identified: the components of the tool, the types of data used in the tools, and the areas of their application. The main components of the work were allocated, with the help of which a thorough study of empirical data that can be used for a specific study was carried out. While the field of knowledge is vast, the correct type of basic research data is selected for further use, together with a plowed set of tools. The areas of application of the developed information tools and methods were also presented, and a list of research areas of activity where such tools can be used was given.

The scientific research is based on analyzing official statistical data from the State Statistics Service of Ukraine, the Kyiv City Council, the Municipal Enterprise "Kyivgenplan," the State Cadastre of Ukraine, private real estate companies, economists, etc. We used statistical analysis, mathematical correlation, polynomial and linear approximations, ratio analysis, utility curves, profit curves, and growth models. Key economic parameters were identified to provide forecasts. This data was used to build linear models of function dependencies and diagrams based on computational data.

For the scientific work, data taken from the reports of the World Organization, the World Bank, and the Statista service were used, namely research, economic analysis, and numerical data. We analyzed spatial and global map data to determine the location of cities and provided a classification of land areas according to the category of their use. The main methods of scientific research are system analysis and data modeling. The data tables were used to organize and present each city studier's relative economic and social data. Graphs and figures are used to present the practical results of the study and outline future states for sustainable development planning.

In our scientific work, we presented a modern, reliable set of scientific research tools in the field of urbanization research. The author is working on presenting a list of computational and informational tools for the study of systems that will allow one to study the process of urbanization effectively. In addition, in scientific work, we outline and analyze different areas of the urbanization process.

To conduct the study, we considered many scientific papers and information on urbanization and computer science [41]. We used a qualitative method to study urbanization in the context of a broad research field. The quantitative method helped us generate the information for the main table and data used in most urban economic work, which is the change in real estate rental rates and is widely used to model and predict land prices. Another key study question is the study of the equilibrium point in modeling land use forecasting. The author used scientific abstraction and modeling systems of theoretical generalization to build the concept of the cycle of the urbanization process as an iterative, cyclical process.

An important part of modern scientific work is the methods and tools used to study a particular area or subdivision. The data presented in Table 2.9 substantiate the results of our work on the list of the most widely used tools for studying the urbanization process. We analyzed and identified seven main types of tools and provided their classification: computing system, information system, city development master plan, GIS maps, white papers, smart-city, and presented the structure, components, data, and applications. The information presented in Table 2.9 is divided into five sections. There are three important sections that we should especially note: the means of research, the types of these tools, and the areas of application. The constituents presented have empirical ranges that can be used for a specific study. At the same time, the data field designates the primary type of data examined to help form a particular opinion about which one can be used to carry out a specific research work. In the table "scopes" column, we present a list of studies examined in which each method can be used.

Table 2.9

Urbanization Tools Classification*

№	Tool	Components	Data	Scope of application
1	Computing system	Date Mining Machine Learning Computer Vision	Digital Images Numerical data	Data Analysis Image Processing Prediction Systems

2	Information system	Big Data Data Visualization	3D Object Data Digital Images Numerical data	3D Modeling Data Processing, Storage, and Analysis
3	General urban data	Real Estate Market City Statistics	Statistics Land Use Data	Economic Modeling Spatial Planning
4	GIS and Mapping Systems	Aerial Photo Maps Cadastral Maps Satellite Maps	Geographical data and information	Data analysis general modeling and planning Geodesy
5	Official documentation	Treaties Laws Planning Documents Rules Reports	Textual and general information	General economic, environmental and urban planning areas
6	Smart City System	City Management System Monitoring Data	Numerical data	City Management Urban Surveillance
7	Tools and equipment	3D/LiDAR Scanners Surveying Drones	Digital Images Data from sensors	Urban Planning Construction Land Use Planning

* Prepared based on personal research data, UN reports, Britannica [42-44]

Table 2.10 contains twelve indicators necessary to study data on the management and development of the city. They are grouped into significant areas of scientific research, such as urban planning, urban services, legislation, and technical infrastructure. The work outlines the main directions of possible research work. Some fields are at the crossroads of sciences and can be combined to form the main research areas, for example, business, finance, e-governance, land management, etc. Research methods are scientific methods that can be used to study each specific field that functions in a city.

Table 2.10

City Research and Management System Components

Component part	System	Constituent elements	Research methods
Transport and road systems	Urban Planning City Services Legislation Technical Infrastructure	International, national and local road surfaces Airports Rail system Water supply system	Analysis and hypothesis Legal Research Quantitative Modeling of Systems
Critical infrastructure	Urban Planning City Services Legislation Technical Infrastructure	Waste Management Water Resources Management Gas and Gasoline Transit System, Management	Legal Research Quantitative Modeling of Systems
Land cover and spatial development	Urban Planning Technical Infrastructure	Architectural urban planning Construction Real estate market Land use	Legal Research Quantitative Modeling of Systems
Population dynamics, activities and health care	Urban Planning City Services Legislation	Public health Policy and regulation Public transport system Employment and social coverage	Legal research Qualitative Simulation of Systems
Business and tax policy	City services Legislation	Law and regulation Taxation system – local/federal/national Real estate and land market	Legal research Qualitative quantitative modeling of systems
Green City and Sustainability	Urban Planning Legislation	Energy Management Natural Resource and Land Use Planning Sustainable Development	Analysis and hypothesis Legal research Quality

Finance and city budget	Urban Planning City Services Legislation	Financial planning	Legal Research Quantitative Modeling of Systems
E-government	Urban Planning City Services Legislation Technical Infrastructure	Electronic City Public Services Electronic City Control Services	Legal research Qualitative Simulation of Systems
Security and surveillance	City services Legislation Technical infrastructure	City Video Surveillance System City Security and Response System	Legal research Quality
Power system and energy management	City services Technical infrastructure	Power Management and Distribution Security and surveillance of energy systems	Qualitative quantitative modeling of systems
Data Management and Forecasting Systems	Urban Planning City Services	Analytical and predictive information system	Quantitative Modeling of Systems
Tourism, green spaces and natural resource management	Urban Planning City Services Legislation	Planning of green spaces of the city Planning of tourism Management of natural resources	Analysis and hypothesis Legal research

Conclusions for Chapter 2

The concept of studying the process of urbanization as a multidimensional study in the context of global, regional, national, and local levels, based on the study of models proposed by leading American urban scientists, has been developed. Large cities and megacities in different regions of the world, including Ukraine, were selected for further study. Based on the processed and analyzed data, a basic model of profiles of urban studies was proposed, considering data on the territories adjacent to the city and the dynamics of changes in economic, social, and financial conditions to model the dynamic states of urbanization processes.

Structured methods of studying branches and sub-sectors of urbanization as a separate science are presented. A system has been developed for classifying the main tools for studying urbanization processes using mathematical and economic research methods, based on which a comprehensive system of computer modeling of urbanization and an overview of the main tools for geoinformation modeling in the context of scientific research have been carried out.

The leading economic, social, financial, and environmental indicators have been collected, analyzed, processed, and structured to create an information model of data on urbanization processes, which are further used for system modeling and forecasting land-use changes.

The key sectors and indicators of socio-economic development as components of urbanization and their relationship with land use in the context of urban and territorial planning have been identified. The components of the city research and management system are described, based on which the following models have been developed: city management system, system of key city institutions, and essential city services. The division of the city of Kyiv and adjacent territories into three zones and a separate Central Business District is proposed based on the calculation of fundamental economic data on the city of Kyiv and suburban territories and the system of territorial zoning. The factors of direct and indirect economic costs of

land use in the context of economic development of cities have been established, taking into account data on suburban areas, territorial distribution, urbanization classification model, and empirical studies based on territorial zoning of the city of Kyiv.

An analysis of the current state of development of urban and suburban territories in different countries of the world is presented, which confirms the hypothesis of the feasibility of a more global approach to the description of options for the development of urbanized areas, which will include the actual state of the boundaries of urban development and suburban areas, data on what can be attributed to the city zone and the spatial location of the leading industrial facilities and areas of work of the urban population, at the same time, taking into account the official policy of the state regarding the definition of city boundaries and the interpretation of urbanized areas.

3. EXTENDED MODELS FOR URBANIZATION ANALYSIS: STATE, PROCESS, AND ECONOMIC REPRESENTATION

3.1 Urbanization as a State: Key Parameters and Indicators

The paper analyzes the current state of land use by category and regional economic and financial data to build and propose a new modern model of cost-effective land-use planning for commercial and non-profit enterprises. The research results serve as important material for decision-making when planning the development of land plots and urban areas in the context of new global economic development. A broad overview of Kyiv's existing land use trends is provided based on analytical data and scientific assumptions. The author believes that this study will be helpful to government agencies, city authorities, international organizations, private institutions, and researchers. Fig. 3.1 describes the prospects of spatial development in urbanization, including land resources, the latest technologies, built-up areas, and structures with information about each component.



Fig. 3.1. Prospects for Spatial Development in Urbanization

An urban area is defined by one or more of the following data: administrative criteria or administrative boundaries (for example, an area within the jurisdiction of a municipality or city council), a marginal population (where the minimum for an urban settlement is usually 2000 people, although this figure varies from 200 to 50,000 people worldwide), population density, economic function (for example, where a large majority of the population is mainly not engaged in agriculture, or where there is a surplus of employment) or the presence of characteristic features of the city (for example, asphalted streets, electric lighting, sewerage, etc.) [58-59]. In 2010, 3.5 billion people lived in areas classified as urban [58].

Urbanization is a property or state that allows a settlement to become urbanized or a process of urbanization formation [58]. It can be attributed to moving from a country (rural area) to densely populated and large settlements. The most urbanized areas are the United States, European countries, India, Brazil, and East Asian countries such as China, according to a 2014 UN report [58]. There is a common misconception that most of the urban population lives in the central area of the Metropolis. In contrast, in most highly urbanized countries, most of the population lives in small suburban satellite cities and towns around the city [58].

No standard definition would define an urban area or urban population and how it differs from suburban or neighboring rural settlements [59]. Most, if not all, countries have their definition of city and urban conglomeration. As a result, statistics can often mislead us, or we can misinterpret them. Based on the above facts, it is not easy to have a realistic view of the percentage of urbanized population and settlements without first working out all the terminology regarding the processes related to urbanization and providing them with clear definitions.

Within the framework of the study carried out on the processes of development and management of the city, it is important to note that the structure of city management, which may vary depending on the country, the list of the central institutions and institutions at the city level changes, as well as the existing classification of the primary services that cities provide to their residents. According

to the results of our analysis, this classification is presented in Figure 3.2. A city consists of the central city administration, the mayor and his office, an elected city council (may vary from country to country), national or federal agencies and organizations that can influence or directly control the city council, city ordinances adopted and approved, and public, non-profit organizations available in the city.

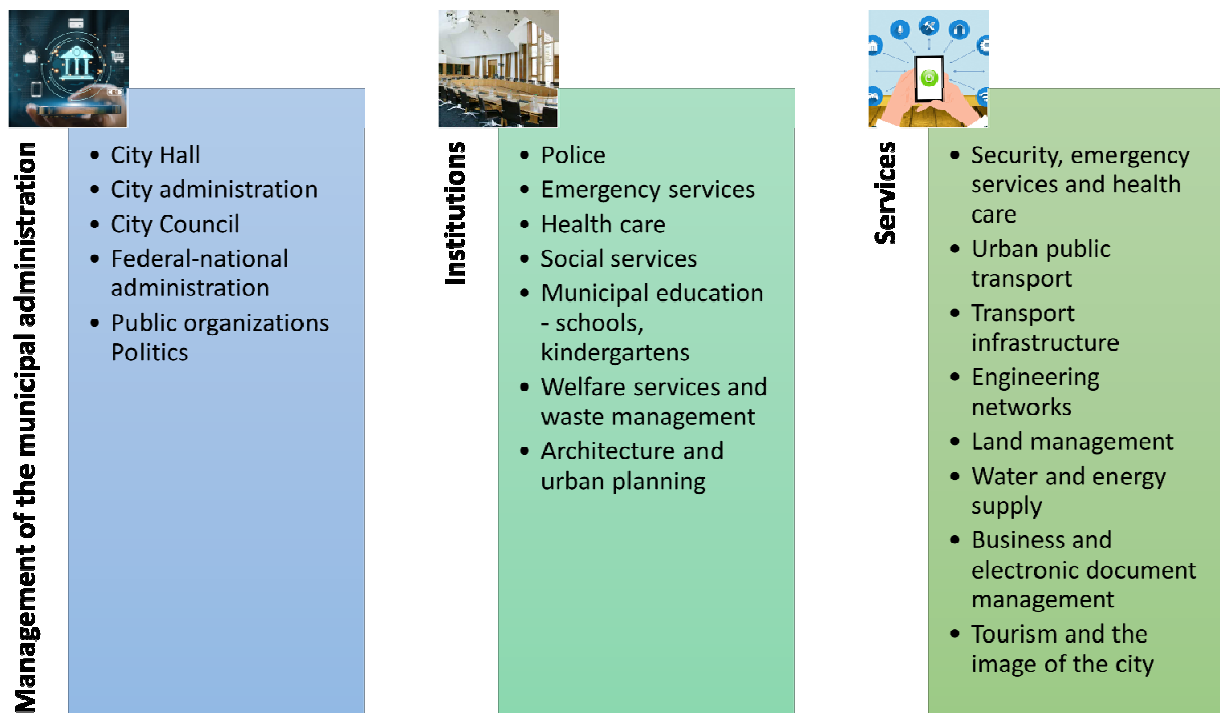


Fig. 3.2. City Management System and Basic City Services

In some cases, international organizations and international acts and documents can directly describe and determine how the city functions. Police, health, social services, and emergency response agencies are among the leading providers of various services at the city level. Architecture and land management are multifunctional services available in every city; they are in the leading positions in developing the concept of the Smart City system. Each city needs residents who will live in it and work here. They also use and develop urban infrastructure, including a network of roads and streets, waste collection and recycling management, water supply and energy systems, etc. The electronic document management system is an essential and modern service for any modern city. It is used for managing land and

property, urban finances, legislation, and planning various services for the city's population.

It is important to study the status of urbanization in Ukraine and the need to develop a regulatory framework at the legislative level and establish definitions for all concepts in this matter. It should be noted that since there is no standard comprehensive and generally accepted terminology in the world today, this issue requires its continued implementation. Therefore, we have thoroughly researched and analyzed the current state of the world on this issue. The results of the work are presented in Table 3.1, which presents the systematized system of territorial zoning and distribution of urban and suburban territories proposed by us, according to which the following types of territories are proposed: central (historical) district of the city, central urban area, general urban area, metropolis territory, urbanized territory, de-urbanized territory, and non-urbanized territory. For each type of territory, their zoning is proposed, the main parameters are given, and a specific definition is proposed.

Table 3.1

System of Territorial Zoning and Distribution of Urban and Suburban Territories*

Type of territories	Zoning	Options	Definition
Central (historical) district of the city	Historical Legal definition (municipal)	Type, profile and general characteristics of the building Legal status of the territory and/or objects Regulated options for the use of land/development of territories Architectural and visual characteristics	Center for Historical, Cultural and Business Activity Preserved historical buildings\historical profile of the city Relatively small area of the city

Central Urban Area	Legal-municipal Territorial - by type or purpose	Type, profile and general characteris- tics of the building Economic characteristics of the territory and/or objects	Center for Economic, Educational, Business and Managerial Activity of the City High concentration of business development, limited area of residential development
Total urban area	Legal (national) - borders Municipal - zoning (urban zoning)	Social and economic characteristics of the territory and/or objects Regulated general territorial zoning and placement of objects	The territory of the city (the boundaries of the urban zone), which is determined by the legislation of the country
Metropolis territory	By type of territories Socio- economic characteristics Type of development	Economic charac- teristics of territories General characteris- tics of the develop- ment of territories General characteristics of the territorial distribution of the population	Territories of the city and adjacent territories that have a combined economic and social zone and meet a certain characteristic of development/distri- bution of the population
Metropolitan area	Legal (national/federal) - boundaries Socio-economic and legal characteristics	Legal status of territory(s) and territorial associations General economic characteristics of territories	A united territory that includes several or more cities or metropolises, which is defined by law and has a common economic or legal characteristic

Urbanized area	International classification Legal definition (national/municipal)	Legal status of the territory General characteristics of development and population placement on the territory	Type of united territory, according to a certain defined system of development/distribution of population and/or economic characteristics or at the legislative level
De-urbanized area	Socio-economic and legal characteristics Legal definition	General socio-economic characteristics of the territory General characteristics of development and population placement on the territory	Type of territory, according to a certain defined system of development/distribution of population and/or socio-economic characteristics
Non-urbanized area	Type of development Economic characteristics	General characteristics of development and population placement on the territory	Type of united territory, according to a certain defined system of development/distribution of population and/or economic characteristics or at the legislative level

* Prepared based on personal research data

For further research and modeling, we selected five major cities to compare: Shanghai, Mexico City, New York, Paris, and Kyiv. Figure 3.3 shows the distribution of the city's land, divided into four categories, as described above.

After conducting research and analysis of these cities, we saw that the cities are very different from each other. Shanghai has the most significant central part of the city, 1498 square meters. The main reasons for this are its administrative divisions

and how the city was officially created. The city is divided into 16 districts and three counties, with 205 cities, nine townships, 99 metropolises, 3278 neighboring committees, and 2935 rural settlements. The center of Shanghai consists of two major cities. The central historical part represents Mexico City, Kyiv, and the center of Paris. At the same time, Lower Manhattan forms the center of New York City. The New York City metro area connects central New York City with other metropolitan cities (Newark, Jersey City, Paterson, Elizabeth, and Edison); most intermediate areas are relatively sparsely populated.

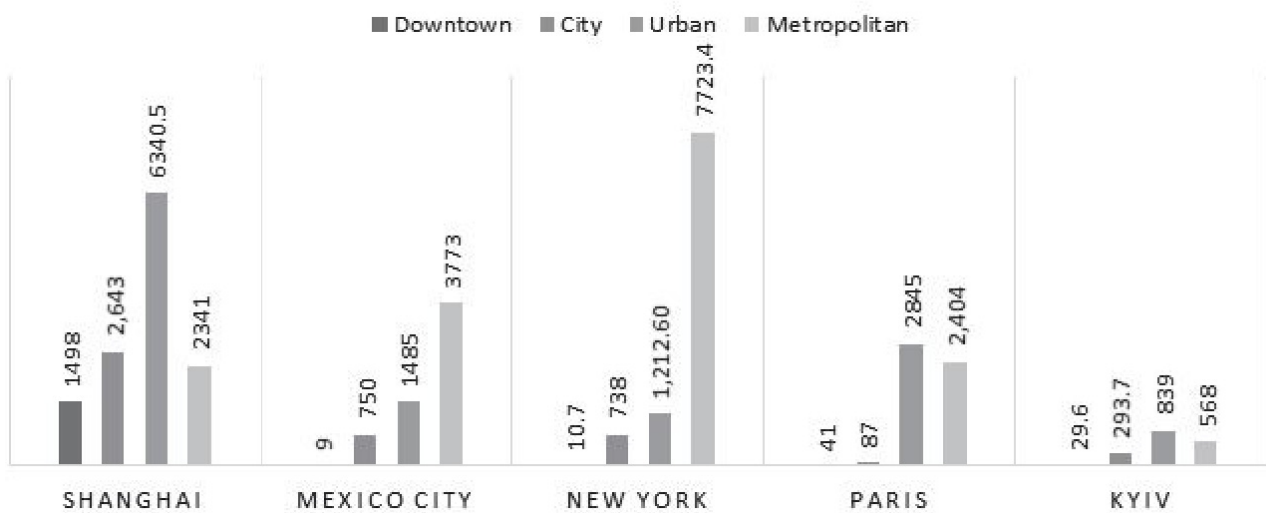


Fig. 3.3. Type of Urban Land Use, in sq. m. km.

Figure 3.4. Furthermore, Table 3.2 presents the study's data on urban urbanization profiles without referencing a specific country or city. The data presented resulted from the research and study of different cities worldwide, with different levels of urbanized areas and populations, including small, medium, and large cities, as well as economic, social, and environmental data. The presented model results from the generalization of the processed data and classification of cities at a high level of scientific abstraction for their further study and construction of a comprehensive scientific descriptive model.

