НАУКИ ПРО ЗЕМЛЮ. ГЕОІНФОРМАЦІЙНІ ТЕХНОЛОГІЇ МОДЕЛЮВАННЯ СТАНУ ГЕОСИСТЕМ

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GEOINFORMATION SUPPORT FOR STRATEGIC PLANNING AND MONITORING OF REGIONAL DEVELOPMENT OF UKRAINE UNDER MARTIAL LAW

KOSHEL A.,
Doctor of Economics
National University of Life and Environmental Sciences of Ukraine
e-mail:koshelao@gmail.com
KOSHEL D.,
PhD student
National University of Life and Environmental Sciences of Ukraine
e-mail: d.koshel@nubip.edu.ua
KEMPA O.,
Dr inż. (PhD)
Wroclaw University of Environmental and Life Sciences
e-mail:olgierd.kempa@upwr.edu.pl

Abstract. *The article highlights the use of geographic information systems (GIS) to address current issues related to strategic planning and regional development in crisis conditions. In the context of the martial law imposed in Ukraine due to the war, the need for effective planning, management and monitoring of regional resources has become particularly acute. This research paper considers the use of modern GIS as a tool for collecting, analysing and visualising geospatial data, which allows for prompt decision-making on regional development in the areas of infrastructure rehabilitation, land management and assessment of the environmental impact of military operations. The authors analyse the key aspects of the implementation of GIS technologies in the planning strategies for the development of Ukrainian regions, in particular, they define the role of such systems in ensuring security, stability and economic recovery of the affected regions.*

The problems of integrating GIS with other monitoring and management systems are discussed separately, and the importance of cross-sectoral cooperation at the state and local levels for the effective implementation of strategic planning is emphasised. The article also focuses on the use of remote sensing data to monitor areas at risk of environmental or infrastructure damage. The study suggests innovative approaches to

the use of geoinformation technologies in ensuring sustainable regional development of Ukraine during military conflicts and other crisis phenomena.

Key words: *geographic information systems, strategic planning, monitoring, remote sensing, land management, regional security.*

Actuality

The issue of strategic planning and monitoring of the state's regional development has always been one of the most pressing, especially now that Ukraine is under martial law due to the aggression of the Russian Federation. As the situation changes every day and the number of damaged and destroyed facilities due to missile and bomb attacks is constantly growing, it is becoming almost impossible to use existing approaches to strategic planning and monitoring of regional development. Given these dynamics and the existing range of modern information technologies, the widespread introduction of geographic information support in the processes of planning and monitoring regional development is an extremely relevant solution that can form a complete system with the ability to manage based on data..

Analysis of the latest scientific research and publications

The issues of strategic planning and monitoring of regional development have been studied by such scholars as K. Pastukh, A. Boyko, N. Popadynets, A. Melnyk, V. Heets, N. Smentina, Z. Buryk, and others. At the same time, the issue of geoinformation support for strategic planning and monitoring of regional development, especially in martial law, is relatively new and poorly understood.

The purpose of the article is to highlight scientific and methodological approaches to the formation of geoinformation support for strategic planning and monitoring of regional development of Ukraine under martial law.

Materials and methods of scientific research

The theoretical and methodological basis of the study is modern conceptual approaches to the problem of strategic planning and monitoring of regional development. It is proposed to use a set of methods aimed at collecting, processing and analysing geospatial data, as well as assessing their impact on management decision-making.

To visualise the results of the study, the cartographic method is used, which allows creating digital maps of territorial development and the impact of military operations on the regions of Ukraine. Scenario modelling is used to assess possible scenarios of regional development after the end of hostilities. The modelling can be carried out taking into account various options for restoring infrastructure, economic resources and natural conditions. This allows us to assess the likelihood of new crises or development opportunities.

To study the dynamics of changes in the regions, the method of analysing spatial and temporal data is used. This allows us to identify trends and patterns in changes in land use, infrastructure and the environmental situation as a result of military operations. Data from government and international organisations: statistical and cartographic materials from open sources to analyse the socio-eco-

nomic indicators of the regions. These methods provide a comprehensive approach to the study of regional development in crisis situations, namely military operations, which makes it important for Ukraine's recovery after the conflict.

The results

Many scholars around the world have been and continue to study the issues of strategic planning and monitoring of regional development. In particular, Marek W. Kozak his scientific work assessed the effectiveness of regional policies at the expense of EU structural funds, with a focus on the impact of such interventions on the socio-economic development of regions. One of the main problematic issues highlighted by the author is the lack of sufficient data or access to it, which limits the possibility of conducting a full analysis of the impact of policies. In general, his article emphasises the importance of improving approaches to the evaluation of EU regional policies and calls for the use of more comprehensive and result-oriented methods [1].

