UDC 332:502 http://dx.doi.org/10.31548/zemleustriy2024.04.07

ECOLOGICAL AND ECONOMIC PROFILE OF CITIES: ON THE WAY TO SUSTAINABLE DEVELOPMENT

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Abstract. *Ecology has become an urgent global problem for modern metropolises. Cities seek to balance their economic growth and preserve the state of the environment. One of the programs that more and more cities are implementing at the municipal level is the sustainable development program (based on the Paris Climate Agreement). This study presents cities' environmental and economic profiles through the prism of their economy. The main focus of the work is on waste management, reducing harmful emissions, and increasing the economic development of cities. The principles of integration of a modern green city were worked out and analyzed to determine the optimal strategies for its development. Such a strategy should synchronize the economic activities of the city with the goals of the sustainable development program.*

A study has been carried out using a multi-disciplinary approach to collecting and analyzing quantitative and qualitative data on the life of cities. With the help of statistical modeling, general social and economic indicators were assessed, and the results of the calculation of important environmental data were presented. Among the data processed, we can highlight the general programs of urban budget expenditures, waste management indicators, and emission profiles. The following three cities were selected to conduct the study and test the results: Kyiv, Paris, and New York. The information on the leading socio-economic indicators of their development was analyzed. The authors considered the norms of the current legislation related to cities' ecology and land use. This made it possible to provide an assessment of the implementations and plans of sustainable development programs. This will allow us to further assess the impact of the sustainable development program until 2035 on the current (annual) level of economic development.

Based on the studies, the selected cities successfully implemented sustainable development programs based on the climate agreement in stages. Green areas are expanding in selected cities, and investment in development programs and support for

the renewable energy initiative continues. It can be confidently stated that at the local level, harmful emissions have been reduced, and the effectiveness of waste management programs has been increased. For example, Paris and New York allocate significant portions of their budgets to sustainability programs, demonstrating effective alignment between investments in environmental conservation programs and the sustainability of economic development. Despite limited resources, the city of Kyiv is demonstrating progress in modernizing waste disposal systems and adopting EU environmental regulations.

The economic development of cities can harmonize harmoniously with implementing environmental programs. First, this is due to targeted investment programs and the adaptation of new urban programs related to the environment. In the future, it is advisable to develop mechanisms of cooperation between municipal authorities, public organizations, and private businesses to solve environmental problems and overcome the negative impact of their consequences. This makes it possible to create a roadmap for effective city management. Such city development programs will improve their environmental and economic profiles, supporting the global pursuit of sustainable development.

Keywords: *urban economic, green city, waste management, harmful emissions, economic development.*

Introduction

Modern cities are at the forefront of the global trend towards sustainable development, where great importance is attached to environmental issues and sustainable economic development. Therefore, the concept of a "green" city is gaining more and more popularity as a model that integrates environmental improvement with the economic development of cities. Today's cities increasingly face significant challenges, including managing harmful emissions, optimizing waste management systems, and promoting sustainable economic growth. These issues necessitate raising the issue of environmental protection and economic support. As cities develop and economic indicators of their life, the impact of such processes on the environment, as a rule, increases. This causes the need to develop strategies for the sustainable development of cities that would be consistent with economic activities. This study aims to strike a balance between economic growth and reducing environmental impact, proposing a focus on policies and practices that will enable cities to move towards sustainable development.

The transition to sustainable urban development is timely and necessary, partly due to the aggravation of environmental problems. Therefore, waste management, recycling, and reduction of harmful emissions are critical aspects of sustainable urban development, which directly affect the health of citizens, ecosystem stability, and most economic indicators. In addition, cities are the economic centers of the respective regions, so their role in the path to sustainable development is indispensable. The relevance of the materials presented in the article lies in the focus of research on the economic strategies of cities and how to implement "green initiatives," such as renewable energy sources, alternative

energy, and the efficient use of all types of resources. Such studies contribute to analyzing the impact of urbanization and urban development strategies and aim to improve environmental performance.