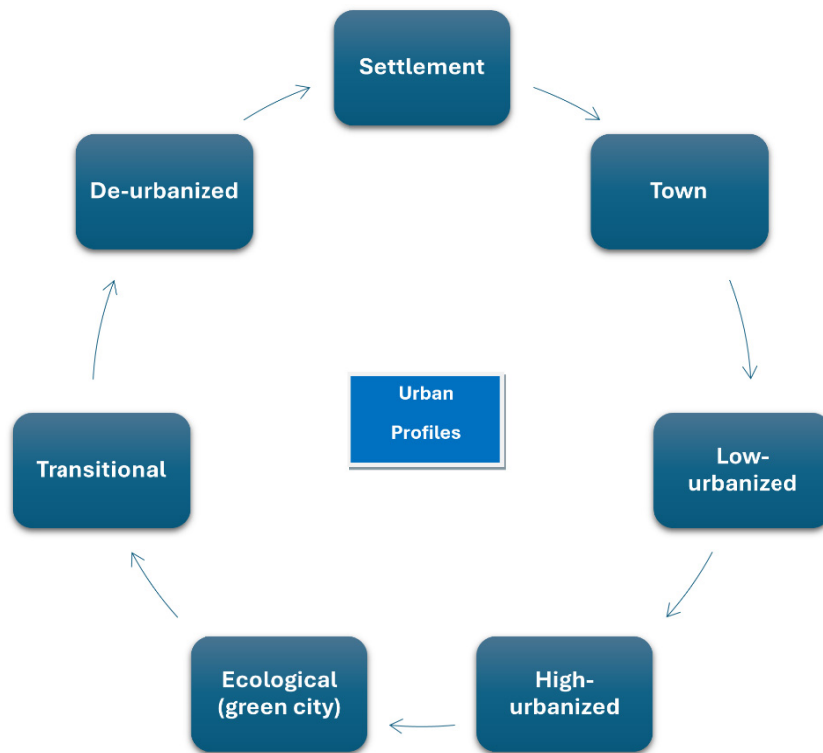
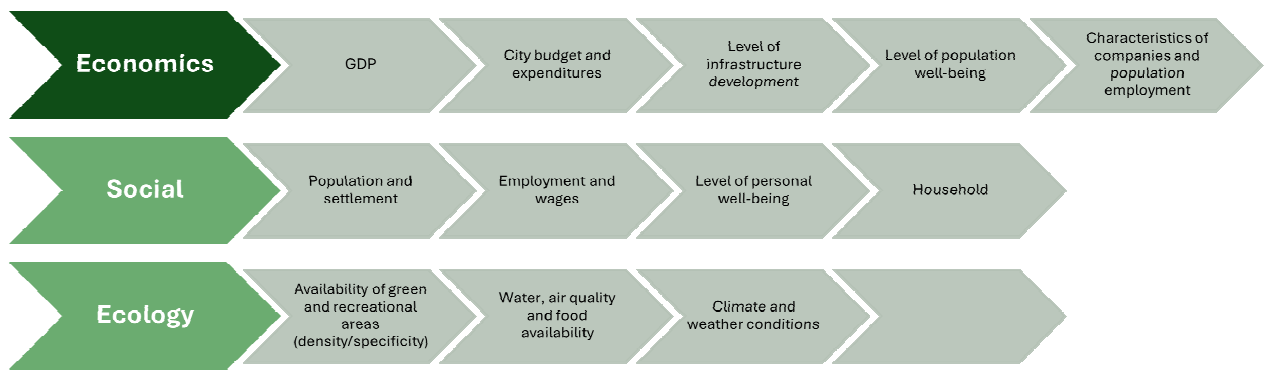


Fig. 3.4. Urbanization Profiles Conceptual Model

Table 3.2

Concept of General Urbanization Profiles *

Profile	Components	Data categories	Examples
Basic (Beginner)	The population is more than 500 thousand. Persons Medium/low population density Manor and low-rise buildings in the city Increase in revenues to the city budget (city GDP) Separate Economic Zone	Social statistics (city) Economic Statistics (City) Area of the territory Building density Population density General demographic profile of the territory Development Profile and	Sejong (South Korea) Khorgos (China)

		Territorial Distribution by Types of Economic Activity	
Typical	The population is more than 500 thousand. Persons Average population density Low-rise and high-rise buildings in the city Central Business District (CBR)	Social statistics (city) Economic Statistics (City) Type and data on the development of the territory Economic profile of the territory Ecological profile of the territory	Kiev Berlin
Low-urbanized	Significant area of urban area Low settlement density Central Business District (CBR) High-rise buildings in the Central Bureau of Investigation and certain areas Manor and low-rise buildings in the city	Social statistics (city) Economic Statistics (City) Level of socio-economic development and current data on the level of well-being Profile and data of territorial zoning, development	Munich Madrid Manchester
Highly urbanized	The population is more than 3 million. Persons Central Business District (CBR) High-rise buildings in the Central Bank and around the city High population density	Social statistics (city) Economic Statistics (City) Waste removal and storage	New York São Paulo Beijing Hong Kong
Ecological (green city)	Availability of green and recreational areas in the city Increasing budget expenditures on environmental expenditures Renewable energy and green tax	Social statistics (city) Economic Statistics (City) Proportion of green areas to the city square Share of renewable energy sources Waste Management and Recycling System	Malmö Vienna

Transitional	Decrease in revenues to the city budget (city GDP) Intermediate crises and the impact of local or global changes Transitional level of well-being of the population	Social statistics (city) Economic Statistics (City) Legal status of the territory (city) Economic indicators of growth (decline)	Lagos Astana
De-urbanized	Variable population Decrease in revenues to the city budget (city GDP) Economic and/or environmental crises Low employment Low level of well-being of the population	Social statistics (city) Economic Statistics (City) Level and volume of impact of the crisis(s) on the economic and social development of the territory	Detroit Naypyidaw (Myanmar)

* Prepared based on personal research data

Practical research begins with identifying and outlining problems, collecting relevant data, classifying or categorizing it, and then analyzing the available data to build an effective research model. In most scenarios of the research process, the data required for research work are multi-dimensional. Such research data must be collected using various sources of information, and they are usually not directly related to financial data, digital images, and land use norms and rules.

Any researcher and scientist have more tools, data, and information than those available to scientists two or three decades ago. Information and computing systems are the primary and necessary tools for researchers of modern cities and land use. Such information and computing systems require selecting data types and then entering them to enter and set parameters.

Table 3.3 presents the most typical data for the study of urbanization processes. Figure 3.5 shows a simplified technical representation of the computer digital service of the environmental and economic monitoring and forecasting system. Before

starting the modeling process, it is necessary to go through each other, process, and analyze all the steps presented. Most of the data used in smart city modeling and research is of a numerical or geographic type (nature), while some research efforts to produce results require both. Below, we provide a step-by-step process for developing the proposed computer system:

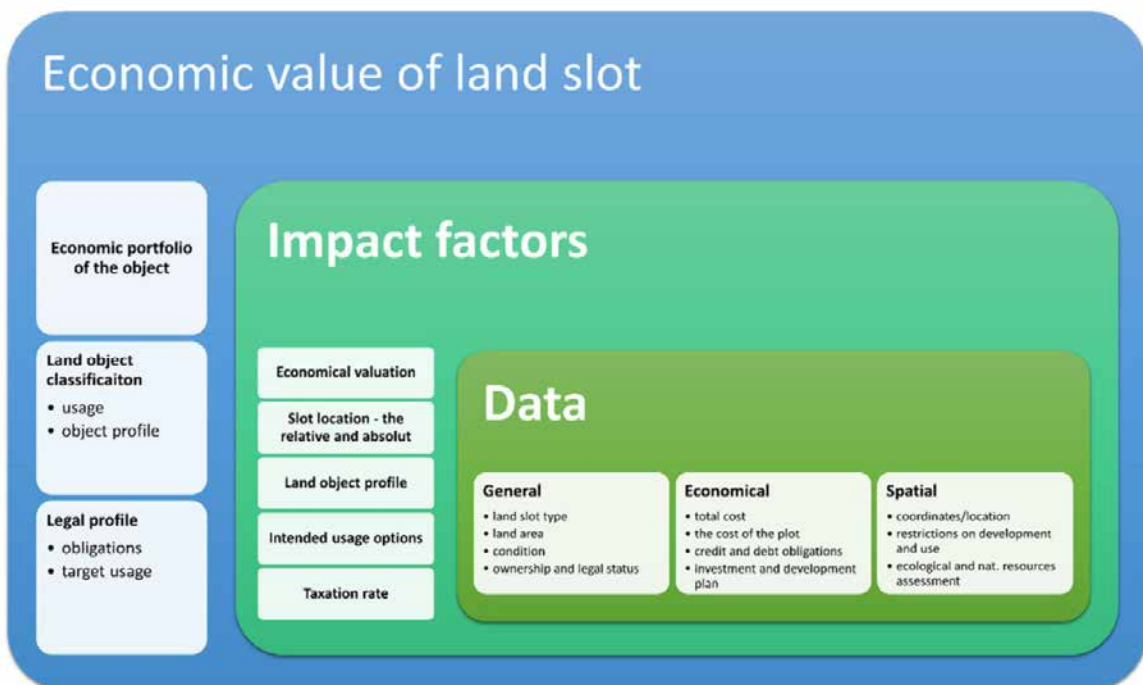
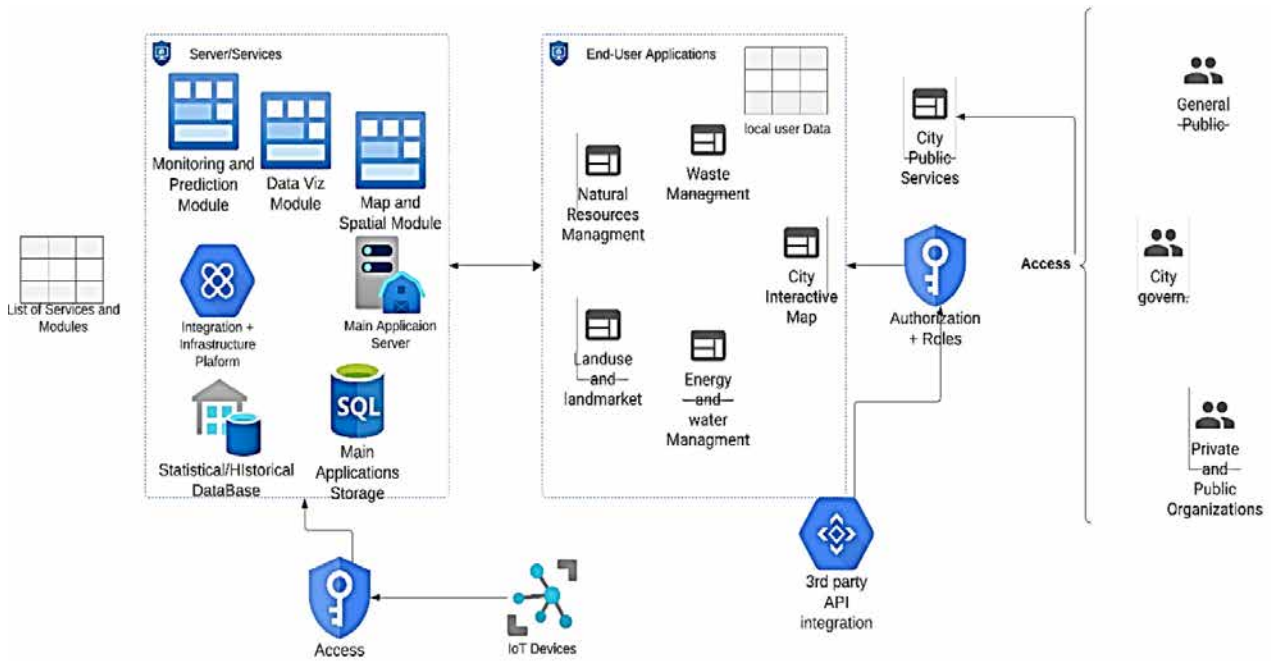


Fig 3.5. Web-service Components Schematic Simplified Representation

Table 3.3

Classification of Research Data for the Development an Information Modeling System*

Data	Category	Description
Satellite image	Cartographic	Map of the area - processed or not processed
Classified zones and territories	Cartographic Computer (digital) data	Result of cartographic classification using machine learning
City Square	Numerical data	Area of districts, zones or urbanized areas within the city and surrounding areas
Population	Numerical data	Number of population living in urbanized and non-urbanized areas, with territorial distribution and household profile
Population density	Numerical data	On 1 of this area
Building profile	Numerical data Financial data Computer (digital) data Image\Diagram	Building density Cost of development/change of purpose\lease Profit for 1 time Classification of buildings
Plans of the cities	Image\Diagram	Schematic or visual representation of plans for development and future development of territories with zoning, classification by objects and types of economic activity
CO2 emissions	Number	for 1 area the total volume Specific gravity per inhabitant
Complex Real Estate Value	Numerical data Financial data	currency per 1 area total area and location of the property
Spatial placement	Numerical data Spatial data Computer (digital) data	town Region and country Suburban zone and its spatial numerical characteristics
Objects of spatial placement	Numerical data Spatial data Computer (digital) data	Infrastructure forest and recreational, industrial and scientific and technical special purpose

Environmental profile	Numerical data Spatial data Computer (digital) data Image\Diagram	The level of saturation with green areas per 1 area/inhabitant The level of saturation and specific quality of the main natural resources Waste management system and power supply Environmental and weather monitoring (report and forecast)
Economic level of development of the territory	Numerical data Financial data Computer (digital) data	WFP (with territorial distribution) Social indicators Environmental monitoring data Expenditures, taxes and budget (territory) revenues

* Prepared based on personal research data and Britannica data [49-51]

- 1) description of the work process and predicted results from the system;
- 2) data collection and analysis;
- 3) development of the mathematical component and methods of system analysis to be used;
- 4) selection of complex algorithms for analysis, structuring and presentation of data:
 - machine learning,
 - computer vision,
 - etc.;
- 5) schematic representation of a computer digital service for development;
- 6) selection of technical tools and development tools;
- 7) development of a software layout and creation of a data warehouse scheme;
- 8) creation of a database and data warehouse;
- 9) verification and selection of complex algorithms for the operation of the system;
- 10) further development of the software part of the system;

- 11) development of a system for presenting and visualizing data;
- 12) implementation and verification of the system.

Our initial assumption is that the development of transport, various types of communication, and ecological systems are key components of urban development. This paper proposes a framework model for defining urbanization in the context of Earth sciences and economic sciences. To conduct the study, we will consider and highlight the following objects - suburbs and suburban areas, including satellite cities and new working locations; land use by types of plots and their classification. The main objects are cities in the context of urbanization, common characteristics of these processes, and differences (Fig. 3.6 and 3.7). To understand each of the above issues, it is necessary to study and analyze the forms of ownership of land resources and real estate, options for the use of land resources, regional features, landscape or natural features (climatic zone, etc.), to explore the land and real estate market; prices and cost of land plots; rental, sale and other types of economically feasible options, as well as their dependence on several factors. Moreover, it analyzes economic data and the parameters under study.

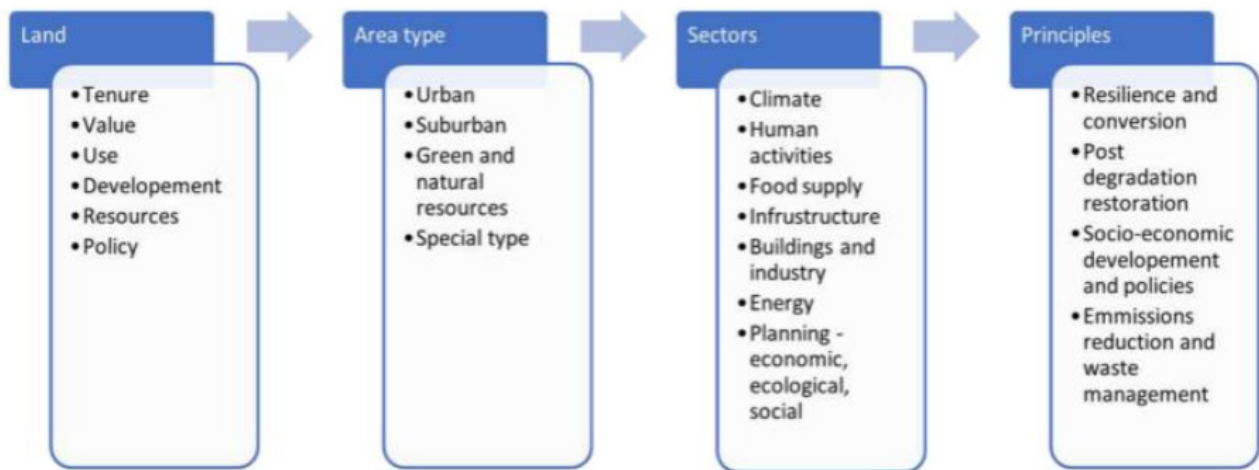


Fig. 3.6. General Classification of Territories and Zoning

Summarizing the results of our analysis of the purpose and use of territories in the city (Fig. 3.7), we provided a classification of city territories and determined their zoning, dividing them into the following: Business center; Zone 0 - areas of business and economic activity of the city; Zone 1 - mixed urban areas; Zone 2 - Sleeping

Urban Areas and Suburban Area. Furthermore, in Fig. 3.7, the territorial zoning of urban and suburban areas was presented, considering the types of objects and general parameter assessments.

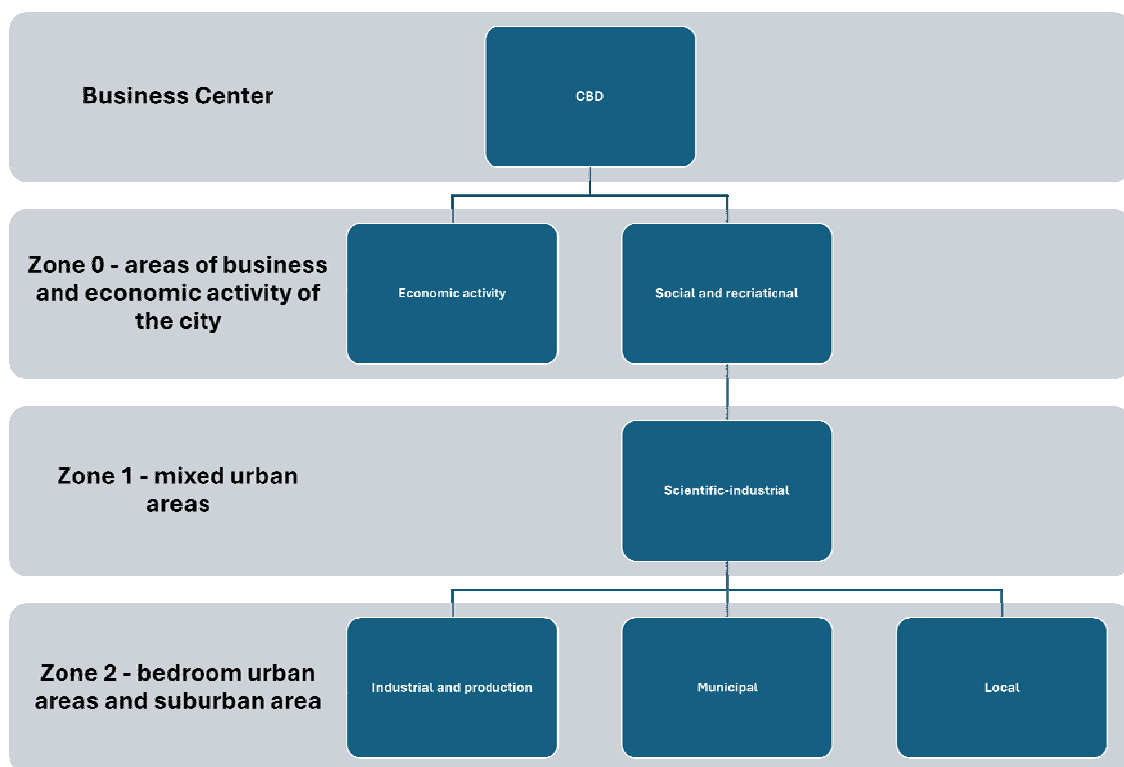


Fig. 3.7. Territorial Zoning of Urban and Suburban Territories

Table 3.4 provides detailed information on such distribution. We should note that we divide territorial objects into general land funds, built-up areas, commercial and social facilities, service systems and management bodies, and natural and unique. For each of them, the use is described, the form of ownership is defined, the characteristics

Table 3.4

Territorial Objects Characteristics and Classification: Main Economic and Environmental Parameters

Object Type	Use Form of ownership	Characteristic Description	Classification of objects	Options-Economics Environmental
Total land fund	Commercial Non-profit Municipal State Private	Terms of Use Rent terms	land by type and purpose	Rent cost state of natural resources Cost of accommodation facilities
Building	Commercial Municipal State Private	Residential facilities General Buildings	low-rise high-rise Manor House Social	Total cumulative construction cost Rent/Sale Price Rent The cost of the land plot
Commercial	Individual Legal entity mixed form of ownership	Terms of Use Rent terms Operating conditions Lease terms	Residential facilities shopping and entertainment Trading Office Industrial Scientific and technical others (by types of economic activity)	Economic characteristics of the object (business planning) Rent The cost of the land plot Operating costs Taxation system and environmental economic regulation
Social	Municipal State Private mixed form of ownership	of general municipal, district, regional/federal, national significance	Educational Medical Law enforcement city services and services	Operating costs Economic characteristics of the object (business planning)

Systems, services and controls	Municipal State mixed form of ownership - physical, legal and mixed	Building objects Engineering facilities and networks Special Objects	Transport networks Life support systems supply facilities (energy, water, etc.) objects of management bodies environmental and special monitoring	Operating costs Economic characteristics of the object (business planning) Operating costs Economic characteristics of the object (business planning)
Natural	Municipal State	Legislative regulation Development plans	green urban areas Water bodies Nature conservation areas	Operating costs Economic economical choose for development/ construction Cost of restoration
Special	Municipal State Other	Legislative regulation Legal status	Defense facilities objects of consequences of man-made and natural disasters of international importance Other	Operating costs Economic economical choose for development/construction

* Prepared based on personal research data

and description are provided, and the main economic and environmental parameters are presented. The assessment's general parameters include financial data, socio-economic and environmental monitoring data and their assessment, general characteristics and description of objects, and regulations for each object.