In their turn, the authors Dubrovskaya Yu.V., Kudryavtseva M.R., Kozonogova E.V. propose the method of 'smart benchmarking' as a tool for strategic planning of regional development. The main idea of 'smart benchmarking' is to compare regions with similar structural conditions for a more accurate determination of strategic priorities. For this purpose, the authors developed a matrix of distances between regions based on various indicators, such as the level of education, innovation activity and transport infrastructure. Their research also emphasises the importance of a two-stage analysis: comparison with similar regions and with national averages, which allows identifying both unique opportunities and gaps in the development of a particular region [3, 4].

The research Retnandari, N. D. on the example of Indonesia is also constructive. In this article, the author examines the implementation of strategic planning in the public sector within the hierarchical administrative system of Indonesia. The authors come to the conclusion that many strategic planning documents are mere formalities, lack strategic character and are not taken into account when implementing development activities. Problems in the implementation of strategic planning were identified as low quality and quantity of information and data, and improvement, in their opinion, should be based on a results-based evaluation model, capacity building of evaluators and the need to involve other parties in business processes, such as reputable universities, which will create a multiplier effect for all stakeholders [2].

A well-known practice is the use of geoinformation software to automate processes and policies of strategic planning and monitoring of regional development in foreign countries. For example, Poland uses the Strateg service, a system designed to facilitate the process of monitoring development and assessing the impact of actions aimed at strengthening social cohesion. The database contains a comprehensive set of key indicators for monitoring (mostly annual) development at the national level, as well as at lower levels of territorial division (Figure 1).

Constructive are the technological solutions in Japan's regional development monitoring system, which provide forecast scenarios of various socio-economic indicators in the context of all prefectures and especially cities by 2040 (Fig. 2).

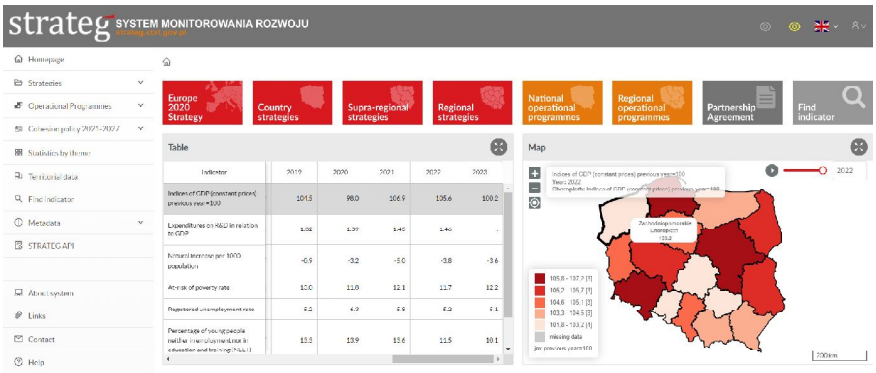

Fig. 1. Geoinformation monitoring system for regional development STRATEG (Poland)

Source: https://strateg.stat.gov.pl

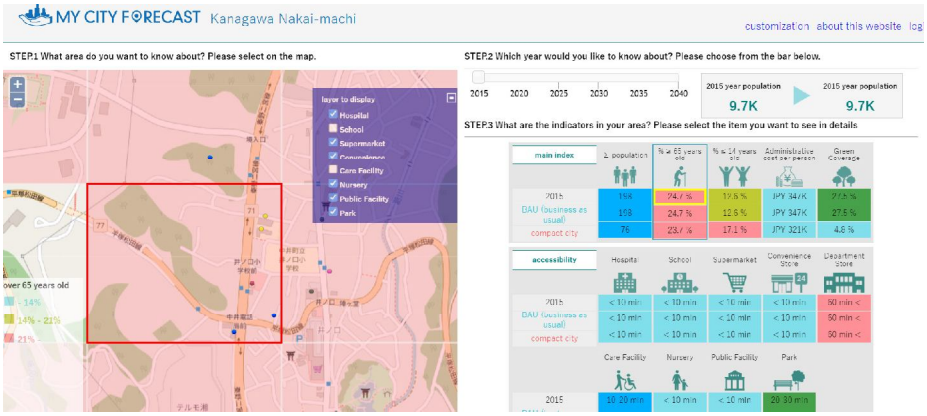

Fig. 2. Geographic information system for forecasting and modelling urban development MY CITY FORECAST

Source: https://v1.mycityforecast.net/

Using the master plans currently being developed by municipalities as input, the tool shows how the living environment of citizens will change in the future if the urban structure changes according to the plan, using a simple simulation with 14 indicators. MY CITY FORECAST visualises the environment of residential areas from 2015 to 2040 based on the current population distribution and location of facilities. To evaluate the plan, a comparison of the current value and the value in the future is displayed, while maintaining the current urban structure. At the same time, by collecting citizens' assessments through questionnaires, this system is a meeting point between citizens' opinions and the future image of the city projected by local government representatives [5].