Analysis of recent researches and publications

The issue of urban development has become an important topic for many researchers considering the consequences of rapid urbanization and environmental problems [1-7]. Klopp and Petretta (2017) focus on integrating the Sustainable Development Goals of cities into global development programs [1]. They explore the political and technical challenges associated with developing indicators accurately reflecting the city's life. The authors emphasize that the urban environment is a complex system that often needs to consider local features, which can lead to false results. Their research highlights the importance of engaging with local governments to analyze indicators for effective, sustainable urban development.

Næss (2001) offers his perspective on sustainable urban planning, exploring the relationship between urban development and environmental impacts [2]. Ness criticizes traditional urban planning paradigms for their inability to balance the economic performance of the city's development with environmental management. The scientist advocates for the direction of urban planning programs towards long-term sustainable development goals, emphasizing the role of compact urban design, efficient use of resources, and community participation in all processes. The scientific study results provide a theoretical basis for integrating environmental principles into urban planning and are consistent with current research on ecological urbanization.

Song (2011) delves into the concept of environmental urban development programs that align urban development with environmental systems [3]. Using examples, Song demonstrates how environmental principles can be integrated into urban environments to improve quality of life. The study highlights the importance of investing in green space development, energy efficiency, and urban ecosystem support. Thanks to this, it is possible to achieve sustainable urbanization. Considering cities as ecological objects, Song demonstrates the gap between urban planning processes and the current state of ecology in cities. This hypothesis complements existing sustainability programs by promoting strategies that simultaneously address cities' environmental and socio-economic problems [4-7]. By conducting a study of scientific works, the authors of this article have formed a fundamental comprehensive understanding of the theoretical, practical, and political aspects of sustainable urban development that it is possible to formulate and present new ideas that should be taken into account by politicians, managers, economists, and urban planners.

Purpose. The study aims to establish the link between economic growth and environment-related costs and implement the sustainable development plan at the municipal level by using selected cities from around the world as a reference and presenting a framework for future economic-ecological urban profiles of cities.

Methods

The study is based on several different materials that have been selected to

analyze urban areas' environmental and economic profiles in the context of implementing the sustainable development program. Key sources of information include statistical and current economic data, environmental impact reports, and case studies of cities aimed at implementing green city initiatives. Statistical data on the effectiveness of waste management, emission levels, environmental status, and indicators of economic development create the basis for quantitative analysis. In addition, legislative acts and regulations, urban planning plans, and best practices of cities from around the world are reviewed and analyzed to consolidate the study results.

tools are used to visualize environmental performance and its effects in cities. According to some indicators, a spatial map of territories is presented about sustainable development. Such materials comprehensively assess the interaction between environmental indicators and economic factors for implementing the city's sustainable development program. Table 1 shows the list of cities selected for the study and general

1. Cities waste management economic profile *

City	Waste generated per person per year, tons	Waste management expenses per person per year, $
Kyiv	450	3.84
Paris	520	64.52
New York	920	52.3

* prepared by Nazarenko V.A. based on open research data

data on waste generation, which is one of the main factors influencing the state of the environment, along with harmful waste and emissions.

The study uses an integrated approach that combines quantitative and qualitative methodologies to study indicators of urban economic activity and current environmentally related urban programs. Quantitative analysis includes statistical modeling to assess the relationship between urban economic development data and environmental indicators, such as waste generation and harmful emissions. The authors use a