Algorithm of the system of classification of territories, zoning and distribution of urban and suburban areas, which has the following steps:

- collection and analysis of data on the city and the state - economic and social data, economic profile of the city in the context of its economic development of the region/federal state and country;
- analysis and elaboration of the legislative framework, regulatory and legal information on the definition of the city, urban areas and territorial distribution at: municipal level, regional/federal and national levels;
- elaboration of terminology, options for definition and constituent elements of urbanized territories by international organizations at the international level:
 - o USA;
 - o Poland and the Baltic countries;
 - o EU countries;
 - o United Kingdom;
 - o developing countries;
 - o China;
 - o UN, FAO, UNESCO and other organizations;
- analysis of existing systems classification of terms/definitions - city, agglomeration, urbanized territory, urbanization, village, urban zoning, land plots, natural areas, etc.;
- determination of the main factors of social and economic impact of the city (urbanized) territory on the economic development of the region or federal state and legislative regulation of the boundaries of urbanized territories at this level;
- Presentation of the system of definition, classification and characteristics of territorial boundaries:
 - o boundaries of the urban area;
 - o boundaries of suburban areas;
 - o boundaries of the metropolis;

- o the boundaries of the metropolis;
- development of models for representing comparative economic, social and territorial characteristics of urbanized territories, taking into account the following parameters:
 - o type of united territory (city, town, metropolis, metropolis, etc.);
 - o the level of urbanization and the profile of the city;
 - o boundaries of territories and territorial zoning;
- development and presentation of a system of classifications of objects of social and economic activity located in the territories of:
 - o of local importance;
 - o local significance;
 - o of international or regional importance;
- presentation of a model of economic characteristics of the territory at the local and national levels, with comparative analysis;
- development of a new classification system for urbanized areas.

The modern globalized world is becoming increasingly urbanized, so states' key economic and political levers are transferred to several of the most significant cities. Such cities form the centers of distribution and development of urbanization, and, as a rule, they are characterized by a specific, narrowly directed orientation in their activities at the macroeconomic level [107]. An example is such cities as London, Paris, Tokyo, New York, Los Angeles, Singapore, Chicago, Shanghai, Guangzhou, Shenzhen, and others. According to current forecasts, the total GDP of the top ten such cities will reach 13.5 trillion US dollars by 2035.

At the same time, it should be noted that not each of these cities - world metropolises of different continents in Europe, Asia, and North America, have the largest population in their countries. Over the next 15 years, the center of economic development of the world will move to some areas of Asia. The leading positions in terms of annual GDP growth will be occupied by cities such as Bangalore (8.5%), Dhaka (7.6%), Mumbai (6.6%) and Delhi (6.5%). According to the results of research

by analysts of one of the leading companies engaged in the analysis of the global real estate market, the main factors of such growth will be narrowly focused specializations in high-tech industries, the rapid movement of a significant number of qualified personnel to such regions, an increase in regional turnover through the most significant seaports and national transport hubs.

On the other hand, we have examples of modern problems, such as changes in climatic conditions caused by rapid urbanization and irrational use of natural resources. An example is the capital of Indonesia, Jakarta, where rapid population growth and significant climate change pose a significant danger to sustainable development. In the coming decades, Jakarta's population is projected to increase to 38 million. At the same time, the city will face serious challenges: possible sea level rise, erroneous state policy, which resulted in irrational use of land resources, and ineffective urban planning in the context of infrastructure development and water protection structures. After the steps taken at the state level, there was a plan to move the capital to the island of Borneo, but this did not solve the problems that had already been accumulated. In the current conditions of rapid urbanization and future climate change, it is advisable to pursue a balanced policy in the context of sustainable development of urban areas and rational use of land resources with a forecast for the next 20-25 years.

According to previous studies, the main challenge in existing economic planning and land use is the lack of a holistic picture and general theoretical models that could be used in practice by institutions, scientists, and officials [108]. In his scientific work, the author proposes such a model. That is why we began to work on analyzing existing data and models to have a clear idea of the existing situation. By utilizing the presented model, it will be possible to develop further steps toward creating a comprehensive model of urbanization, considering economic, environmental, industrial, and other modern challenges.

3.2 Urbanization as a Process: Stages and Transitions

The process of urbanization is a multifactorial and complex area of scientific research. It exists at the intersection of many fields of knowledge, such as economics, ecology, sociology, urban planning and urban planning, and law and regulations [46]. In recent decades, many researchers have focused on economics, researching and analyzing real estate prices, financial modeling, and economic forecasting. With the current state of affairs regarding the rapid expansion of urbanization, it is no longer adequate to limit the volume of research work only to city data. Instead, such modern challenges provide a massive opportunity for new shifts in studying urban development processes, considering related spheres of life.

When studying the process of urbanization, it is worth paying attention to the development of the real estate market since urbanization is associated with population growth and the resettlement of people from the periphery to the urban center - cities and suburbs. In addition, new enterprises have been created, and the need to organize the service sector for the population is growing. All this attracts people from different regions of the country, other countries, and even continents [109]. Land and forest resources undoubtedly play an important role in the formation and development of cities. Their presence and use affect cities' economic development and environmental situation in the surrounding areas. The available forest and land resources are essential for large cities.

Currently, large urban agglomerations serve as one of the main catalysts for the development of economic trends. Urbanization, as a new and modern process, plays a key role in transforming local, regional, and global economies. The process of urbanization should be considered an important factor in the development of the economy of both the city and the state as a whole, which dictates the development of micro- and macroeconomics of regions, perhaps not directly, but in the context of long-term land use and spatial development, this process can play a significant role. We cannot exclude from consideration and analysis such issues as the development

of suburbs, industrialization, post-industrialization, environmental issues, and the continued existence and development of rural regions adjacent to cities, always bordering urban centers and agglomerations.

Along with the new opportunities that arise in the economy of large cities, a significant number of problems need to be solved. In addition to economic issues, irreversible environmental changes, namely sea level rise, forest fires, global pandemics, and the development of new technologies, all these factors and the production process in cities should be included in the study of urbanization. This requires a new approach to how we see the city, build economic models, and make development forecasts for the future. In this work, we have built the initial stage of such a reliable economic model, using a variety of data and statistics on the life and development of the city of Kyiv. This city could serve as an ample testing ground for the proposed model, as it is a relatively new urban center that is part of the country's intensively developing economy.

According to a study by the Global Real Estate Research Agency, the main factors that will determine the growth of the city in the next 15 years are a narrow focus on high-tech industries, the rapid movement of a significant number of qualified personnel to such regions, an increase in regional cargo turnover and transportation through major seaports and national transport hubs. The center of economic development of the world is likely to move to some areas of Asia. Meanwhile, London, Paris, Tokyo, New York, Los Angeles, Singapore, Chicago, Shanghai, Guangzhou, Shenzhen, and other cities are the centers of economic development in the world.

It is regrettable to note that Ukraine and its largest urban center and capital, the city of Kyiv, lag in economic development and the average monthly salary of \$ 560 from other large cities of the world, and the primary type of economic development and labor activity of the city is construction and trade. It is necessary to change approaches to the existing closed model of land use and stimulate the production of raw materials and finished products with high-added value to compete effectively in

the world market. It is necessary to rapidly develop and support the placement of new modern technologies in Kyiv and, thus, ensure high employment of the population of Ukraine, following the examples of neighboring cities - Warsaw, Bratislava, and Berlin.

In the future, conducting a comprehensive multidisciplinary study is necessary to present the city as a clearly defined functional territorial unit - an agglomeration. Such a definition and its comprehensive analysis will make it possible to identify the main problems and challenges of the city as a separate economic functional unit, highlighting the factors of the city's flow to regional development and the economic development of the state and neighboring countries. It is advisable to consider the city from the point of view of autonomy of the acceptance level, as well as the formation of social, economic, and environmental policies. As an autonomous unit of urbanization, the city must have its own plan for the development of territories, which considers future challenges and predicts negative scenarios for the development of situations, primarily environmental problems and cataclysms, to change the current scenario and improve the situation. This will minimize potential losses in the future, as well as prevent some undesirable events. The concept of the "Smart City" system is an example of the use and practical implementation of the proposed concept - the city as an autonomous unit of urbanization. The Smart City system will allow monitoring, analysis, and environmental and economic forecasting of changes in urbanization.

We will present the concept of the algorithm for research and visualization of urbanization processes, which includes:

- economic component - from theory to model;
- cities and states - real data on the share of the economy in the total component;
- territorial distribution and urbanization;
- definition of urbanization - economic, environmental and general;
- projects of models that can be built;

- technical means for their use in the process of modeling (technical, informational, mathematical and data processing methods);
- areas of study that are included in urbanization;
- factors and factors that have an impact on urbanization processes and identification of those that do not have, or have a minimal level of impact;
- micro and macroeconomic balance and their relationship in the context of urbanization;
- a step-by-step plan for the development of a model and components of a sub-system (neural networks);
- mathematical representation of data, input and output models (in the context of computer modeling and forecasting);
- the result of how the software system should be like.

Urbanization cannot be classified exclusively as a category of microeconomics research. The urban development process affects the environmental situation, local and national economic development, financial markets, and national and international legislation and regulations that regulate the comprehensive life of a modern city. In our work, we present tools and methods that can be used by researchers and scientists in different fields of scientific research. The current state of the urbanization research field and its connection with the existing main scientific directions are presented in Figure 3.8.

Four main areas of study allow us to study and analyze the urbanization process. These are ecology, economics, urban planning, and legislative framework. Each of these four areas has many branches and levels. Figure 3.8 presents the areas of activity we identified that are directly related to urbanization. Some areas, such as sustainable development, urban infrastructure, or the urban budget, are related to other areas of activity and are based on what is currently classified as multidisciplinary research. Only this fact can prove that urban studies is multidisciplinary and requires experience, knowledge, and research in related fields.

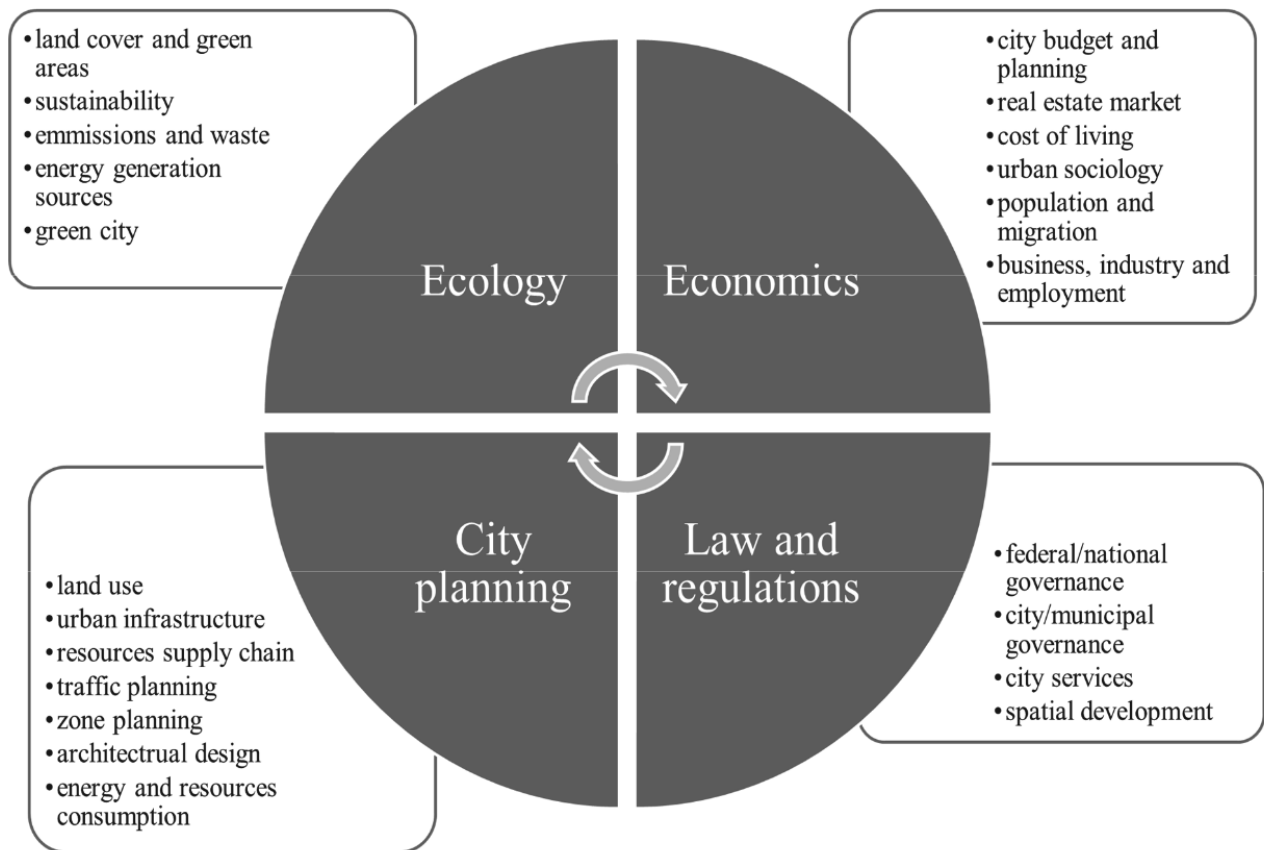


Fig. 3.8. Sub-Branches Constituent Elements of the Model of Urbanization Processes [47, 48]

Studies of cities and urbanization processes require the scientist first to identify the problem and then analyze the available data to build an effective model. Note that the data required for any new research is multifactorial and comes from various sources, usually not aimed at financial data, digital images, and land use regulations. Any researcher has more tools and information than two or three decades ago.

Information and computing systems form a basic set of tools for modern research on the process of urban development or the process of urbanization. However, both require the data to be primarily reliable and the parameters set for simulation purposes. More significant amounts of such data used in urbanization modeling studies are of a numerical or geographic type, while most research efforts require both. In our work, we have provided a definition and classification of four primary areas of urbanization – economics, ecology, urban planning, law, and regulations in this area. Based on this classification and the study of different

research tools and methods, we have presented the cyclical concept of the study of the urbanization process. In the future, developing and presenting a comprehensive research base based on the methods and tools presented for analyzing computing and information systems is necessary. Let us give an example of the operation of the system of classification of territories and spatial zoning using computer vision and machine learning systems:

- 1) collection of cartographic data on selected territories;
- 2) choosing a tool to carry out pattern recognition and machine learning or improving an existing one or developing your own system;
- 3) checking various recognition methods on the selected type, territorial object;
- 4) creation of a database for determining the classifier of the type of object on the map;
- 5) conducting machine learning according to the selected classification system;
- 6) the process of automated classification and territorial zoning based on the selected algorithms (methods) and the classification system;
- 7) obtaining the resulting map, terrain plan, etc.

The author studied and analyzed many scientific papers and information on urbanization, land management, and information systems in the context of the presented work. The qualitative assessment method was used to create a smart city system in the context of a broad study of such processes. This method helped us outline the city management system's leading economic and financial parameters. Another key result of the research is the understanding of the importance of using the presented tools and methods to create an urbanization model (city) – these are land management services emphasizing maps and ground surveillance and services for collecting, processing, and providing statistical data. The author uses the method of scientific abstraction, system modeling, and theoretical generalization to build the concept of urbanization and develop requirements for the technical implementation of such a model.

Urbanization is a long-term continuous process of spatial development of territories. Understanding such a process requires a clear definition of the boundaries of the urbanized area, not only from a legal point of view but also based on actual economic data and the spatial zoning of urban and suburban areas. Today, most of the population of our planet lives in cities, but how can we determine the number of people living in urbanized areas? Moreover, is living in cities safe, and what does their future hold? The research community and public leaders have only recently begun to pay attention to such problems and issues. One of these issues is urbanization. Urbanization is one of the main challenges for modern society.

Unfortunately, with the current trend of rapid urban development, we cannot be sure of a bright future. Modern examples of rapid urbanization often led to uneven economic development of society and stratification of the urban population by levels of socio-economic development. This is alarming since factors such as the percentage (%) of sick people - (medical facts) must also be taken into account: demolition and decline of green areas (forest area decreases), climate change and CO₂ emissions, and pollution of water and natural resources in cities.

Based on the results of research and analysis of numerical data, more and more people are moving to cities, accelerating the growth rate of urbanization. As a rule, population resettlement occurs in several areas with low real estate prices. At the same time, the main business activity takes place in other urban areas and the CBR. This, in turn, leads to an increase in traffic, an uneven level of social security for the population, and a sharp differentiation in the income levels of the population. Instead of reducing the burden on other districts, the negative impact of territorial zoning in cities becomes noticeable in less urbanized and suburban areas. The statistics of population growth, combined with the projections of the following urbanization centers, show us dim facts - more and more districts and regions are suffering from the consequences of rapid urbanization.

If we define the process of urbanization as one of the problems of our time, this will raise the question of the need to solve some problems related to the process of

urbanization. Usually, problems in society and life are not visible from the outside until they lead to serious consequences, and with urbanization, we have similar patterns. This situation can be traced to urbanization, and we see that the changes it leads to and the scale of such changes are dramatic in most cases.

At the beginning of their creation and development, the first cities were tiny in size and number of inhabitants and isolated to impact the environment significantly. In some cases, they provided people with shelter and housing, protection from dangers, access to food, water and personal hygiene, etc. However, these small towns were the roots and founders of modern dangers and problems. Over time, cities increasingly attracted many people; they stimulated the development of the surrounding areas. In order to grow and develop, cities needed more and more resources, materials, fuel, etc. Using various resources for their development, cities led to ecosystem degradation and the death of flora and fauna, forcing them to adapt or disappear. Based on this, one cannot deny that urbanization resembles one of the significant problems of our time. On the one hand, urbanization stimulates the economic development of the city and the level of socio-economic security; on the other hand, it affects the deterioration of the environmental situation and social stratification according to the level of economic and social security. Both of these aspects of urbanization have high correlation values, especially in economic terms at the level of households, families, etc. It can be confidently stated that urbanization can negatively impact the state of the environment and the overall health of the urban population if no action is taken. To prevent or minimize the negative impact of urbanization, it is necessary to develop an information system to support municipal, non-governmental, and national decision-making.

Since urbanization is inevitable today, the question is whether all urban centers are subject to such consequences, how permanent the negative impact is, and whether it can be reversed or minimized. The present poses these and several other questions, but there are no quick and unambiguous answers. The solutions can be steps to study,

analyze, and research the development of cities and adjacent territories and plan for their future.

There are cities and urban centers in the world today that can already be taught by the cities of the future, which have found a balance in their development and managed to minimize the negative impact of urbanization. The best examples of such cities are Malmö, Vienna, and other small, prosperous cities in the EU and Asia. Several other cities, such as Kyoto, São Paulo, and Paris, are taking important steps to transition to a green economy. The examples show that to move from defining and analyzing problems to solving them, the first indicated issues must be recognized by all stakeholders - municipalities, governments, corporations, citizens of the city, and residents. Future research should focus on the East, Latin America, and Africa, as these regions will be where urbanization will develop the most in the next decade. The best treatment (as is known) is preventive measures and intensive prior treatment, which is the case with urbanization. Not all facts and examples were adverse; some cities found a way to minimize negative consequences and build better sustainable systems. Important steps to overcome issues related to urbanization are a waste management system, their disposal, reduction of CO₂ emissions, closure of enterprises that carry out harmful challenges, or change of technologies to minimize environmental damage.

In this brief overview of the development and state of urbanization, we have sought to highlight the negative factors of urbanization, their rapid expansion, and how they can be classified. The facts have confirmed that problems exist and have a significant impact now and even more shortly. In order to prevent this, we must recognize that the problem exists, join our efforts, and propose new solutions.

In the future, we will study and analyze such a concept as the axis of urbanization, its contributing factors, and how cities turned into large urban centers. We will make forecasts for the future and build an urbanization model.

In order to provide a clear definition of urbanization, we focused on preparing a conceptual model in the context of Earth sciences and economic sciences studies.

Figure 3.9 presents a concept model that denotes and unites three areas of urbanization: land management, spatial development, and urban economy. The result of constructing the presented model is a generalized definition of urbanization: state and process.