These systems have made a significant contribution to the development of geoinformation support for strategic planning and monitoring of regional development in their countries. However, we are facing a higher level task, based on the accumulated international experience, to form a geographic infor-

mation system capable of addressing the needs of regional development and strategic planning in wartime.

Evaluating the experience of many countries in the processes of strategic planning and monitoring of regional development, it should be noted that over the past 30 years, a whole galaxy of various scientific and methodological approaches to solving this problem has been formed. For Ukraine, this accumulated knowledge base is invaluable, however, when forming the national system of strategic planning and subsequent monitoring of regional development, the first question was to take into account the peculiarities of the country's martial law. This makes significant adjustments to the existing practices of the world, because almost no country has ever built a modern system of regional development under martial law. The introduction of geoinformation tools can solve a task of this level of complexity, taking into account the constant change in conditions. A modern geoinformation system is a powerful information support that ensures the processes of geodata collection, processing, analysis, modelling and forecasting in both static and dynamic modes.

Since 2022, Ukraine has been rapidly moving towards the gradual creation of a geographic information system for regional development. Thus, in accordance with the current legislation, issues related to strategic planning and monitoring of Ukraine's regional development have been formed and defined in many legal documents, the key ones being the Law of Ukraine 'On the Principles of State Regional Policy', the State Strategy for Regional Development for 2021-2027, the Action Plan for the Implementation of the Roadmap for Reforming Public Investment Management for 2024-2028, the Resolution of the Cabinet of Ministers of Ukraine 'On Approval of the Procedure for the Functioning of the Unified Geographic Information System of Ukraine', and the Law of Ukraine 'On the Development of the Unified Geographic Information System of Ukraine'. These regulatory and legislative acts create the legal framework for the functioning of a unified geographic information system that monitors and evaluates the socio-economic development of regions and territorial communities. This is intended to improve the efficiency of management decision-making and control over the implementation of the state regional policy. In general, the main parameters and principles laid down in the resolution of the Cabinet of Ministers of Ukraine stipulate that the unified geographic information system includes several functional modules that allow for the collection, storage, processing and analysis of data on the development of territories. The information is collected from external information resources (state registers, cadastres) and integrated into the database to provide access to users. It also provides for two categories of users: authorised (government agencies, local governments) and external (individuals and legal entities). Authorised users have access to the database to monitor, prepare reports and forecasts on the development of territories. External users can access public information.

Integration between the geographic information system and other state resources is carried out through special software interfaces, which ensures automated data transfer. One of the important aspects is ensuring information security, including protection of personal data and prevention of unauthorised access.

The system implementation is funded by international technical assistance, EU grants and other external sources, which underscores the importance of international support for the development of the national geospatial data infrastructure.

In general, this geographic information system should create an opportunity to monitor and evaluate the implementation of the state regional policy in the country. In other words, as a result, territorial communities, regional administrations and the Cabinet of Ministers of Ukraine approve development strategies. These strategies define the vectors of movement, goals, objectives and activities for which budgetary or international funds are allocated. Monitoring and evaluation are needed to understand the effect of the implementation of these strategic documents.

Over the past two years, this system has gone from the development of

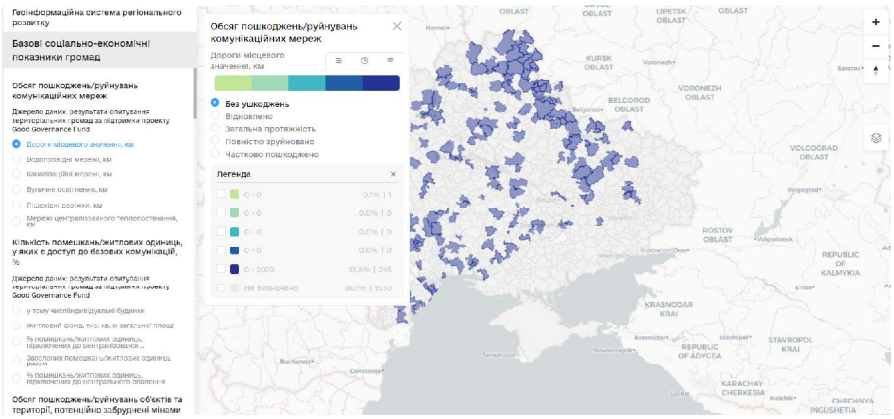

Fig. 3. Geographic information system of regional development (socio-economic indicators of communities)