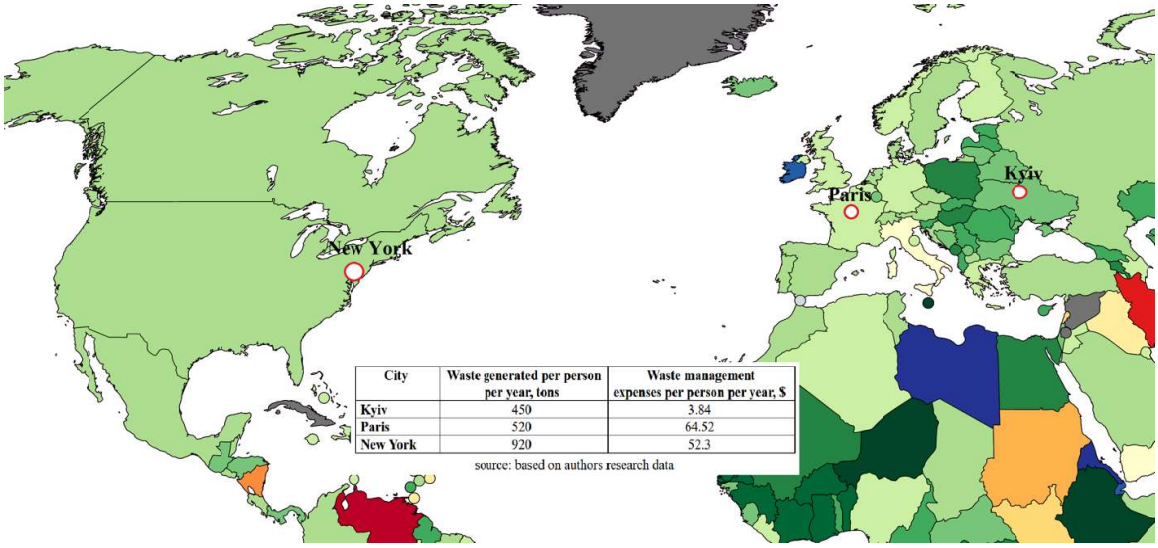

Fig. 1. City's location, planned economic growth and general waste related data (based on Nazarenko V. and Voytovich O. research data and IMF world economic outlook database)

comparative analysis of case studies to identify successful strategies of "green" cities that effectively balance economic growth and environmental preservation.

The study also includes an analysis of the content of legislative and regulatory documents and reports on sustainable urban development, providing additional information on governance structures and regulatory frameworks. Analytical work has been carried out, and a methodological system has been developed that has made it possible to conduct a multidimensional study to highlight important factors that form sustainable urban development. Figure 1 shows the geographical location of the cities selected for the study. The expected level of economic development of the territories is shown in green, and data on the generation and costs of waste management in these cities are indicated.

Results and discussion

The study models a system of a comprehensive but achievable balance between the economic growth of cities and their environmental sustainability. Cities that adopt green city principles show notable reductions in harmful emissions through policies that encourage using renewable energy, public transport systems, and energy-efficient infrastructure.

Efficient and energy-saving waste management becomes the cornerstone of sustainable urban policies, with cities implementing circular economy models, demonstrating increased resource efficiency and cost-effectiveness. For example, introducing recycling programs and technologies for the use of waste for energy reduces the environmental impact and contributes to job creation and innovation in the city's economic sector. Table 2 outlines the summarized data for three cities - Kyiv, Paris, and New York in the context of sustainable development, namely - carbon emissions, waste generation, and the level of urban green cover.

The analysis emphasizes that the economic development of cities does not contradict environmental objectives; instead, targeted investments in green technologies and regulatory frameworks can contribute to sustainability. However, significant problems still need to be solved in financing environmental initiatives and providing socio-economic groups for the population. The findings highlight the importance of political responsibility, public awareness, and multi-stakeholder cooperation to promote sustainable urban development and urbanization.

Table 3, "Sustainable Urban Development Profiles," provides a detailed comparative analysis of urban perfor-

2. Cities emissions and green cover related data*

City	Total carbon emissions, millions of tons per year	Total waste generated, millions of tons per year	Urban green cover areas, km^2
Kyiv	5.3	1	450 54% of city area
Paris	16.8	10	250 8.8% of city area
New York	157	14	2546 21% of city area

* prepared by Nazarenko V.A. based on open research data

mance indicators by three important parameters: waste profile, emission profiles, and sustainable development programs. The "Waste Profile" column includes indicators such as the total amount of waste generated per capita in the city, recycling rates, and the percentage of waste removed from landfills. Cities with robust waste management systems, such as those that adopt the principles of a circular economy, indicate that their recycling rate exceeds 50%, combined with little reliance on landfills. Conversely, cities that lack an efficient waste management infrastructure developed over the years show a large amount of waste generation and significant use of landfills, indicating inefficiencies that hinder their movement toward sustainable development. These data highlight the potential of integrated waste management systems in reducing their environmental impact while supporting the economic activities of cities by restoring resources and creating new jobs.