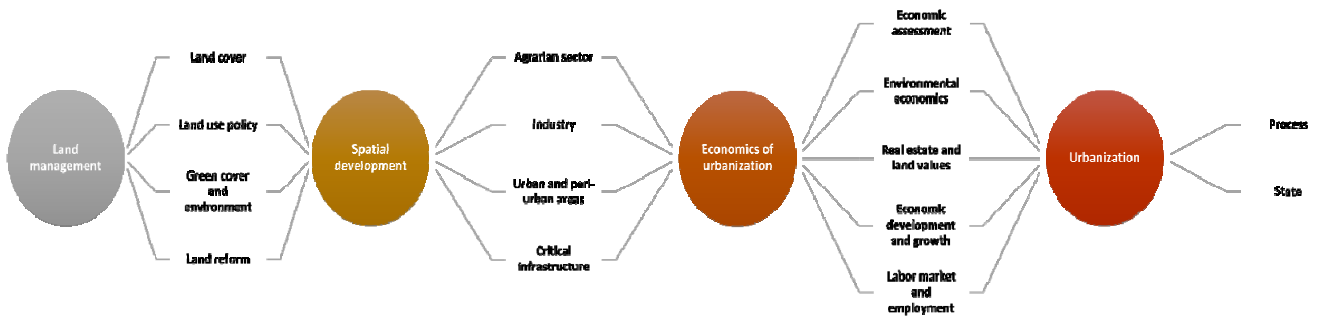


Fig. 3.9. Conceptual model of urbanization classification in the context of Earth sciences and economic sciences

The list of the main categories, data types, and components of urbanization is presented in Table 3.5. The results obtained because of the study are classified into six main general categories, which are analyzed based on the data presented in the previous sections of the work. An important section of the data in Table 3.5 is the indicators regarding the scope of their application. It presents sub-branches of the concept of urbanization research and shows the practical application of such data. Most of the data in Table 3.5 are economic and financial costs for the life and development of cities or legislative regulations. These data can be used for further research on urban processes and related fields. It should be noted that some scientists and data from official printed sources exclude the impact or do not pay enough attention to such components as ecology and sustainable development in the study of urbanization. We considered this issue and added their results to the table data as components of ecology and data related to sustainable development.

Table 3.5

Urbanization, key data and applications*

Category	Components	Data (type)	Scope of application
Economic development	City budget and planning Investment and taxation Industry and agriculture Real estate and land market	Tax rates Property tax GDP Inflation rate Investments by sector Interest rate Real estate value Real estate market Market and pricing	Urban planning and urban development planning Economic policy and municipal/state regulations Economic policy on industry and agriculture
Population and sociology	Health Employment Demographics Accommodation and accommodation	Urban, Rural and Suburban Statistics Dynamics/Change in Growth Household data Distribution of terrain Property and financial statistics	Policy to increase equality and living conditions Financial rules
Geography	Landscape topology Natural resources	Land cover Topography Districts and zoning	Statistics of land plots of settlements, planning and planning of spatial development Natural Resource Policies
Land use and sustainable development	Town Suburban areas Infrastructure and power grids Industry and agriculture	Location Area size Area Type of land use Total Area/Length Mapping Zoning and Ownership	Long-term plan for the construction of the settlement Smart City Management Zoning Policy of Settlements and Land Use Planning

Ecology	Green coating Water resources Waste and landfills Technology and power Emissions and hazards Healthy ecosystem Effective management of natural resources Water Resources Management	Spending on green energy Cost savings and adaptation Restoration costs Land use change costs Ecological fee	Green Cities Plan Financial rules of energy and ecology Program and Policy of Sustainable Development of Human Settlements
Politics and management	Terminology Land Use and Property Rights Municipal and local government	Planning Policy Determination of the state Use of rules and regulations Taxation, interest rate and market regulation	Policy of centralization and decentralization of cities Urban, rural and suburban planning and development policies

* Prepared based on personal research data

The author offers an example of a sustainable development program in the broader land use and management context (Table 3.6). This information will be the basis for the city's future sustainable land management plan. The program has six stages, starting with the initial system analysis and planning, leading to the action plan and its monitoring (observation). Many factors influence each phase, while stages 1 through 3 focus on a broader set of data, resource planning, and sequencing of actions relying on land management aspects of urban development.

Table 3.6

Sustainable Development and Urbanization Program

	Phase	Influencing factors	Urban and suburban aspects
1	System analysis	Social Ecological Economic Political	Quality of life and state of resources Condition and coverage of infrastructure Economic profile and health care State of the environment and natural resources
2	Planning	Problem statement Study and research Verification and evaluation Usage patterns and cost	Planning and distribution of land use Zoning and special zones Construction plan Resource allocation
3	Policy and Priority	Public opinion Costs Environment, Land Resources and Ecology	Land market Spatial placement and distribution Climatic aspects Quality and use of natural resources
4	Planning and allocating resources	Public opinion Costs Environment Land resources and ecology	Spatial development Energy supply and infrastructure distribution Investments and financial planning
5	Action	Timeline of implementation policy Land Cost and Use Land and the transformation of natural resources	Layout of houses and dwellings Construction and placement of industry City management Economic activity and planning of the use of resources
6	Monitoring and changing the plan	Monitoring Policy and System Public monitoring	Transport and traffic control Land use and use of natural resources, restoration costs

* Prepared by the author based on data [114-118]

To conduct the study, the author included both urban and suburban aspects of development in one column of indicators. However, each has unique properties and a set of data that will be covered in further research. The sustainable development program is like the general urban development program. However, at the same time,

it focuses on effective resource planning, extensive preliminary research, and public opinion research. Also, it relies on climate agreements and state bodies' general recommendations to consider environmental aspects of urban planning in the future [112, 113].

The result of using the proposed sustainable development program is a new land and city management policy. Such a program benefits communities, city residents, and private organizations. In Figure 3.10, the author presents a set of key advantages that lead to implementing a sustainable land management program. One of the main reasons for the benefits of a sustainable land management program is long-term planning, which takes into account the complex area of city management and development, its social, economic, and environmental aspects, as well as governance, policy development, food supply, water supply, waste management, electricity supply, and construction. Land management policies, resource allocation, and market regulation are the main factors contributing to cities' sustainable development. Careful planning and consideration of various factors should be aimed at restoring land and natural resources and planning the costs of introducing new energy-saving and other technologies.

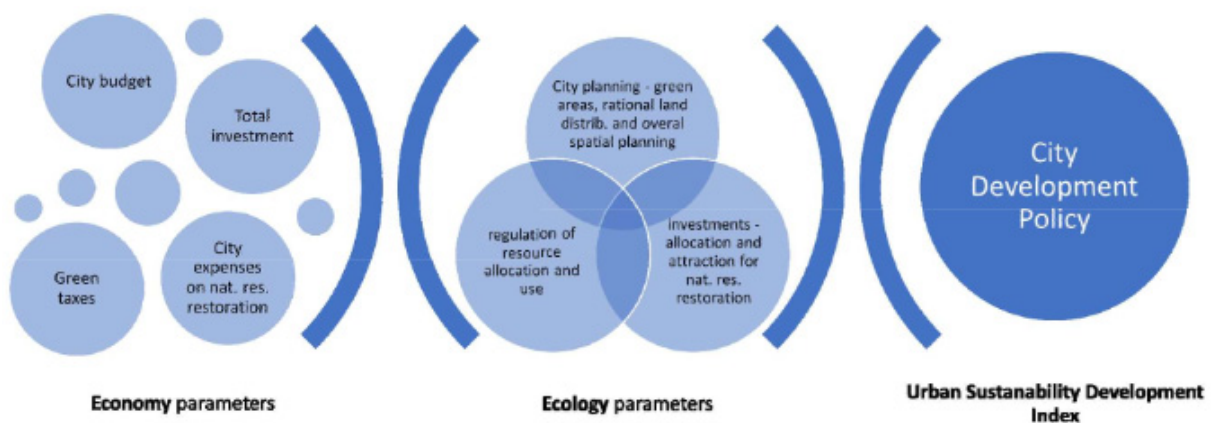


Fig. 3.10. The Main Advantages of Sustainable Land Management

Step-by-step algorithm of the program of sustainable development of the city in urbanization (a key factor of influence and a driver for decision-making in the future), the stages of which are:

1) Definition of processes:

- Ecology;
- Urbanization;

2) Determination of factors:

- how the city affects the environment,
- how ecology affects the city,
- other factors;

3) Recovery:

- biosystems,
- Ecosystems
- natural resources;

4) Economic planning:

- development of the city,
- development of suburban areas,
- renewable energy sources,
- green tax;

5) Prospects:

- short-term environmental and economic planning (up to 5 years),
- long-term environmental and economic planning (in stages for each subsequent 5 years);

6) Environmental impact

- to slow down economic development and quality of life,
- How much does the creation of an ecosystem in the city stop its development and what consequences does this entail,
- how much the city loses its attractiveness from harmful environmental factors;

7) Sustainable Development System:

- action plan,
- environmental and economic forecasting,

- policy and regulation, normative legal acts.

One of the difficulties in conducting this study was that each country has a different definition of city boundaries. The factors that have led to this are historical events, the colonial past of some countries, economic booms, and many other causes and influencing factors. However, the study of such data is beyond the scope of our study.

We studied and analyzed how each country selected for the study interprets the definition of "big city – metropolis." It should be noted that some countries, including Ukraine, grant separate statuses to the capital, the center of the federal territory, and the large city. The selected countries define a large city as follows.:

- Japan - a prefecture of the metropolis;
- India is a territory of the Union;
- China and Brazil – municipality;
- Mexico is a city-state;
- Egypt – governors;
- USA – city;
- Turkey is a metropolitan municipality;
- The Philippines is a highly urbanized city;
- Nigeria is a state;
- France is a commune;
- Ukraine is a city-district.

Analysis of the data obtained shows no direct relationship between the population of megacities and the area of land plots in cities. This factor may be the result of a specific geographical location, for example, on islands (Japan, Philippines) or near mineral deposits (Lagos), convenient waterways and transport highways (Istanbul), or zones of rapid economic and industrial development (Shanghai, Kyiv). In addition, as mentioned above, the legal regulation and demarcation of urban areas affect the presentation of the relevant research data.

For example, Paris is a city usually called a connected urban center, but at the state level, the central part of the city is a historical population center. Although official

data say that 2 million people live in the city of Paris, the total population of the Parisian metropolis is more than 10 million. Inhabitants. Such discrepancies between official regulation and the actual situation in a state or city can lead to significant economic and social consequences, such as the level of average wages, the concentration of enterprises, etc.

Table 3.7 presents the proposed urbanization profiles - basic (initial), Typical, low-urbanized, highly urbanized, ecological (green city), transitional, and de-urbanized, as well as their main components: spatial, land use component, social, and ecological-economic.

Table 3.7

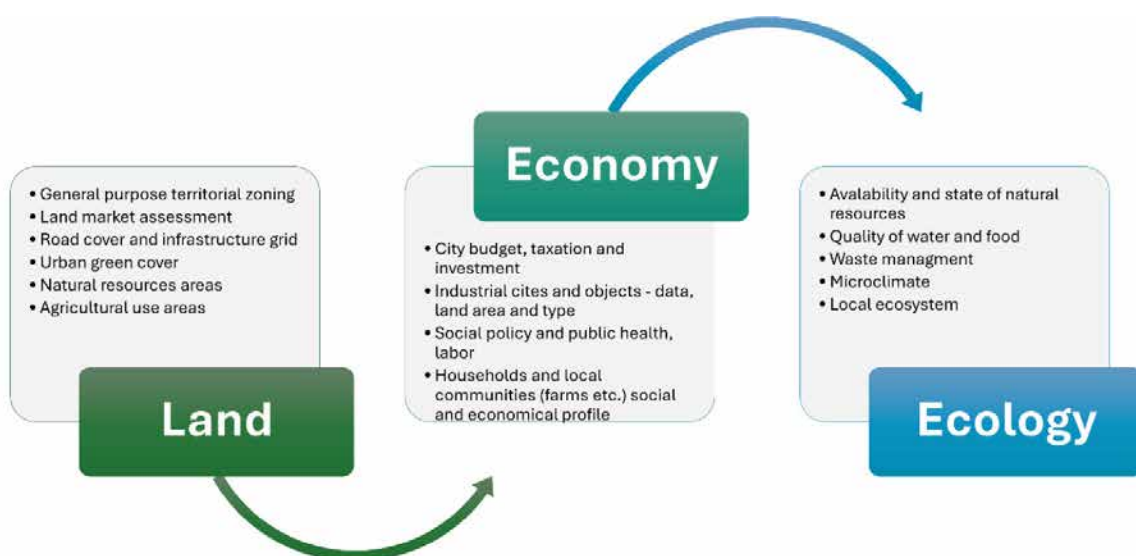
Urbanization Profiles: Spatial Zoning, Economic Development and Land Use*

Profile	Spatial component	Land	Social and ecological-economic components
Basic (initial)	Spatial zoning of territories	Territorial expansion and territorial planning	Social status and development of the population, economic plan for the development of the territory
Typical	Economic zoning of territories	Plan for expansion, change of purpose and real estate market	Employment and economic development of the territory Ecological and economic forecasting of the development of the territory
Low-urbanized	Territorial location of objects and spatial zoning	Territorial Features of Location Zones and Real Estate Market	The level of socio-economic well-being of the population and economic development of the city
Highly urbanized	Territorial zoning by economical profiles and special territorial zoning	Real estate and land market Weather conditions and climatic features of land and natural resources	Economic Profile of Changes in the Real Estate Market and Employment Profile Territorial development and distribution of objects of economic activity

Ecological (green city)	Recreational zoning and spatial placement (green technologies)	Conservation and green areas	Waste Management System, Water Quality and Food Supply - Municipal Supply Level
Transitional	Development plan and plan for the economic development of territories	Change of purpose and changes in the real estate market	Change in the economic profile of the territory
De-urbanized	Economic zoning and planning, change of spatial profile	Significant change in the level of exploitation of the territory and real estate market	Alteration of the economic, environmental and social profiles of the territory

* Prepared based on personal research data

Figure 3.11 details the urbanization profile for each of the above components. Thus, the spatial components include the spatial location of objects and functionally united territories, territorial zoning of city districts, zones of economic activity, development and territorial expansion plan, the historical and visual profile of the territory, restricted access zones, etc.



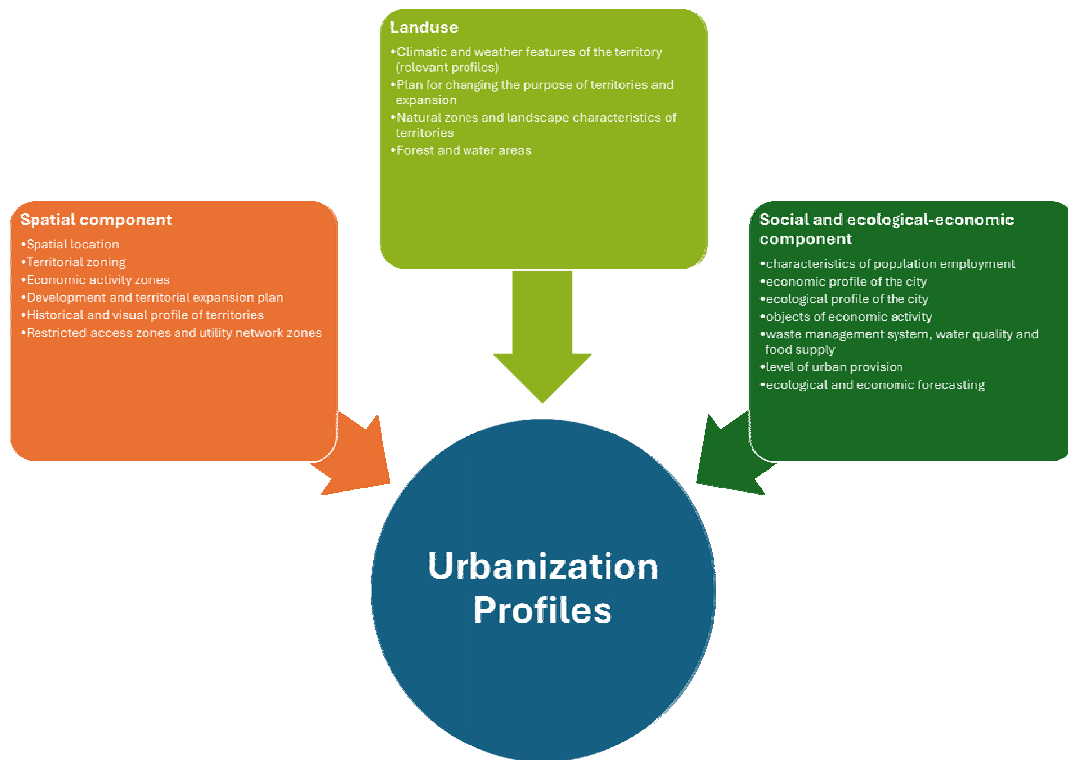
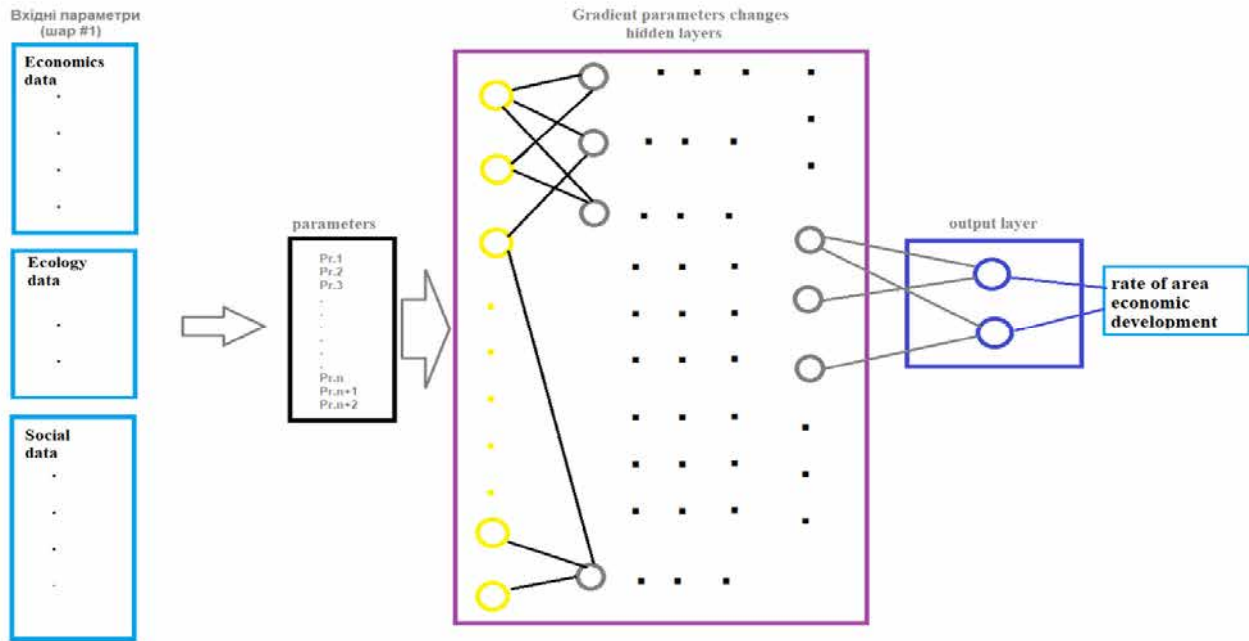


Fig. 3.11. Urbanization Profiles: land, economy and ecology connection

The urbanization process affects the environmental situation, local and national economic development, financial markets, and the national and international legal frameworks and regulations that regulate the modern city. In our work, we present tools and methods that can be used by researchers from different fields of scientific knowledge who study land management, information technologies of urban management, and social aspects of cities. Mathematical and computer methods for economic modeling and forecasting of urbanization are shown in Figure 3.12. and Figure 3.13 presents the theoretical model of calculation of the "Economic Index of Spatial Development" developed by the author, where P is the cumulative index of land prices over time (the sum of all parameters + credit - taxes); L is the loss of land value over time (due to environmental changes, weather conditions, use, etc.) and takes into account the levels of inflation and the loan rate with a change in time ; I – index of investments over time by type (type, durability); Tc - parameters of the cost of the object; C - the index of attractiveness of the object, which includes the following parameters - economic assessment of the object, the ratio of current demand to supply for this type and in a given area, the index of competition for conducting this type



$$H_k = \sum_i^n P_i * w_i \quad O_k = \sum_i^m P_i * w_i \quad net_L = \sum_i^n P_i^L * w_i^L$$

n – number of inputs in layer L

m – number of inputs in previous layer

For classification or activation: $H_k = A(H_k)$

$$O_k = A(O_k)$$

$k = 1, 2, \dots, t$ (t – number of neurons in layer)

A – network Propagation (activation) function

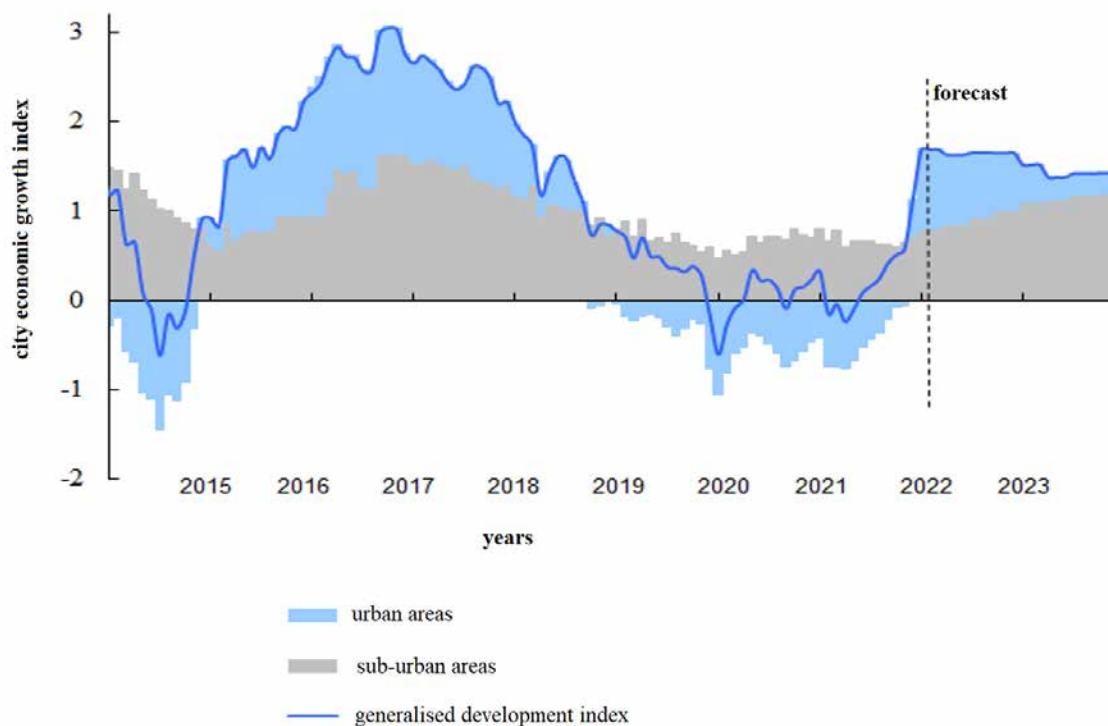
Network weight function:
$$S(\theta_0, \theta_1) = \frac{1}{2 * m} * \sum_{i=1}^m (h_{\theta} * (w * x_i) - y^i)^2$$

Fig. 3.12. An example of the application of the neural network method to predict the level of economic development of territories (cities\urbanization)

of business on the territory, the index of territories of attractiveness at the moment, the projected profit index (multiplier), the total index of adverse events (climatic, social, etc.) and includes the index G - the index of state or municipal regulation/impact - this index C can be evaluated only approximately and it represents economic growth/decline over time and is determined by the differential

levels $C_i = F_i(X_i, t)$. Table 3.8 lists tools and computer tools for researching, modeling, and calculating urbanization processes.