Source: http://gisrr.mtu.gov.ua/

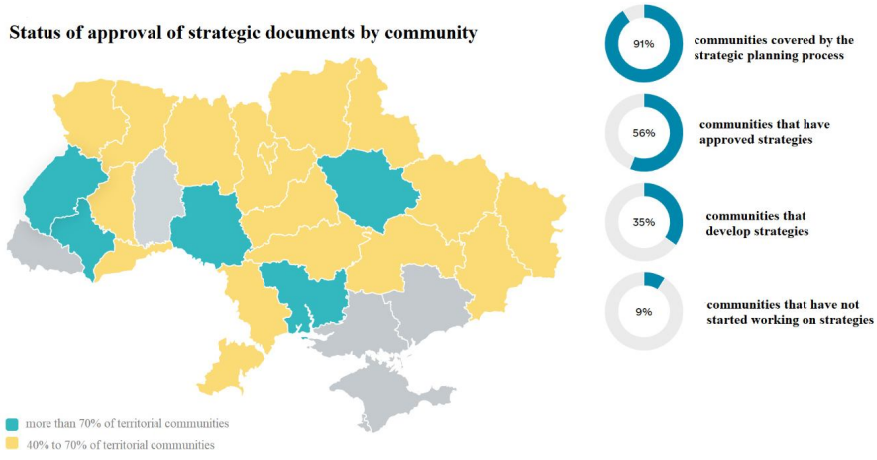

Fig. 4. Geographic information system for regional development (strategic planning)

Source: http://gisrr.mtu.gov.ua/

a technical concept, technical requirements, and the creation of its MVP to the test mode of its industrial use. According to the vision of the Ministry of Communities and Territories Development of Ukraine, this regional development geographic information system will be integrated into the Digital Restoration Ecosystem for Accountable Management (DREAM). Analysing the current stage of the system's test mode, the following components should be noted (Fig. 3-4).

Thus, the GIS of regional development should, in the final version of its implementation, provide a full cycle of formation, implementation and monitoring of regional policy: from data-based decisions and strategic planning to stakeholder engagement and monitoring of regional development.

According to the authors, in order to effectively implement the goals and objectives of strategic planning and regional development of Ukraine under martial law, a modern geographic information system for regional development should contain components of an integrated approach to the management and restoration of territories:

1. High-quality geospatial data base (cadastral data, space and aerial photographs, demographic data, infrastructure facilities, natural resources and ecosystems, etc.)
2. Integration with state registers and information systems (State Land Cadastre, State Register of Real Property Rights, Register of Damaged and Destroyed Property, etc.)
3. Analytical and forecasting modules (modelling and forecasting, analysis of destruction and recovery, risk assessment, etc.)
4. Interactive maps and data visualisation (infrastructure development maps, environmental maps, demographic maps, etc.)
5. Monitoring and evaluation tools (implementation of strategic development plans, assessment of resource efficiency, etc.)
6. Data protection and cybersecurity (protection against unauthorised access, protection of personal data).
7. Opportunities for integration with international systems (geoinformation platforms of the UN, EU, NATO).

Conclusions and perspectives

The analysis of existing regulatory and legal documents and existing information support for the modern digitalisation of strategic planning and monitoring of regional development has shown that the foundation has been laid for the formation of a modern geographic information system, which is critical for monitoring and assessing the socio-economic development of Ukraine's regions, especially under martial law. This will improve the quality of management decisions at various levels of government and increase transparency in regional policy.

A modern geographic information system for regional development should be a multifunctional tool that provides comprehensive monitoring, analytics and management of Ukraine's recovery processes in the context of war. It should integrate data from various sources, ensure reliable data protection, include tools for assessment and forecasting, and be transparent to the public and international partners.

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Кошель А.О., Кошель Д.О., Кемпа О.

ГЕОІНФОРМАЦІЙНЕ ЗАБЕЗПЕЧЕННЯ СТРАТЕГІЧНОГО ПЛАНУВАННЯ ТА МОНІТОРИНГУ РЕГІОНАЛЬНОГО РОЗВИТКУ УКРАЇНИ В УМОВАХ ВОЄННОГО СТАНУ

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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.*