The data in Table 3 on "Emission Profiles" provide information on greenhouse gas emissions in cities, air quality indices, and reductions achieved thanks to the intervention of the authorities. The data shows that cities that take several precautionary measures, such as switching to renewable energies and expanding the public transport (e-transport) network, achieve significant reductions in harmful emissions. For example, cities that introduce carbon tariffs and energy-efficient building standards have seen a 30% reduction in annual CO_2 emissions compared to the baseline. The "Sustainability Programs" column of Table 3 describes key initiatives, including introducing renewable energy sources, green infrastructure projects, and community engagement activities.

Cities that have been implementing sustainable development and green investment programs for some time combine the social stability of the population with environmental goals, for

3. Cities sustainable development profiles*

Waste profile	Harmful emissions profile	Sustainability Programs
Type of waste: — Plastic — Metal — Glass — Paper — Organic — Other species	— CO_2 emissions — Temperature deviation — Annual emissions — Green and fossil fuel energy ratios	— Plan for the sustainable development of territories or cities — Climate agreements
Type of waste recycling: — General landfill - landfill; — Burning; — Recycling; — Composting; — Spontaneous landfills	— Reducing carbon emissions — Subsidizing green energy	— Ecological fee — Green tax — Ecosystem maintenance costs — The cost of ecosystem restoration — Taxation % of income $ per month — Calculation of green tax
— Waste Policy and Legal Regulation — Waste Management (Transportation and Storage) — Waste sorting — New technologies for garbage collection and recycling	— Air condition monitoring — Inspection of territorial objects and various sources of pollution - making appropriate decisions to overcome the consequences and minimize damage	— Provision of resources — Quality of natural resources — Biodiversity — Microclimate and bio-heritage

* prepared by Voytovich O. based on open research data

example, providing subsidies for energy-efficient appliances in low-income areas and projects for the restoration of forest and park areas in cities. The study highlights various city strategies to address environmental issues, emphasizing the role of local solutions and governance in driving sustainability. Figure 2 shows maps of green zones in the cities selected for research. On these maps, the current state and distribution of green areas in different city districts and their overall concentration level can be traced.

Figure 3 presents the results of a comparative analysis of environmental cost priorities in the cities of Kyiv, Paris, and New York. Regarding waste and carbon dioxide reduction costs, New York City is the leader, with 17% of the city budget allocated to modern waste-to-energy systems and carbon capture technologies. It is followed by Paris with 15% on such spending, focusing on reliable recycling systems and the transition to a low-carbon transport network. Kyiv allocates 11% for such needs, mainly focusing on the modernization of waste processing infrastructure. In terms of spending on the maintenance of "green zones," Paris allocates an average share of 8% of its city budget, guided by its

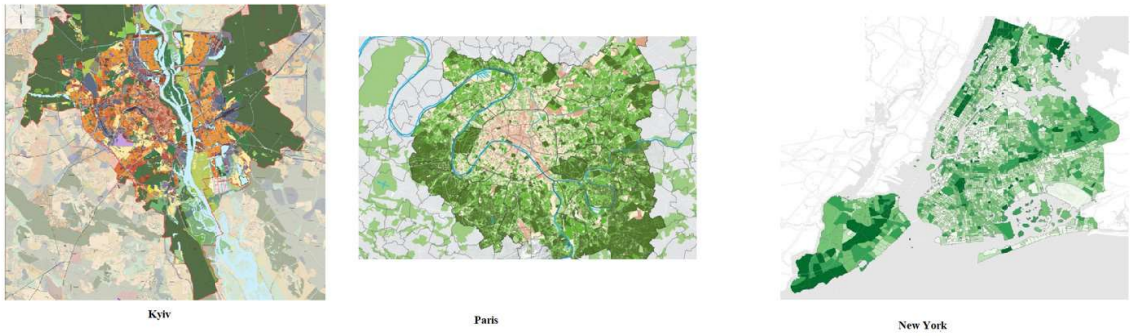

Fig. 2. Citys green-cover maps (based on Nazarenko V. and Voytovich O. research data and USA Regional Plan Association, Kyiv Gen. plan)