To better understand the possible results obtained and the consequences of the development of large cities, we determined what they incur costs for ecology and urbanization. We calculated the corresponding indicators for five cities. For calculations, we used three categories of costs in cities that are related to the environmental situation and are presented in the Paris Agreement. These are carbon emissions (in tons per year), solid waste (in tons per year), and the spending on urban green areas provided annually by the city budget. The results of the calculations are presented in Table 3.9. The most significant differences regarding this situation in the cities we have studied and investigated are how they recycle waste and what environmental consequences this leads to.



$$SDEI = f(T_c, t)$$

$$SDEI = C * \sqrt[3]{P * L * I}$$

Fig. 3.13. An example of the application of a mathematical method for forecasting the growth/decline of the index of economic development of territories (cities\urbanization)

Table 3.8

**Tools and Computer Tools for Research, Modeling and Calculation of
Urbanization Processes***

№	Remedy	Areas of application	Data	Results
1	Rent curve	Real estate price modeling	Price Object Type Distance to CBR	Choosing the optimal object type and placement for maximum profit
2	Gradient of territorial distribution	Economic assessment of the optimal location of the object with the type of activity	Price Object Type Distance to CBR Time gradient	Representation of the change in the value of rent or the value of the type of object depending on its location
3	Computer vision	Map analysis Analysis of urban images - traffic, pollution, etc.	Satellite Maps Orthophoto maps Maps of territories Type of object\zones\territories Algorithmic	Automated identification of objects, territorial zoning according to certain parameters
4	Machine Learning and Neural Networks	Forecasting the economic parameters of the real estate market Processing, structuring and modeling of complex economic systems	Economic data Classification and forecasting data Algorithmic Data Structures	Calculation of complex economic indices, progenitors and forecasting of value or changes in value by type of object
5	System modeling of processes and states	Complex analysis and development of complex scientific and practical models of economic processes	Economic data Theoretical model Algorithmic Data Structures Time gradient Type and data on the object/territory	Transport planning Planning the development of territories Presenting changes in the real estate market and more

6	Visualization and presentation of data	Structuring and visual presentation of information on certain tasks or categories to support decision-making	Input and structured datasets Cartographic Graphic Visualization methods	Visual plan for the development of territories(s) Economic charts System analysis of the necessary data
7	Complex economic and mathematical	Economic modeling of multicomponent systems for forecasting	Economic data Mathematical models	Environmental and economic forecasting Forecasting the
7	model and computer representation	and comprehensive assessment of options for the development of the situation	System models Algorithmic Data Structures and others...	selected economic index or parameter Modeling of the city budget Modeling of potential factors of influence on the development of territories

* Prepared based on personal research data, UN reports, Britannica [42-44]

In Kyiv and Ukraine, waste disposal costs at landfills are relatively low, and most of the garbage there is stored and not recycled [52]. Data from 2020 show that out of 999,100 tons of waste, 800 tons were disposed of; 200300 tons were burned, and the rest was taken to landfills.

For comparison, in New York City, for example, most of the waste is transported by diesel trucks, producing many carbon dioxide emissions. This must be done because the processing plants and landfills where the garbage is taken are located outside the city limits. So, the average distance that trucks take the garbage out of Manhattan is 7.8 million miles yearly. Landfill emissions in the United States account for 36% of all methane emissions in the country [52]. It should be noted that Shanghai has a daily recycling rate of 22,000 tons, below 20% of the total waste, and is one of the lowest in the region. There are positive examples in significant cities of

the world when, for example, the authorities of Shanghai and Mexico City use volunteers to supervise the sorting, collection, and removal of garbage. The data showed 30000 volunteers in Shanghai and more than 10000 in Mexico. A more significant proportion of waste is organic, which pollutes the rest of the waste and emits even more methane during its decomposition process.

Table 3.9

Current Data on the Status, Forecast and Normal Range: Waste, CO2 and Cities Green Areas*

Town		Carbon emissions		Waste		Green areas	
		Tone per year	Social Cost, \$	Tone per year	Waste collection (and recycling) costs, \$	km2	Annual budget, \$
Shanghai	normal	3,400,000	-	6,555,978	-	218.5	-
	Current	8,500,000	425,000,000	8,030,000	1197,353,300	1,201 (19%)	3,245,207,483
	Scheduled	9,010,000	-	1,525,700	-	-	-
Mexico City	normal	2,940,000	-	2,408,036	-	80.2	-
	Current	6,000,000	300,000,000	7,300,000	156,585,000	33 (2.2%)	224,230,840 105,522,100
	Scheduled	5,040,000	-	-	-	-	-
New York	normal	31.4 ml	-	2,267,662	-	75.6	-
	Current	157 ml	7,850,000,000	14,000,000	9,604 mil. 432,000,000 per export	2546 (21%)	891,000,000 now 3,000,000,000
	Scheduled	133.4 ml	-	7,000,000	-	-	-
Paris	normal	4,375052	-	2,726,064	-	90.8	-
	Current	16,843950	842,197,500	10,057,989	720,956,651	250 (8.8%)	900,000,000
	Scheduled	12632962	-	5,028,994	-	-	-
Kiev	normal	9,800,000	-	801,187	-	26.7	-
	Current	5,300,000	265,000,000	999,100	9,431,504	450 (54%)	216,664,414
	Scheduled	20736	-	-	-	-	-

* Prepared based on personal research data, reports of the UN, the World Bank, Open Data bot and Statista services [52-56]

Cities, information on which is presented in Table 3.9, are ranked by the number of urban populations in them. In our calculations, we took as a basis the following statistical and scientific data: the social price of carbon emissions is \$ 50 per ton, the optimal size of the green zone is nine sq.m per city inhabitant, and 270 kg of waste per year per capita, as average data from all over the world. We used data from official statistical sources to analyze the volume of waste collection and processing costs. In France, collecting and recycling waste for individuals is about 60 euros per kg. The average price for recycling and garbage collection in Shanghai is \$149. Most of the waste in Kyiv is taken out, not processed, sorted, and stored in a landfill, costing about \$9.44 per kg [57]. In New York City, the total cost of recycling garbage is \$686 per ton, and the Mexico City government pays \$21.45 to garbage collectors.

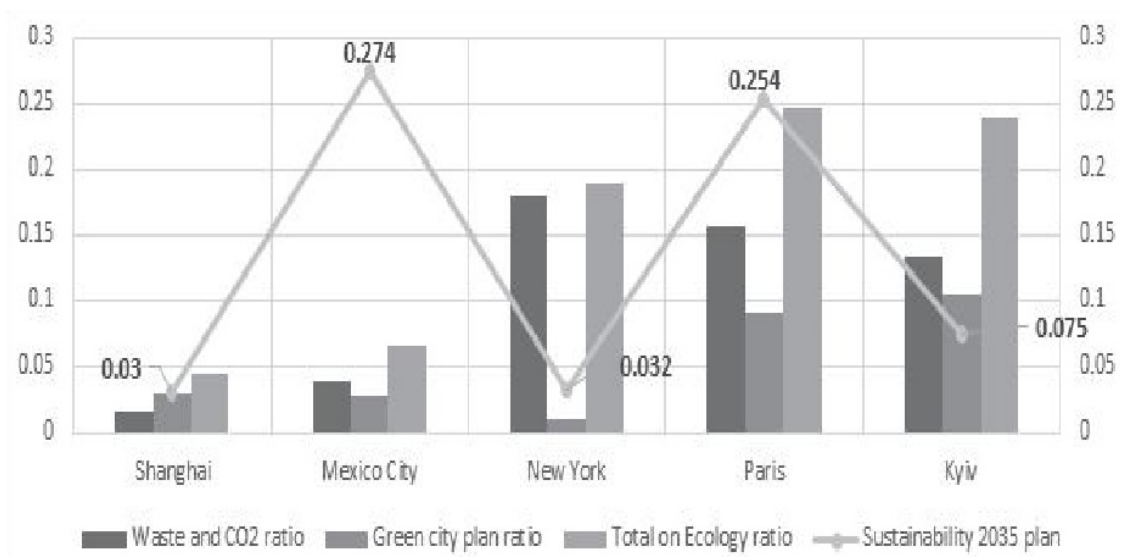


Fig. 3.14. Ratio of Total Environmental Costs to City Expenditures in 2019 and Forecast Data on the Sustainable Development Plan for 2035

Information on accumulated costs related to the environment is presented as a diagram in Figure 3.14. We used the data in Table 3.9 to calculate the ratio of the total cost of environment-related costs to the city's total costs for 2019; the line in the figure shows the forecast of the 2035 Sustainable Development Plan (according to the plans of the Paris Agreement). The indicators of the aggregate level of urban expenditures that we used for calculations are as follows (data for 2019):

- Shanghai – 108 billion dollars. USA;
- Paris – 12 billion. USD. USA;
- Mexico City – 11.2 billion. USD. USA;
- New York – USD 92.5 billion;
- Paris – 12 billion. USD (USD 20.5 billion in 2035);
- Kyiv – 2 billion. USD (USD 3.2 billion in 2035).

Based on the study results, we calculated environmental costs in each city for 2019 and forecast indicators for 2035. For three cities, changes in such indicators are not excessive. Thus, Shanghai spent 2.9% of its budget on ecology, with a projected growth of up to 3% in 2035. The situation is different in Kyiv, with a decline from 10% in 2019 to 7% in 2035. In contrast, environmental-related costs will increase in New York City from 1.8% to 3% in 2035. The cities of Mexico City and Paris will see the most dramatic changes based on our forecast. Mexico City will increase the total amount of environmental-related spending from 2.7% to 27.4% in 2035, and the amount will increase in Paris from 9% to 25.4% in 2035. In the context of such results, it is important to consider the total expenditures from the city budget in absolute numbers. For example, New York's budget is 46 times larger than that of the city of Kyiv and 7.7 times larger than that of Paris; accordingly, the amounts of environmental costs in monetary terms will differ significantly.

Figures 3.15 [56] and 3.16 [57] present the results of the study and analysis and present the waste management system, municipal policy to reduce CO₂ emissions, and the urban system of planning and management of green areas and their landscaping in the cities selected for the study:

1. Tokyo (Japan). The waste undergoes intermediate treatment - incineration, and then 100% of the ash of the incinerator is disposed of in landfills in Tokyo; general waste is disposed of at a landfill in Tokyo Bay; by 2050, the city plans to reach zero CO₂ emissions; the policy of implementing the Tokyo Green Spaces Plan (Green Protection Belt);

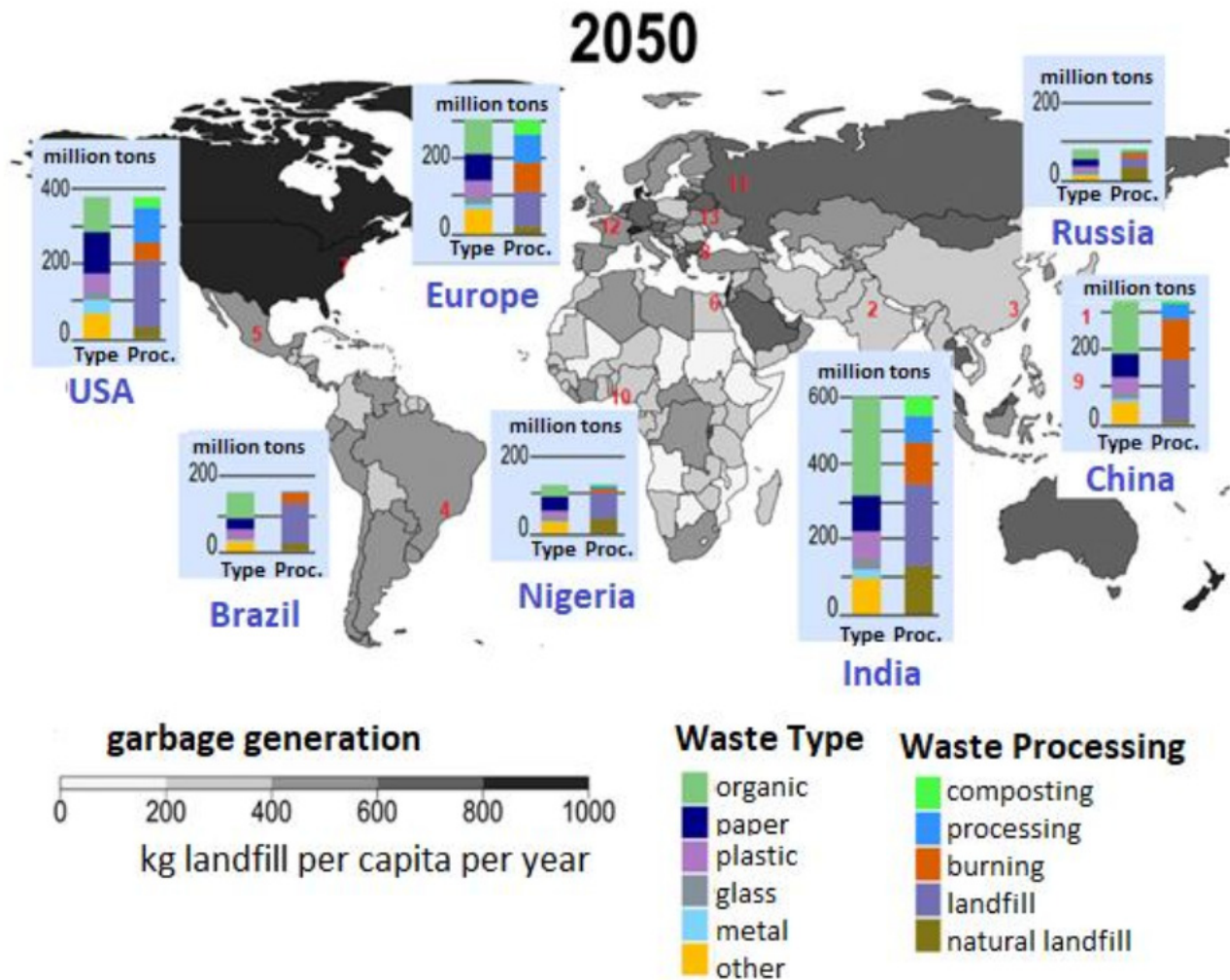


Fig. 3.15 Waste Generation with its Distribution by Type and Different Waste Recycling Options in the Countries Forecast for 2050 [56]

2. Delhi (India). Waste is placed at landfills by the services of the Department of Urban Planning and urban organizations of local self-government on the territory of 3 landfills - Bhalswa, Ghazipur, and Okhla; no global plan for zero emissions - the current plan to reduce waste by 4.8 million tons by 2024; implemented a master plan for landscaping and sustainable development of the city until 2041;

3. Shanghai (China). In 2019, a new waste management plan was adopted - from a 2-level sorting system (residual urban waste is incinerated for energy) to a 4-level one (recyclable, hazardous waste, residual waste, and kitchen waste); phased 2025, 2035, 2050, in 2060 the city plans to reach zero CO2 emissions; a municipal plan for controlling the landscaping of the city has been introduced;

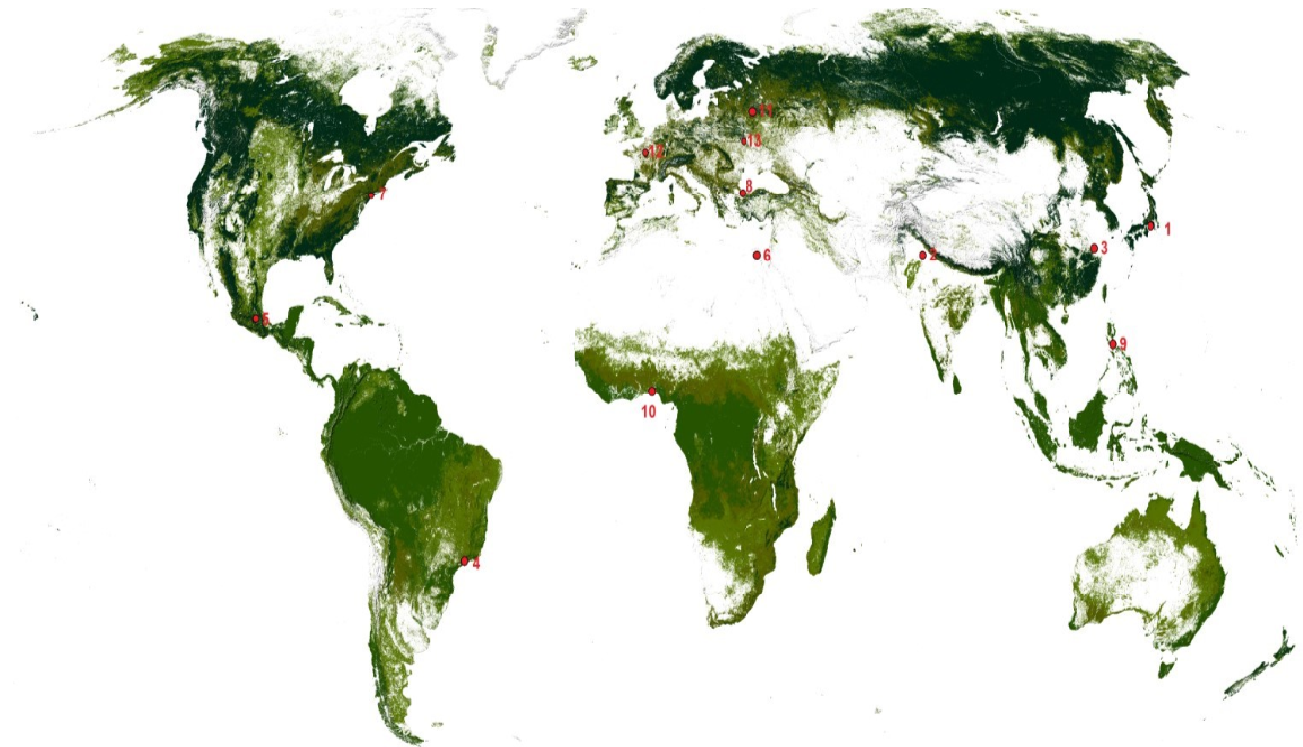


Fig. 3.16 Current State of the World's Forest Cover by Tree Types and Highlighted Locations of Selected Cities [57]

4. Sao Paulo (Brazil). Garbage is sorted into two types - general garbage (placed in landfills) and organic (reused by the city as fertilizer); by 2050, the city plans to reach zero CO₂ emissions (43 components of the plan have been implemented); a municipal plan for controlling the landscaping of the city has been introduced;

5. Mexico City (Mexico). Garbage is sorted into three types - general waste is placed in landfills, part is recycled, and the other is used as compost. By 2030, the city plans to reduce emissions by 51%, and by 2050. reach zero CO₂ emissions; a municipal plan for the control of landscaping of the city was introduced in 2007;

6. Cairo (Egypt). There is no general waste management system; since 2014 and 2017, new systems have been introduced; a nationwide Vision 2030 plan has been introduced, which provides for reducing emissions and introducing new programs from 2021; proposed plan for the development of urbanized control areas for urban landscaping in 2015;

7. New York (USA). There is a system for removing garbage from the city, and the city hires public and private contractors to dispose of garbage (about a quarter of garbage is incinerated in energy plants); by 2030, the city plans to reduce emissions by 60% and by 2050 to reduce CO₂ emissions by 85%; the city and state have introduced an Open Space Conservation Plan (adopted in 2016);

8. Istanbul (Turkey). The city sorts garbage into five categories - paper/cardboard, packaging, glass, organic, and domestic; part of the waste is incinerated, part is composted, and the rest is placed in landfills; there is no plan for zero emissions, individual steps are taken to reduce emissions in the current way; the Regional Plan for 2014-2023 on the Management of Natural Resources and Green Zones was adopted;

9. Manila (Philippines). In 2012, a waste management plan was developed, but the waste management system does not work; the current plan is to reduce emissions by 25% by 2030; in 2011, the strategy for greening the city until 2030 was adopted;

10. Lagos (Nigeria). Garbage is placed in 4 landfills, part is composted, and in 2021, a program of investment and development of a waste management system was adopted; in 2021, a 4-year program to reduce CO₂ emissions was adopted; there is no municipal strategy for the management of green areas and urban landscaping;

11. Paris (France). The implemented municipal zero-waste strategy is to reduce the volume of waste incineration. Instead, it is necessary to reduce, reuse, recycle, and recover waste; by 2050, the city plans to reach zero CO₂ emissions; adopted and implemented a plan for sustainable development of the city until 2030; in 2021, a strategy was adopted - by 2060, the city plans to reach zero CO₂ emissions;

12. Kyiv (Ukraine). Most of the garbage is placed in landfills; a small part is burned; by 2060, the city plans to reach zero CO₂ emissions. In 2021, a draft plan for developing the concept of a green city was adopted.

3.3 Future directions of urbanization research

An important theme of further scientific research is the creation of prerequisites for further study of urbanization and its allocation as a factor in economic development. It is necessary to justify the need for a new look at the city, planning, and urbanization. It is important for building a flexible and practical model of planning and development of the modern economy is a comprehensive analysis of factors that will take into account the issues of industrialization, industrial development, efficient and expedient use of land resources, and their impact on the environment, as the main lever and litmus test for testing the developed models. After all, all the above factors are interrelated and have a complex outflow. In the context of the development of the land market in Ukraine, the implementation of land reform, and the creation of databases and registers of land resources for various purposes, it is advisable to analyze and understand the actual situation in the state on this issue. In order to better outline how the urbanization process takes place and how it affects the development of territories, we will present the concept of "Waves of Urbanization," which is based on the definition of urbanization as the state and process of development of urban and suburban areas. To do this, one needs to perform the following steps:

- 1) to substantiate the factors influencing the state and process of urbanization:
 - to determine in which years urbanization was especially active;
 - to make a correlation between years and periods when financial growth or decline occurred;
 - to make a correlation between the years and periods when natural disasters, political events and environmental crises occur, etc. (of local, regional, national and global importance);
- 2) to determine how financial crises are related to changes in land and real estate prices, and to determine the following factors:
 - key factors shaping land and real estate prices;

- how crises affect the state of the national currency and the market as a whole;
 - the leading causes of financial crises that are related to real estate and land markets;
- 3) to substantiate the economic and social factors of the transfer of centers of economic development to certain cities of the state and the economic decline of other cities. An example is cities such as San Francisco, New York, Berlin, London, Manila, Shanghai, Mexico City, Lagos, and others;
- 4) to study the impact of urbanization on the environment, because such an impact does exist, but it does not appear immediately, so many cities do not conduct a balanced environmental policy and monitoring until the onset of the crisis:
- First, there are sea anemones investments in construction and industry;
 - then the real estate market is formed;
 - the urban population and the level of economic development of the city are exponentially increasing;
 - land and natural resources are actively used;
 - a natural disaster occurs or the environmental situation in the city deteriorates sharply;
 - there is a decline in the real estate market and a decrease in demand;
- 5) to develop an integrated approach to forecasting options for the development of urbanization and its impact on land use, considering the environmental component:
- to identify environmentally friendly cities (green city);
 - to resolve the issue of the conflict of functions of territories - buildings, green areas and industrial facilities;
 - to develop a concept for the development of ecological networks in the city and suburban areas;

6) to offer options for the new development of cities, megacities through the construction of transport highways:

- new buildings will arise around developed road arteries;
- stimulate the development of urbanization in a particular direction thanks to the new transport network;
- to introduce a policy of balanced regulation of the growth of real estate prices and infrastructure;

7) to develop the concept of "Waves of Urbanization" based on the above steps.

In Table 3.10, the author lists classifications of the most used tools for research in smart cities. This list includes seven main tools and provides their classification; these are digital tools and technologies, technical tools, information systems, computing systems, control systems, and analytical and forecasting systems. The information presented in Table 3.10 is divided into five sections. We should note three important components, especially the components of the tool, the types of these tools, and the areas of their application. The "Components" column of Table 3.10 presents empirical subfields that can be used for a specific study. At the same time, the data field denotes the primary type of data used by this tool to help form an opinion about which tool to use to achieve a specific goal in a research paper. In the column "Areas of application" of Table 3.10, we presented a list of research areas where these tools can be used.

Table 3.10

Urbanization Model: Data, Tools and Techniques Classification

Tool	Components	Data	Areas of application
Digital technologies and tools	Servers and computing resources Digital Mapping and GIS 3D Visualization Tools Telecommunication Technologies	Digital Images Numeric Data 3D Object Data Land use data Geographic data and information	City Management and Management Architectural Planning

Various technical means and tools	3D/LiDAR Scanners Ground Surveillance UAVs Surveillance Cameras Sensors and Surveillance Systems	Digital Images Numerical Data Sensor Data	Urban surveillance
Information systems	Data Entry Data Mining Data Storage Data Presentation	Digital Images Numerical data Text and general information Visual data	Electronic City
Computing systems	Computer Vision and Object Recognition Computing System	Digital data	Data and systems modeling
Decision Management Systems	Digital Documents, Taxation & E-Commerce City Governance & Supervision Security & Critical Resource, Management Communication System	Digital data Sensor data Text and general information	Land Use and Spatial Planning Electronic City
Analytical Systems	Big Data Analytics Machine Learning City Statistics	Numerical Data Digital Images	Real Estate Electronic City
Forecasting systems	Machine Learning Data Modeling	Digital Data Visual Data	Electronic City

* Prepared based on personal research data

Three main types of data are used in studies of the urbanization process:

- numerical data (financial, remote sensing data, statistical, etc.);
- geographical data and information (including maps and digital visualization of cities);

- textual information (city plan, legislation, municipal regulations, etc.).

One of the new application areas for computer modeling and information presentation is the Smart City system. Smart city research requires the researcher to work and analyze vast amounts of data and information. It should be noted that a detailed description of the constituent elements, city services, scientific expertise, and presentation of the "Smart City" concept will be presented in the following sections of this work.

Figure 3.17 presents four primary areas of conceptual research of the "Smart City" – urban planning, city services, legislation, and technical infrastructure. We have provided a list of the main components and research areas for each of the four areas. The conceptual model of a smart city is based mainly on the example of Kyiv, its structure, management, city administration, and publicly available data on infrastructure and performance indicators of the city.

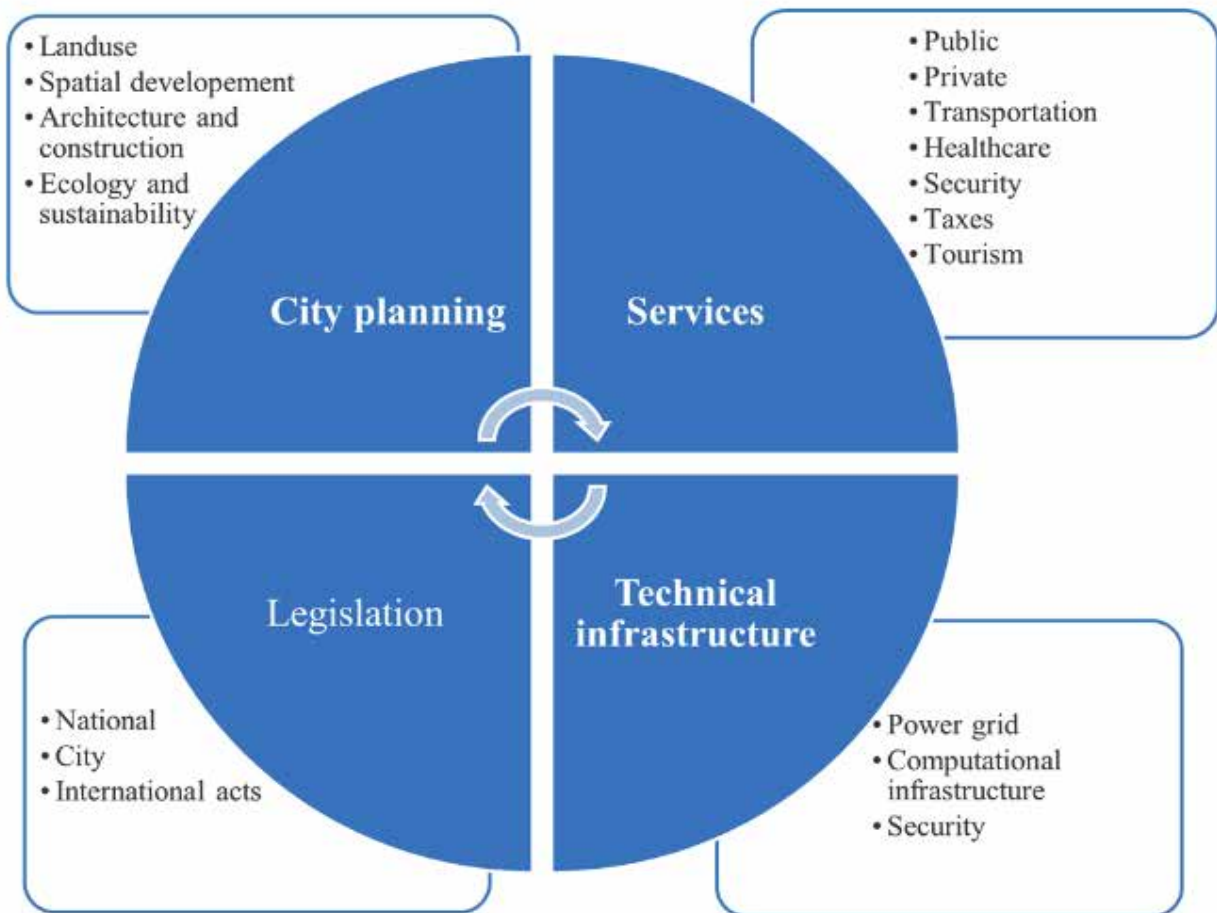


Fig. 3.17. Components of City Management Systems

Cities are complex objects; these are their inhabitants, land plots, and buildings with all the infrastructure and the presence of various types of government institutions and organizations. City dwellers are the primary catalyst for the change and development of cities, and their activities serve as the main reason for this. A city's population comprises permanent residents and non-residents, such as tourists, business travelers, business travelers, etc.

Cities are governed by local governments, city councils, or city administrations, as well as by the country or federal government, which also have some level of influence over the city. Enterprises, organizations, institutions, and international non-profit organizations can participate in the city's development or influence its growth at any pace. Figure 3.18 presents a generalized list of the main actors and their roles in the context of the life of the city and how they interact with the city as a whole.

The services provided to the city's residents are at the forefront of any activity related to the city. Services may be provided or consumed by their users. The city budget, tax policies, and legislation affect these services and how the city government provides them. Factors such as construction, regulation, land use patterns, environmental burden, and environmental situation directly affect the city and its population.

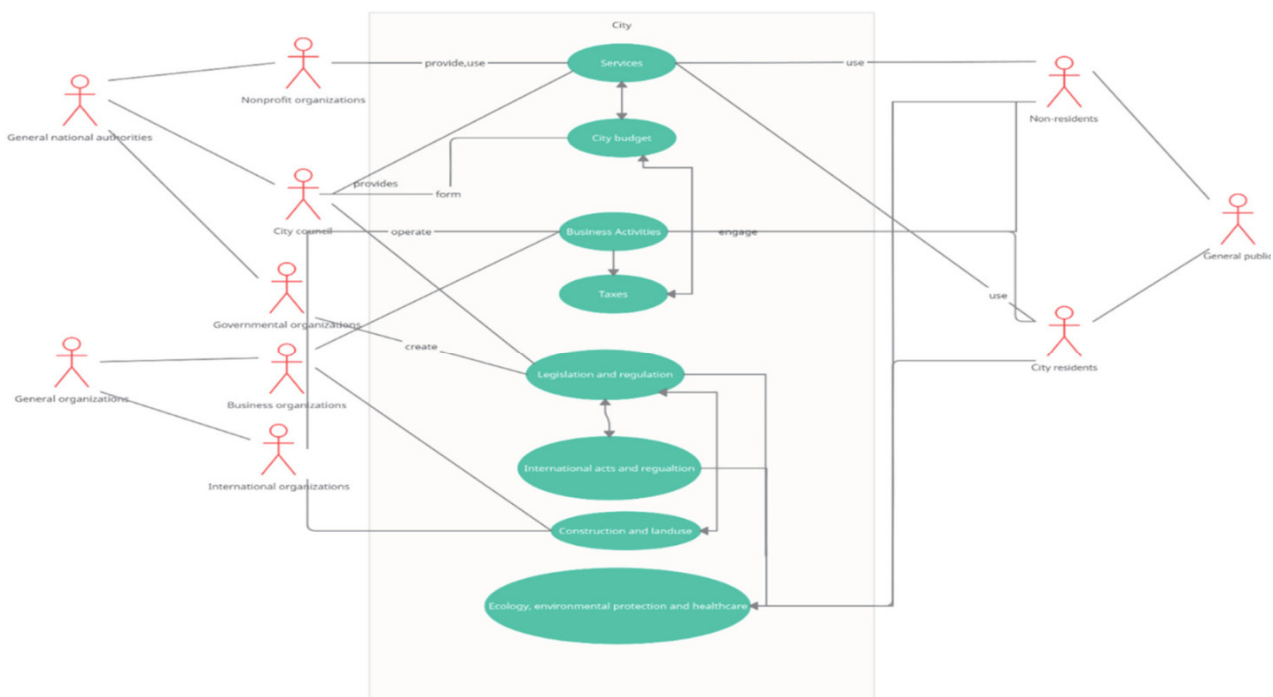


Fig. 3.18. Main Roles in City Management and Key City Services

Information technology tools and techniques are widely used in all major modern fields of scientific research, and urbanization is one of them. Table 3.11 provides a list of the main tools for the analysis of computing and information systems that can be used by scientists working in the field of urbanization studies and urban planning.

Table 3.11

Classification of Modern Computing Systems and Data Analysis Information System*

№	Tool	Category	Data Type	Imprint	Urbanization industries
1	3D visualization	Simulation Presentation	Geographical representations	Digital Model City Plan (Visualization)	Green City Spatial Planning and Accommodation
2	Computer vision	Simulation Presentation	Image Digital Data	Cartographic data	Urban planning and monitoring
3	Digital recording devices	Modeling Technical Systems	Digital data	Metrics Different data types	Smart City Urban Ecology
4	GIS	Simulation Presentation	Geographical representations	Cartographic data City plan	Land Use Land Development Land Use and Infrastructure Planning
5	Information systems	Solution Support Simulation View Planning	Financial Statistical	Information	Smart City Population, Dynamics and Health
6	Machine learning	Solution Support Simulation Planning	Numerical Scientific	Information	Real estate market
7	Forecasting systems	Planning Simulation	Numerical Financial Statistical	Information	Smart City

* Prepared based on personal research data and Britannica data [49-51]

Table 3.11 contains extended and in-depth information on the development of the data presented in Table 3.10 and focuses specifically on the computer toolkit. Table 3.11 presents five sections: the computer science tools, the category of tools, the types of data used with this toolkit, the results of their output with this tool, and the areas of the urbanization process in which this tool is most appropriate.

Modern information technologies can serve as a solid and reliable scientific tool for the study of modern urbanism. A tool such as computer vision will allow us to analyze and classify spatial data efficiently. Furthermore, it is also necessary to use advances in machine learning, which allows for building reliable models for forecasting the real estate market or accurate urban models, using 3D modeling platforms, which provides a strong argument for their use by researchers of urbanization processes.

We will use case scenarios to understand the city's life in an environmental context, including different points of view, the main sections of city management, and functions. The above data is used to create a conceptual model of a smart city. Figure 3.19 shows a conceptual model of a smart city focused on providing services. Three main categories or groups of people can work according to such a system, both directly and indirectly influencing it (change parameters). Each city service may have different structures that provide services, for example, private organizations or communal social services, or they may rely on citizens to carry them out.

Figures 3.10 and 3.21 illustrate a sample of smart city architecture, as well as indicate the main technical requirements for it. Figure 3.21 describes explicitly the significant additions and sections of the information system of the conceptual system of the smart city. The intelligent city system consists of three sections – a standard cloud array of sensors and surveillance devices, a software solution – an interface for the interaction of people with the Smart City system, and the technological infrastructure of the smart city computing cluster.