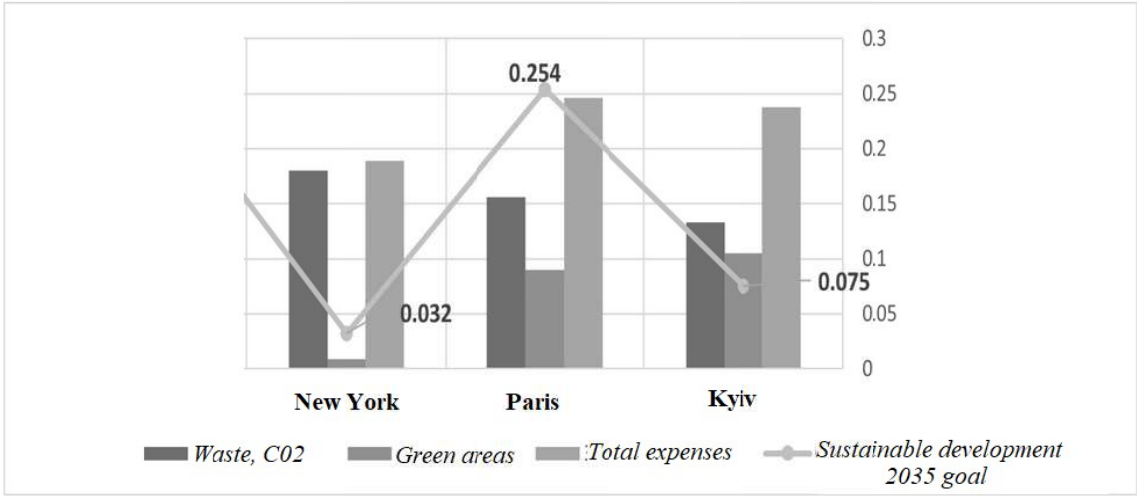

Fig. 3. The ratio of environmental expenditures to the total expenditures of city budgets for the year and planned expenditures under the sustainable development program until 2035 (prepared by Nazarenko V. based on author research data)

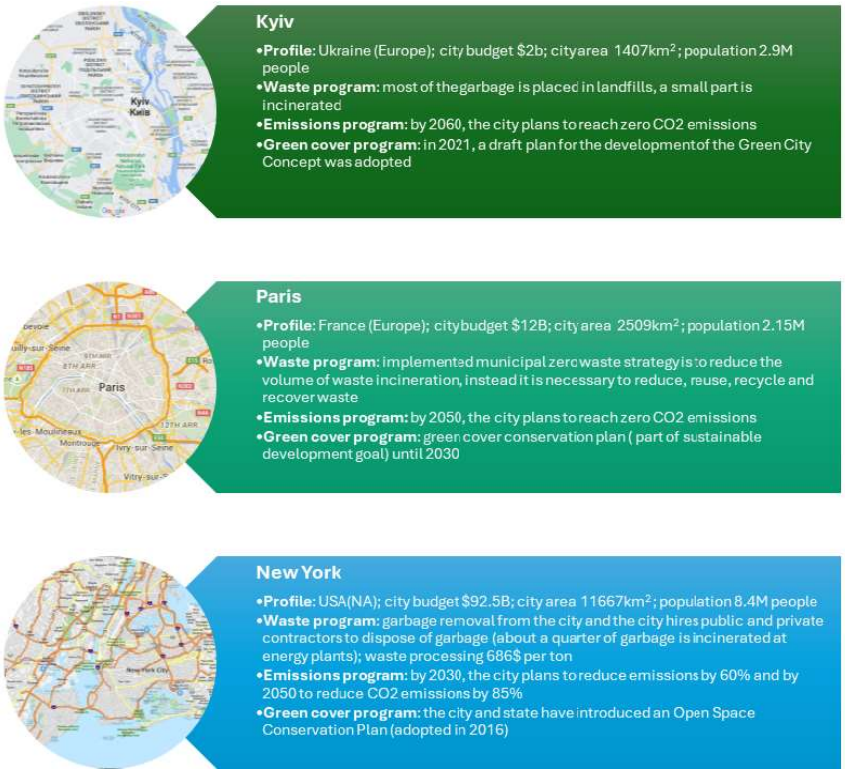

Fig. 4. Sustainable city plan and related data (based on Nazarenko V. and Voytovich O. research data)

strategy for preserving urban parks and implementing biodiversity zones. New York allocates about 1%, emphasizing the introduction of projects to restore urban forests and green roofs (in the future, it is planned to reach 6%). Kyiv spends the most, with a relative comparison of 10%, focusing on restoring urban green spaces.