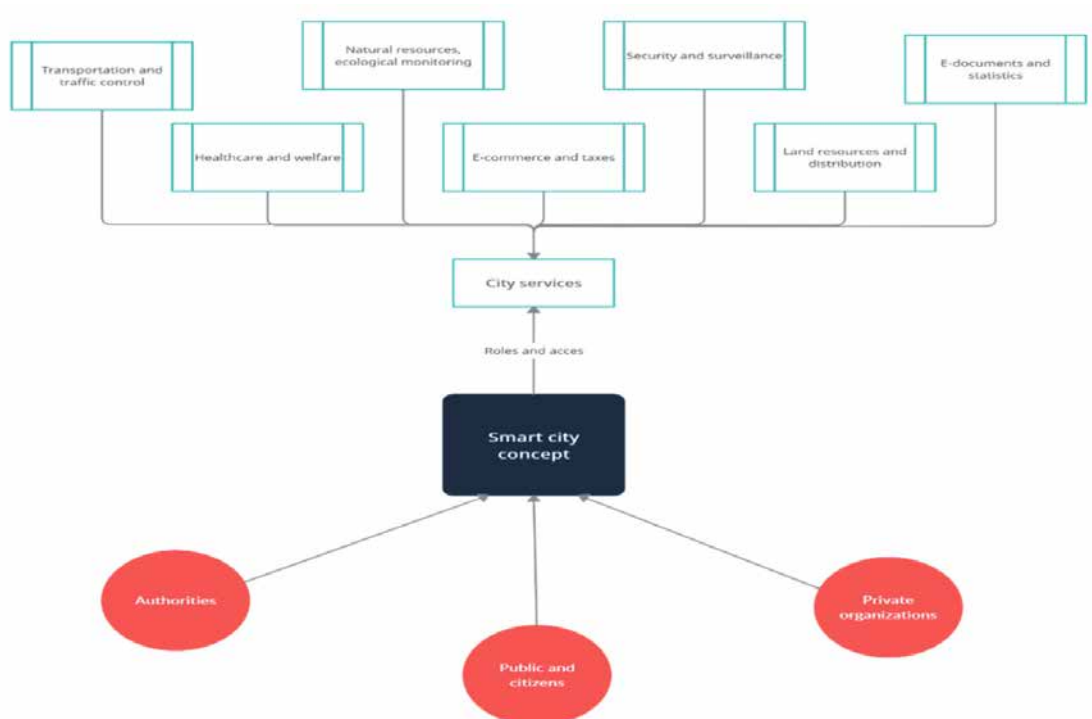


Fig. 3.19. "Smart City" Model Concept

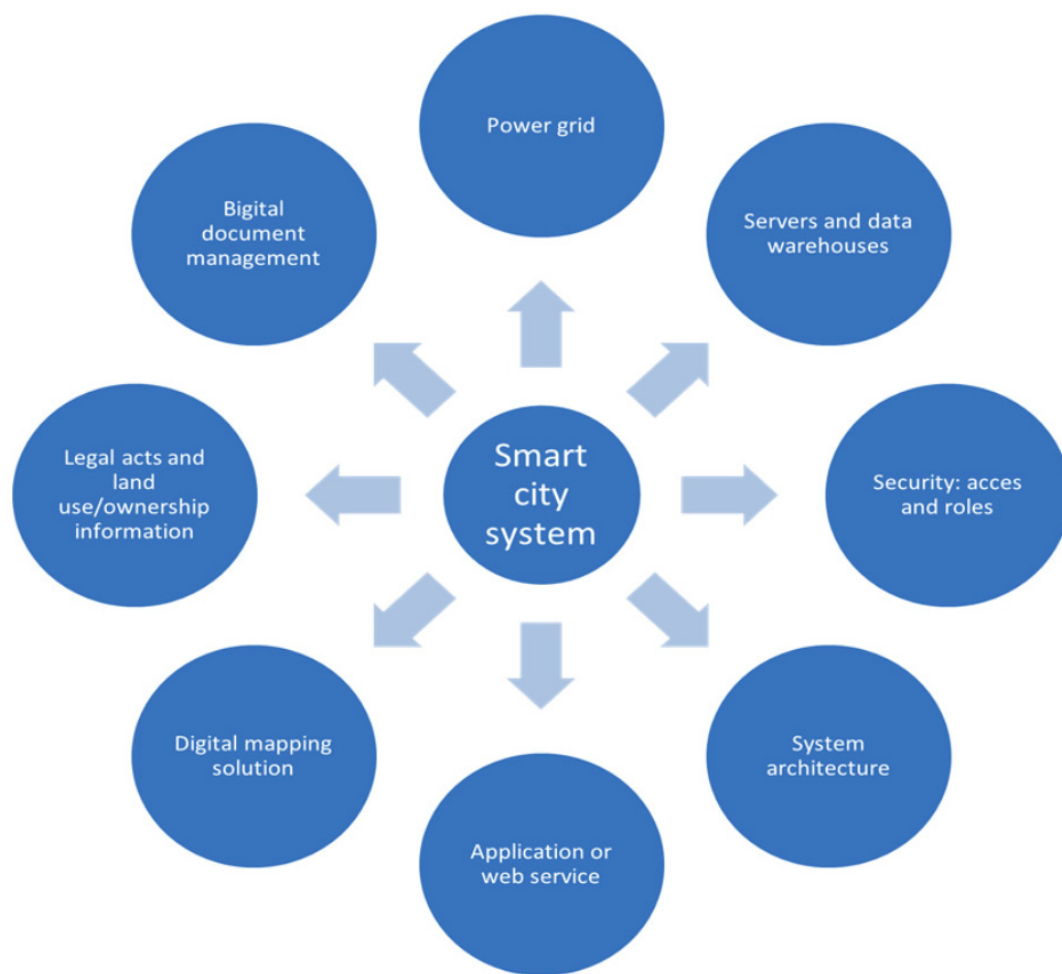


Fig. 3.20. Smart City System: Technical Component

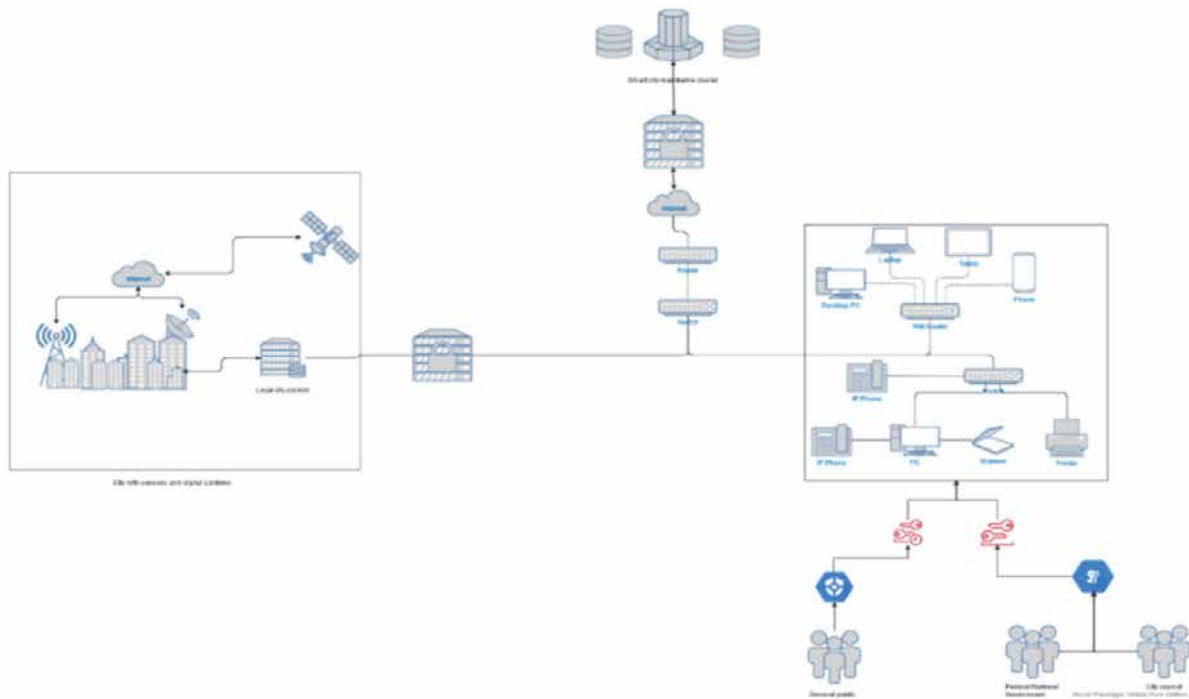


Fig. 3.21. Smart City System Concept

The city is the central territorial unit and one of the key places for developing the state's economy under modern conditions. Cities account for a significant share of the economy in the world's developed countries. Thus, according to the UN, countries with a higher level of urbanization (60% and above) have a higher GDP. In Ukraine, there are constant changes and expansion of urban areas, intensive construction is carried out, and the purpose and use of land resources are changing. For example, in Kyiv, residential and civil buildings increased by 25 percent, while agricultural areas decreased by 76 percent and industrial areas by 6.2 percent, respectively. Since, first of all, the level of construction increases while the percentage of industrial and agricultural territories decreases, it is advisable to investigate to what extent these factors affect the development and state of the economy of the state as a whole and what consequences these processes will lead to in the future.

The city's ecology is an important modern problem related to urban development and urbanization. Massive development of the city, the development of transport infrastructure, and the city's territory, which has grown by 37.3 percent in Kyiv, can negatively impact the population's health. It is worth exploring how the above factors affect the capital's economic development and making a forecast for the future.

It should be noted that the main feature of the study of the state of affairs in Ukraine, and in particular the city of Kyiv, is the development of the land market, problems with development and inefficient land use, as well as the lack of long-term planning with clear development plans and full compliance with regulatory documents and legislative acts. It is necessary to understand and analyze this data better, have a holistic picture, and conduct further research. It is advisable to develop a general theoretical concept of city planning in modern conditions based on foreign experience and existing research and developments in Ukraine.

Many publications are devoted to the issues of land use, city planning, economic forecasting, and real estate prices. The formation of real estate prices and their constant changes are studied in detail. Various authors pay sufficient attention to the study and analysis of the issue of ecology. Ecology is a very important factor that impacts the state and development of the economy; it must be considered when conducting research and building models.

The development of urban areas, urbanization, industrialization, and ecology are closely related to the modern world. However, many authors focus on only one of the problems or point out the negative consequences of urbanization on the environment. Therefore, considering social and political challenges, it is necessary to conduct a more detailed study and establish the relationships between urbanization and ecology in modern economic development. In our work, we focused on the essential criteria and general factors of the relationship between ecology and economy under the influence of urbanization (Table 3.12).

Table 3.12

Socio-Economic Profile of Urbanization: Key Indicators*

Profile	Socio-economic component	Environmental component
Basic (Initial)	Labor market development Investments in real estate, industry and infrastructure development, energy	There is no general urban plan for waste management, distribution of green spaces and reduction of environmental pollution

Typical	<p>Increase in revenues to the city budget</p> <p>Socio-economic stratification of the population</p> <p>Real estate and industrial investment</p>	<p>Garbage is taken to landfills, emissions management is carried out at the level of current planning, natural resources and green areas are exploited depending on the development plan and/or the city budget</p>
Low-urbanized	<p>Sustainable (projected) growth of the city budget</p> <p>Uniform state of socio-economic provision of the population</p> <p>Investing in a sustainability program</p> <p>Green taxation</p>	<p>Implemented city waste management system, emission reduction and green energy</p>
Highly urbanized	<p>Qualitative development of the labor market and uneven increase in household incomes</p> <p>Investments in real estate, services and services</p> <p>Growth of the city budget and the impact of a country's level of economic development (GDP)</p> <p>Development of investment in new technologies</p> <p>Implementation of the city management system</p>	<p>A plan for a municipal waste management and emission reduction program is being developed</p>
Ecological (green city)	<p>Sustainable Economic Development Program of the City</p> <p>Investing in green technology</p> <p>Implementation of an environmental monitoring system and an automated system for managing city resources</p>	<p>A balanced policy of allocating green areas to development is carried out, most of the garbage is recycled and constant environmental monitoring is carried out</p>

Transitional	Decrease in the pace of economic development of the city Low level of social security of the population Impact on the economic development of the region Decrease in the total volume of investments in the city's economy	There is no monitoring and decision-making policy on the environmental situation and waste management
De-urbanized	Unstable and unpredictable economic and social development of the city, changes in the priorities of the city budget and the volume of investments	A new policy is being developed in accordance with the level of economic development and provision of territories

* Prepared based on personal research data

3.4 Economic representation of urbanization

The author believes that urban and regional economic development plans should be centered around the development of suburban areas. It is necessary to present an updated version of potential plans for the economic development of urban and suburban areas, which is presented in Figure 3.22, and in the future to take into account the results of previous studies [66] and new research results that were presented in this section of the scientific work. Let us present an algorithm for developing a plan for urban and regional development in the economic dimension. To do this, one need:

- 1) to carry out territorial zoning and distribution of territories by the following components - suburban areas, transitional zones around cities, urban areas by types of development and economic profile, metropolis territories - zoning by economic profile;

- 2) to study the existing urban planning and general plans for the development of territories within the general territory of the agglomeration, to present the concept of the spatial development of settlements;
- 3) to analyze existing and past plans for the development of the city, to conduct a comprehensive economic and social assessment of these plans, to highlight the key factors of changes and impact on the process of spatial development of territories;
- 4) to develop a comprehensive model of the social component of urbanization in order to investigate the impact of the development of territories on the quality of life and standard of living of the population, to conduct socio-economic modeling of the impact of urbanization on the economic and social profiles of urban households;
- 5) to model the curve of changes in the value of real estate in cities and suburban areas by the proposed system of territorial zoning and classification of territorial objects according to economic data;
- 6) to carry out ecological and economic forecasting of the impact of urbanization and its consequences on the economic development of individual territories, metropolis, and region;
- 7) consider current legislation and regulation in construction, spatial development, urban planning, taxation systems, and state regulation of the land and real estate market;
- 8) to assess economic development at the global macro, national, and regional levels; to study the dynamics of changes in the value of the national currency and the investment market;
- 9) to present a system of recommendations for determining the optimal location of new territorial economic objects, investment centers, changes in the designation options of certain territories, and environmental and economic assessment of risks from negative environmental changes.

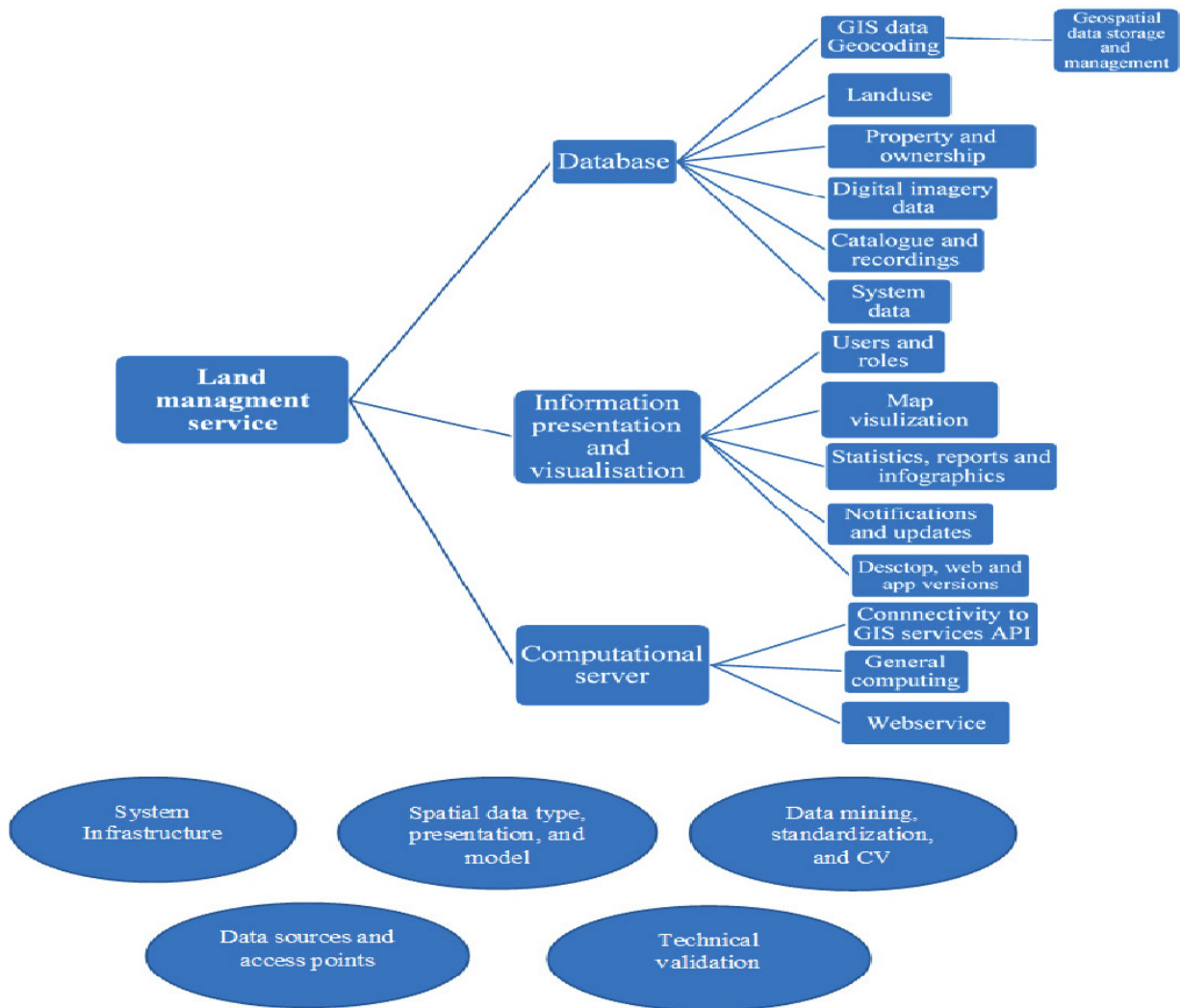


Fig 3.22. Economic Development of Urban and Suburban Areas Model

Draft plan of socio-economic development and policy for the city management and decision-making system:

1) Economy as a driver of urbanization:

- determine the main path of economic growth and development of the territory,
- to develop an investment plan in industry and providing the city with food (support for the local agro-industrial complex),
- introduce a regulated real estate and land market, change the purpose of land and expand catalogs of types of its use,
- macroeconomic planning at the city level,

- to develop and implement plans for basic social security of the urban population and forecasting its growth;
- 2) Consequences of rapid urbanization and impact on development:
- create plans to minimize negative consequences in the real estate market, social security and environmental impact,
 - territorial zoning and planning of the construction of new territories and facilities,
 - to develop levers for regulating the general economic situation with rapid construction and an increase in urban population;
- 3) development of the concept of the open market of land and real estate with levers of control and monitoring of compliance with the established norms and principles of law:
- mechanisms for forming prices for objects,
 - factors the influence of the market on the object and vice versa,
 - parameters of the economic development of the city, which affects the formation of value and offers in the market,
 - factors and mechanism of influence of adjacent transport networks and infrastructure facilities or zones of special (limited access) purpose on the market;
- 4) conducting a comprehensive study of the economy of other cities and economic development and urbanization in developing countries, paying attention to the following parameters:
- banking sector and distribution of finances for construction,
 - investments in real estate and the land market,
 - social and economic policy and profile of the population,
 - Other;
- 5) Development of a long-distance and regional memorandum or agreement:
- economic plan for regional development,

- master plan for the development, investment and construction of suburban areas in the context of the development of the metropolis economy,
 - introduction of a trade and economic memorandum of trade turnover and an open market between cities and within large metropolitan cities;
- 6) creation of an information system for accounting data for the city, which will include the following data:
- economic activity of the population - profits, employment and expenditure profile,
 - economic statistics and data on spatial development, construction and land use in the context of city development by time intervals,
 - data of environmental monitoring systems, waste management statistics,
 - data of urban life support systems and engineering systems,
 - data of the transport, traffic and emergency monitoring system,
 - Other;
- 7) Development of a plan for sustainable development of the city to conduct a comprehensive study, with the involvement of the public and various institutions, to determine the factors of influence of ecology on the economic development of the city and agglomeration, and the reverse impact of urbanization on the state of ecology of territories:
- 8) presentation of the city management system, which should contain the following parameters:
- assessment of the dynamics of changes and the state of the financial sector in the city and by types of economic activity, key sectors of the city's economy,
 - determining the factors of the relationship between interest rates, incomes, GDP growth and housing prices within the city and on the territory of the agglomeration,

- monitoring the state of social security and basic city services for residents and other persons,
- the level of provision of the city with natural resources and their condition,
- a plan for diversifying the source of energy and heat supply to the city, a taxation system for new green technologies, etc.;

9) macroeconomic planning of the agglomeration, which includes the main factors and indicators of the national economy and the global economy, determining the role of the state and development of the urban economy on a national and global scale

- stability of the national currency,
- Index of Industrial Development and Investments by Types of Economic Activity,
- open trade market,
- policy in the energy and climate change sectors,
- the impact of regional cataclysms on the stability of the local economy, and others.

Modern research tools, such as information and computing systems, are essential for effective economic modeling and forecasting of the market situation. Each of these individual information systems uses data classified by type and value. Table 3.13 presents the results of the work on the classification and distribution of data by categories that can be used in the information system to calculate economic costs for land. The distribution of data into categories (Table 3.13) is directly related to the classification of regions: factors of direct and indirect economic costs of land use in the context of cities, among which it is worth highlighting important economic indicators:

- the volume of GNP per capita and the dynamics of its changes;
- inflation rate and stability of the national currency;

- the level of employment of the population by types of economic activity and by urban areas;
- the level of average income of the population, by types of economic activity;
- the value of the discount rate;
- average median values of loans and deposits by type of banks;
- the total level of profit of companies by type of economic activity, per capita urban population and territorial zoning;
- trade balance indicators;
- the volume of products sold by companies by type of economic activity and by territorial zoning;
- and others.

Based on the results of the study and analysis of the data presented in Table 4.1, and based on the materials of previous research, the author proposed to determine the global economic model of urbanization, which determines urbanization processes, as a factor of changes in land values:

- make a visual and numerical representation of changes in the boundaries of the city/territory over 5\20\ years or more, conduct a comparative analysis to identify patterns to predict spatial development in the future;
- to assess growth and options and purpose for the use of resources, to present a cost assessment of changes;
- to analyze due to which economic and other factors, the development of territories, which is closely related to the economic development of the country, affects the economic development of the city, and what is its impact on the decolonization of rural areas;
- factors of economic impact on the development of urbanization: segregation, social and cultural components;
- system of risk assessment and calculation of financial consequences of the conflict of functions of territories: ecology, construction, industry, agriculture and others.

To better understand how real estate prices were formed, it is necessary to study the price of land leases in the city. In addition, it should be noted that the classification proposed in Table 3.13 is based on economic factors such as interest rate, national GDP, or real estate market, which influence price, supply, and demand.

Table 3.13

Land Value Factors: Data and Categories

Factors	Data Type	Data	Data category
Location of the land plot	Geographical location	Location coordinates	Land Real estate
Terms of Use of Land Property	Information	Sale/Rent/Leasing	Land Real estate
Plot type	Information	Protected /Agricultural/Municipal/National	Land
Type of land use	Information Documents	Personal/Corporate/Public Agriculture/Industrial/Construction/Farm/Natural Resource Deposit/Forest/Water Zone (Reserve)	Land
Land Cost	Financial	\$ per unit area \$ per unit of time	Land
Plot size	Numerical Geographical Location	Unit Area Coordinates of area boundaries	Land
Legal documents	Documents	Terms of Use Lease or lease period	Land Real estate
Economic growth	Numerical financial	National GDP Federal/Municipal GDP, Investment and Budget	National economy
Interest rate	Financial numerical	National Course Rate of commercial financial institutions	National economy
Supply and demand	Numerical information	Supply and demand of the commercial market Federal/Municipal City/Building Plan	Land Use Ownership

Landmarks and relative location	Geographical location High-quality financial	Plot location (relative) Land valuation Potential prospects Investment and economic growth opportunities	Land Use Ownership Industry
Natural resources	Geographical Location Qualitative Numerical	Water resources Mineral deposits Soil fertility Relative Location/Spatial Position	Objects of common use Farms Industry
Labor market and infrastructure	Geographical Location Qualitative Numerical	Relative Location/Spatial Position Labor market and supply (including quality) Investment prospects National/Federal/Municipal Economic Plan	National economy Local economy
Real estate value	Financial	\$ per unit area \$ per unit of time	Land Use Ownership
Cost of maintenance	Financial	\$ per unit of time	Farms Industry Public space, institution
Environmental costs and factors	Financial quality documents	Land Degradation and Restoration (Soil) Deforestation and changes in green cover Waste Management Sustainable development, environmental regulation	National economy Local economy

* Prepared based on personal research data

While conducting the study, the author drew attention to legislation and local municipal land regulations, including legislation and regulations related to ecology.

Unfortunately, not all of this information is available in a publicly available official format, and the available data is minimal to create economic models and take it into account when modeling land use. The data we found from online sources has only been available since 2016. Statistics in the field of land relations show that the monetary value of land is very different in different districts of Kyiv. So, the closer to the city center, the higher the land cost, and the lower - the farther from the center. The average level of normative monetary valuation of commercial land plots in remote areas of the capital is 250000 UAH per 100 sq.m. It can be calculated that the rent for a small plot of land, for example, 400 sq.m, which can be used by a small commercial facility, will be at least UAH 1000000 per year. The rent will be much higher in the city center, about 10% of its normative monetary value.

Economic parameters that should be considered for the study and modeling of the economic side of urbanization: consumer spending; exchange rate; gross domestic product; GDP per capita; GNP; stock market; interest rate; public debt; inflation rate; Unemployment; trade balance, real estate prices. In addition, when studying the impact of urbanization on the economic development of cities, it is necessary to consider the following indicators: population density, zoning, inflation rate, etc. In addition, data on the number of apartments available, vacant, rented, and under construction should be considered. Whether it is worth including prices and the number of parking lots is not resolved today because megacities can be more expensive than apartments.

It should be noted that the model of urban development and urbanization economics is significantly influenced by such factors as population density and its number, specific weight of built-up areas, directly built-up areas (number of stories of buildings and number of apartments), cost of infrastructure costs, capital invested in the development of the territory and concentration of further development, assets of enterprises, size and total volumes of taxes collected, density of registered enterprises and organizations, the density of retail chains, average per capita incomes, as well as the size of the average wage, etc.

The main goals of the development of urbanization processes are spatial expansion, the change of urban boundaries, the intensive use of land resources, and territorial expansion in various directions. Of course, urbanization can take place internally - by changing the purpose and development of internal urban areas (for example, forest areas, lakes, and ponds, etc.), as well as thanks to the latest construction technologies - combined underground, ground and above-ground buildings and high-rise buildings, the development of water bodies or mountain ranges. Another example of territorial expansion is the change in the use of suburban areas, such as agricultural land. This variant of urbanization expansion often leads to a conflict between non-urbanized rural areas and urban ones. In this context, the city can indirectly affect the surrounding rural areas, not through development but through the development of the economy and the migration of the population to the cities. There is no universal solution to the presented conflict, and such issues should be resolved at the national and state levels and considered when planning the development of the economy and territories at the national or at least regional (federal) levels. When developing such a plan, the following factors should be considered:

- definition and purpose of urban expansion - territorial expansion/need, economic development, rapid population growth, industrial development or industrialization of territories, and others;
- state policy of support and protection of agricultural land, environmental policy;
- programs of economic and social support, investments in rural development;
- economic and social assessments of the projected impact of urbanization on the development and condition of adjacent territories;
- economic planning and prospects for changing land use options for suburban and surrounding areas;
- ecological and economic assessment of options for the development of urban areas and their impact on the state of ecology, climate change and other factors of influence;

- national plan and programs for the development of the distribution and maintenance of the state of natural resources by various territorial associations;
- federal/regional system of distribution of financial resources, international investments and trade between cities and towns;
- national program for monitoring, accounting and assessment of the state of free land;
- environmental planning of land use options, restoration of the state of natural resources, planning of spatial development of urbanization, taking into account the environmental component;
- economic planning of the development of the national economy and the inclusion of economic planning for the development of urban agglomerations as important components.

There are many economic costs related to ecology and forest cover. The list of the main tools and methods used for such studies is presented in Table 3.14. Among the most important are national or local tax policies, the costs of technological adaptation, the cessation of deforestation, and the restoration of ecological biomass.

Table 3.14

Tools and Methods of Economic Costs Related Framework to Ecology

№	Tool Method	Components	Data	Outcome
1	Economics of restoring the state of ecology	Sector/Industry Business function Type of work Type of impact Effects - indirect, induced, general	Employment Labor income Added value Gross output Environmental Performance Index	Weighted Sales Added Value Curve of ecological dynamics Environmental tipping point
2	Climate	Reducing carbon emissions Subsidizing green energy Health	Atmospheric CO2 Reserve Temperature deviation Annual emissions Green and fossil fuel	Replacement costs Power consumption Emission generation Conflict of interest regarding wages and

		Environmental taxation Melting ice Rising water levels in the ocean	energy ratios National health expenditure Environmental quality Tax level	reductions MRS Citizen/Business Marginal private costs for cuts
3	Energy and transport	Technology of electricity production by source Policy and regulation Level of taxation by technology	Cost per unit Power Supply Efficiency Available resources Market Price Taxation	Cost of electricity generation The cost of new technologies Cost of adaptation New electricity costs
4	Ecosystem	Provision of resources Quality of natural resources Biodiversity Microclimate and bio-heritage	Resource Type Land cover type Type of system services	Ecosystem maintenance costs The cost of ecosystem restoration
5	Financial policy	Price Cost	Market Replacement Restoration Willingness to pay Transportation costs	Cost reduction Benefits of sustainable development policies Taxation
6	Policy	Technology Source of electricity, electricity Evaluation of eco-system services Labor market	Taxes Cost of reducing resources Monetary valuation Replacement costs Environmental costs Technology replacement cost Employment and social spending	Taxes \$ per unit area Ecosystem transformation process Technology Adaptation Speed/Cycle Salary Employment Rate

* Prepared by the author based on research data and from sources [120-125]

The model of the economic costs of deforestation in cities is presented in Figure 3.23. A list of the main economic factors related to the data is presented on the left side of the figure, along with the tax rate, the value of the forest ecosystem, and the system that affects the parameters of land lease.

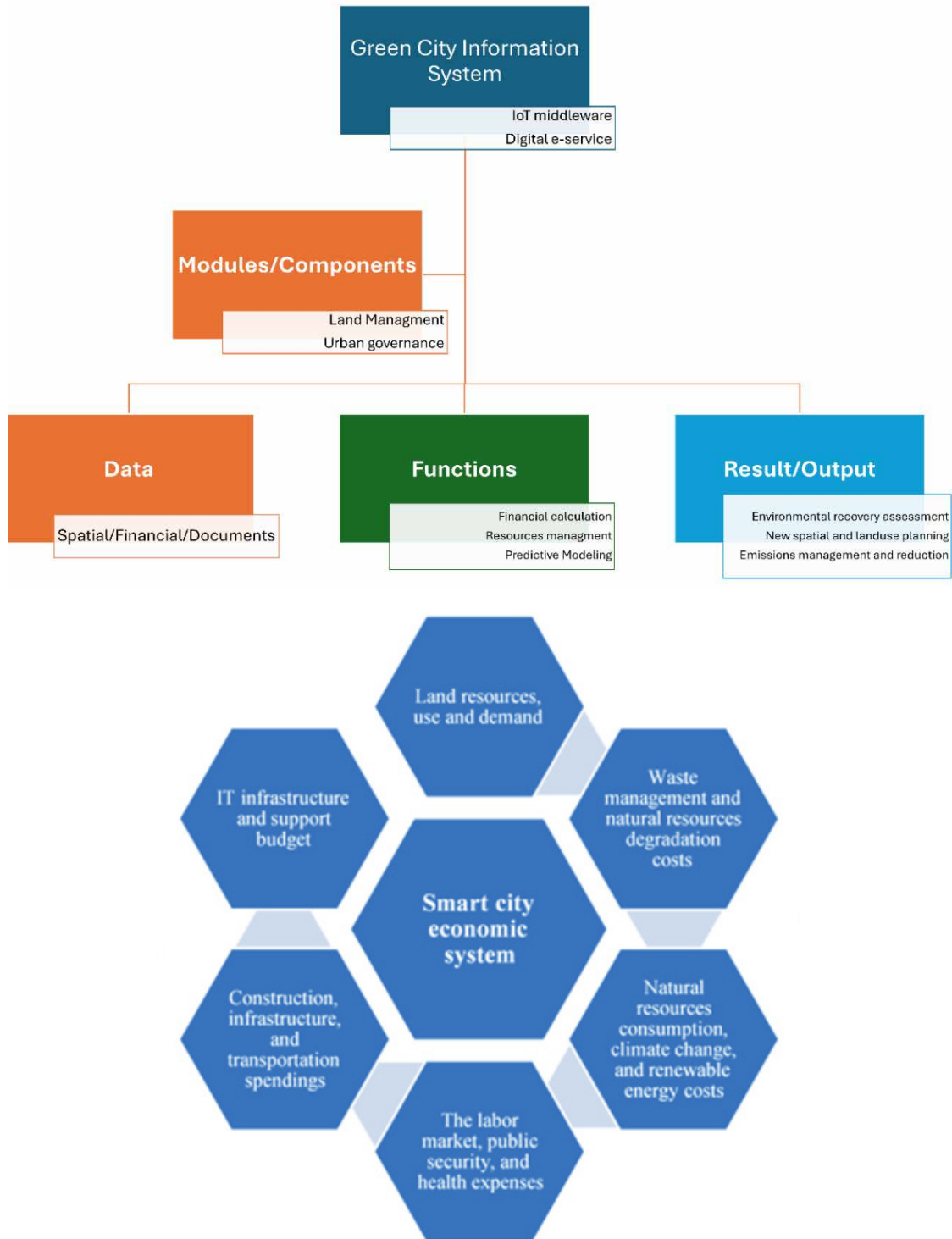


Fig. 3.23. Green City Information System Model

The goals of allocating land resources should be grouped by land use and land costs, the state of local employment and significant industries should be determined, and whether agriculture plays a significant role in local forest land use. The net total benefit is calculated together with the forest areas as a result of systematic modeling of the reforestation tax and the relative costs of land use during deforestation or cooling.

The development of the city and the change in its state of ecology are inextricably linked factors. The size of the city and its suburbs significantly impact the environment, as do the concentration of roads, the location of industrial plants, factories, etc. Moreover, due to their activities, we have an increase in harmful emissions and pollution, affecting residents' health, the state of local flora and fauna, and the state of soils and air. Urbanization also significantly impacts water resources and the state of rivers and reservoirs.

In further research, one of the important issues that will require attention is the state of water bodies in cities, changes that occur with them under the influence of the processes of life of cities and their active development and development, the value of real estate located near water bodies and trends in real estate prices near water bodies. Of interest is whether there is a difference in such an impact depending on the size of the city - small, medium, and large, as well as access to water bodies in the city and urban area.

It would be interesting to choose several cities from different countries, for example, in Ukraine, such cities as Kyiv, Dnipro, and Odesa. In Poland, such cities as Warsaw and Gdansk use their example to make a comparative assessment of economic indicators and environmental parameters of the impact of the presence of water bodies on the processes of city development, the cost of real estate, and their changes depending on various parameters. Indeed, of particular interest in such studies would be the cities of Amsterdam in the Netherlands and Bruges in Belgium, the wealthiest natural water resources located directly in cities.

An important question arises - how can one assess the value of having a reservoir for each city, the impact on real estate prices, the environmental situation, biodiversity, etc., make catalogs of types of water zones in cities, offer various solutions for their ordering, development and design and further development, the impact of precipitation for replenishment of water resources, etc.

Table 3.15 provides data, units of calculation (measurement), and examples of use to represent economic data for the economic information model of costs associated with green spaces in the context of urbanization. Such data include the following: the total value of the system (territory), the total loss of a natural resource (territory), the volume of investments in restoration or maintenance, taxation, the cost of natural materials, the cost of raw materials, the volume of exports of raw materials, rent, oxygen supply, the total value of real estate/land, the conversion price for the exploitation or destruction of a natural resource, the total value of land after the loss of a natural resource, net profit from the sale of raw materials or finished product by the enterprise, the tax on the restoration of the territory, the total economic benefit from the territory and the volume of CO2 emissions. Such a system allows one to calculate the cost, costs, and losses associated with natural resources, both per unit area, per unit of time, and profit from the sale of raw materials.

Table 3.15

Urban green spaces economic data model*

Data	Unit of Calculation	Examples of use
Total cost of the system (territory)	\$ per ha	Calculation of the economic value of the forest or nature reserve
Aggregate losses of natural resource (territory)	ha per year	Deforestation or reduction of the area of agriculture. Grounds
Amount of investment in recovery or support	\$ for full recovery \$ per year	Calculation of the required level of investment in the restoration of forests, reservoirs, soil quality, etc.
Taxation	% of revenue \$ per month	Calculation of the green tax

Cost of natural materials	\$ per m ³ \$ per ton	The cost of unprocessed, clean natural resources before they are used
Cost of raw materials	\$ per m ³ \$ per ton	The cost of raw materials as a result of processing or processing a natural resource (wood, granite, etc.)
Volume of exports of raw materials	m ³ ton	Volume of raw materials exported or processed from the area or territory
Rent	\$ per ha	Land lease payment for the use of the territory with available natural resources
Oxygen supply	O ₂ per year O ₂ per ha	Total volume of oxygen generated per unit area of the territory
Total value of real estate/land	\$	-
Conversion price for exploitation or destruction of a natural resource	\$ per ha	-
Total value of land after loss of natural resource	\$ per ha \$ per hectare per year	-
Net profit from the sale of raw materials or finished products by the enterprise	\$ per unit of production	-
Territory restoration tax	% of net profit	Costs for the restoration of a natural area - forest, water body, etc.
Cumulative economic benefit of the territory	\$ per ha	Social (social) benefit from the presence of a certain type of territory within the city or adjacent territories
CO ₂ emissions	units per ha units per year units per ha per year	Increase or decrease in emissions depending on the type of natural resources and area (area of forest, reservoir, etc.)

* Prepared by the author based on his own research

Conclusions for Chapter 3

A model for describing processes related to urbanization has been built using a multidisciplinary approach, which includes the following components: economy, ecology, urban planning and urban planning, legislative and regulatory acts at the local and national levels; As well as a system of classification of data, tools, methods and a modern information and computing system for data analysis, which are used in the study to present a model of ecological and economic forecasting of urbanization, are presented.

A descriptive model of urbanization profiles is presented at the analysis of the main roles of direct and indirect city management and systematization of key urban services, as well as taking into account the urbanization model, socio-economic indicators of city development and territorial zoning models.

A global concept of the study of the urbanization process is proposed on the basis of the constructed information model and using the main methods of ecological and economic research, which takes into account schemes, methodological guidelines and data on environmental monitoring in the context of urbanization processes, current data on the state, forecast and normal range of waste, CO₂ emissions and the presence of green areas in 13 cities of the world selected for the study. Calculations of the ratio of total environmental costs to total costs for selected cities in 2019 are presented and the results of environmental and economic forecasting under the sustainable development plan until 2035 are presented.

The expediency and necessity of territorial zoning of urban and suburban territories, taking into account the data on the types of land plots, has been confirmed; current and proposed systems of classification of territorial division into urban, suburban and adjacent zones; as well as the developed author's system of territorial zoning in land use.

A meaningful study of the current definition of urbanization and related processes has been carried out; The results are classified according to the following

criteria: organization or country, terminology, definition, and key components and components of the definition. The author's definition of urbanization as a state and process, which includes the following components and components: social, land use and economic, based on the postulates of the concept of sustainable development and considering the development of environmental processes, is proposed. The author's definition of urbanization is detailed in the context of Earth sciences and economic sciences and is presented as a conceptual model of urbanization classification.

The concept of rational development of territories is presented - a program of sustainable development and urbanization, taking into account the expediency of conducting a balanced policy of sustainable development and rational use of land resources of the city and suburban areas, which will allow to make environmental and economic forecasting for the next 5, 10, 20 and 25 years under the conditions of rapid economic and social development of the city, taking into account climate change and its possible consequences (as a consequence of the processes related to urbanization)

CONCLUSIONS

The scientific novelty of the results obtained lies in introducing an integrated approach to the study and definition of urbanization as a state and process. The constructed scientific and methodological model incorporated economic and environmental aspects and specific factors, among which can be distinguished - harmful emissions in the form of CO₂, the area of urban areas, the total GDP of the city, the number and density of the population of the city and suburban areas, the area of adjacent territories and zoning of the city.

The main results of the study, which are marked by scientific novelty, include the following:

- A new mechanism of situational modeling of the use of land resources in urbanization processes in megacities and large cities is proposed, considering the relationship with suburban areas and the region;
- A computer information system for the development of the city in the future was developed based on the international scientific and practical model concept "Green City";
- An information model of land resources and processes management in the city in the context of the Smart City system has been developed;
- A model for calculating the monetary valuation of costs for improving the environmental situation and minimizing the negative consequences associated with the rapid development of the city and the use of natural resources of suburban areas, including land.
- Chronological model of changes in the value of land plots from 1995 to 2020. in the city of Kyiv with further forecasting of its average cost in 5 and 20 years;
- ecological and economic model of optimal development of territories and use of land resources based on experimental data in the context of sustainable development of cities and suburban areas;

- A mathematical model for calculating the optimal location of new commercial facilities, taking into account changes in land prices, the opening of the land market, and environmental costs, using a system of neural networks and analyzing data for past periods;
- elaboration and analysis of a significant number of documents on the Paris Climate Agreement and the policy of its implementation by the world's leading countries in the context of urban and suburban development;
- the process of comprehensive analysis and collection of data on the use of land plots in urban and suburban areas of large cities in the territory of Ukraine;
- methodological recommendations and proposals for the optimal choice of commercial land plots within cities and suburban areas;
- economic justification of optimal locations for the location of shopping, office, and production centers within the city of Kyiv and its environs;
- algorithm and computer model of machine learning for the study of urbanization and changes in land use (prices, changes in boundaries, economic and social indicators);
- algorithm and computer model of computer vision for the study of urbanization and changes in land use;

Forecast of the development of the infrastructure of the city of Kyiv and the transfer of its city boundaries in the future. Several main economic models have been developed from scientific research and practical work. For the first time, a model has been proposed for calculating the monetary assessment of economic costs for improving the environmental situation and minimizing the negative consequences associated with the rapid development of the city and the use of suburban natural resources, including land. A new mechanism for situational modeling of the use of land resources at urbanization processes in megacities and large cities, considering the relationship between suburban areas and the region. Continuing the above-mentioned topic, a new mechanism was developed to forecast the creation of new centers of economic development in Kyiv for the next 20 years, including the

development of infrastructure and the transfer of urban boundaries. In addition, the author has built a well-grounded mathematical model for calculating the optimal location of new commercial facilities, taking into account changes in land prices, land market opening, and environmental costs using a system of neural networks and analysis of data for past periods.

The author has developed a coefficient of change in the value of real estate in different options for the development of urban areas, which will be used in the future to build a system of assessment and comprehensive forecasting of urbanization as a general factor. Much economic, social, environmental, and spatial data was processed and collected to build the presented model. For system analysis and modeling, the subject area and key factors that affect or shape urbanization as a complex process, i.e., what economic and environmental aspects are key to urbanization, were allocated. An analysis of existing models and solutions for building the author's models was also carried out. The author identified the main impact factors, and which data can be neglected for system analysis and modeling.

An ecological and economic model of optimal development of territories and use of land resources based on experimental data in the context of sustainable development of the city and suburban areas has been developed and implemented. The results can be used to model and predict land-use changes for Kyiv and other major cities of Ukraine, ATCs, and calculate environmental costs in the context of urban land use. The use of the results obtained in the work makes it possible to achieve a potential long-term improvement of the ecological condition of lands in urban and suburban areas and a reduction in the environmental burden from land use, which can improve the economic and social condition of the population of a city or community.

Methodological recommendations and proposals for optimal commercial land plots within cities and suburban areas have been developed and implemented. A new model was used to calculate the value of land plots, determine the economically feasible location and type of object for development, and determine land use within

Kyiv and its suburban areas with a radius of 60 kilometers. The results' significance lies in reducing economic costs, reducing the environmental burden from a new land use object, and considering the global goals for sustainable development of urban areas for the next 20 years.

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