The analysis of total expenditures of city budgets shows that environmental investments in the context of cities are 18% in Paris, 15% in New York, and 11% in Kyiv, which reflects the different levels of financial capacity of cities in different countries and the state of political commitment to sustainable development. The 2035 Sustainable Development Plan indicates quite ambitious goals for all cities: Paris plans to increase environmental spending by 30% to achieve carbon neutrality, New York envisages a 25% increase in spending focusing on infrastructure development, and Kyiv plans a 20% increase, directing funding to align its policies with the European Union on environmental standards (the current ratio of the level of investment under the Sustainable Development Program to of total urban expenditures is shown by the line in Figure 3).

The presented results of the data calculation highlight the trends toward increasing expenditures on environmental conservation as the main component of sustainable urban development. However, certain economic planning features are related to different regional priorities and resource constraints (usually financed). Figure 4 simulates the sustainability profiles of the cities selected for the study with detailed information on current and planned sustainability programs and general socio-economic indicators for these cities.

Conclusions

According to the study results, the balance between preserving the environment and maintaining the economic development of cities is likely achievable. Maintaining such a balance is essential for sustainable urban development. Cities that adhere to the "green city" principles show significant progress in reducing harmful emissions and optimizing waste management methods, strengthening economic resilience and well-being of the population. The studies highlight investments in sustainable development programs such as renewable energies, green infrastructure, and efficient waste disposal systems. This, in turn, leads to creating a communication cycle that promotes economic development, minimizing environmental impacts. For example, cities such as Paris and New York are leading the way, allocating large portions of their budgets to environmental spending and demonstrating that proactive regional policies can align environmental goals with economic priorities. However, while making significant progress, cities like Kyiv need help scaling up these efforts due to limited resources. The results show the important role of developing strategies based on processing large databases and ineffective policy decisions at the local and state levels. An important factor for the effective implementation of sustainable development programs is the involvement of all responsible parties in promoting the sustainable development of urban ecosystems. The study confirms that sustainable development is a dynamic process that requires constant adaptation and innovative approaches to solve new problems facing cities effectively..

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МОДЕЛЬ ЕКОЛОГО-ЕКОНОМІЧНОГО ПРОФІЛЮ МІСТ: НА ШЛЯХУ ДО СТАЛОГО РОЗВИТКУ

ЗЕМЛЕУСТРІЙ, КАДАСТР І МОНІТОРИНГ ЗЕМЕЛЬ 4'24: 80-89

http://dx.doi.org/10.31548/zemleustriy2024.04.07

Анотація. *Стаття висвітлює використання геоінформаційних систем (ГІС) для вирішення актуальних проблем пов'язаних зі стратегічним плануванням та регіональним розвитком в кризових умовах. У контексті воєнного стану, який встановлений в Україні через війну, потреба в ефективному плануванні, управлінні та моніторингу регіональних ресурсів стала особливо гострою.*

Дана наукова праця розглядає застосування сучасних ГІС як інструменту для збору, аналізу та візуалізації геопросторових даних, що дозволяє оперативно приймати рішення щодо регіонального розвитку у сфері відновлення інфраструктури, управління земельними ресурсами та оцінки екологічних наслідків військових дій.

Автори аналізують ключові аспекти впровадження ГІС-технологій у стратегії планування розвитку регіонів України, зокрема, визначають роль таких систем у забезпеченні безпеки, стабільності та економічного відновлення постраждалих регіонів.

Окремо розглянуто проблеми інтеграції ГІС з іншими системами моніторингу та управління, а також наголошено на важливості міжсекторальної співпраці на державному та місцевому рівнях для ефективної реалізації стратегічного планування. У статті також акцентується увага на використанні даних дистанційного зондування Землі для моніторингу територій, що перебувають під ризиком екологічних або інфраструктурних пошкоджень.

Проведене дослідження пропонує інноваційні підходи до використання геоінформаційних технологій у забезпеченні сталого регіонального розвитку України під час військових конфліктів та інших кризових явищ.

Ключові слова: *геоінформаційні системи, стратегічне планування, моніторинг, дистанційне зондування Землі, управління земельними ресурсами, регіональна безпека.*