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Modernisation of state land monitoring system as a basis for management decisions in post-war reconstruction process

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Abstract. The research relevance is determined by the need to modernise the state land monitoring system in Ukraine in the context of post-war reconstruction, when sustainable development of territories, food security and social cohesion directly depend on the quality, efficiency and adaptability of management decisions. The study aimed to justify the possibilities of applying the Agile paradigm as a conceptual basis for updating state land monitoring and monitoring of land relations in the post-war period. The study used a narrative review of scientific sources, analysis of the regulatory framework, elements of the case method and conceptual modelling. As a result, the study determined that the modern system of state land monitoring in Ukraine is fragmentary, has limited data integration, is insufficiently adapted to the conditions of the war and post-war period, and has weak institutional coordination, which reduces the effectiveness of management decisions. The study argues that the combination of the principles of Strong Land Governance, digitalisation, stakeholder and polycentric approaches creates the preconditions for the transition from static monitoring models to adaptive iterative systems. The concept of Sustainable Agile Land Management was proposed, which integrates resilience, adaptive management and institutional change, prioritising the use of geospatial data in near real time. A conceptual framework for sustainable

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land management in post-war Ukraine and a model of an Agile ecosystem for monitoring and managing land resources with a stakeholder core have been developed, demonstrating the logic of interaction between monitoring, auditing and management decision-making. The study demonstrated that the Agile approach can ensure a rapid response to the risks of land degradation, incorporating the local context and ensuring the coordination of environmental, economic and social development goals. The practical value of the study results is determined by the possibility of using the proposed approach and models as a methodological basis for modernising state land monitoring and supporting management decisions in the process of post-war reconstruction of Ukraine

Keywords: public administration; land resource management; social welfare; sustainable development; land use

Introduction

Land relations are a key foundation for the functioning of the state, as they determine the specifics of the use, distribution and protection of one of the most substantial strategic resources: land. The economic development of the country, ecological balance and social justice depend on how effectively the state manages these relations. This issue is particularly relevant in Ukraine: the country faces two critical challenges simultaneously: significant problems and contradictions in the field of state regulation of land relations, on the one hand, and critical problems caused by the Russian military aggression, on the other.

The issue of land relations management in Ukraine attracts considerable attention from both scientists and experts. Aspects of information support for this process are of particular interest. O. Dyshlyk *et al.* (2018) emphasised the relevance of complete and reliable information on land resources for effective management decisions. In this context, priority is given to the implementation of geographic information systems (GIS) and remote sensing technologies. According to O. Braslavska (2025), the use of GIS methods can significantly improve the accuracy, speed and clarity of land use change analysis. At the same time, R. Mishchenko *et al.* (2020) highlighted the significance of integrating data from different sources into a single system.

L. Vasilieva (2024) emphasised that the integration of administrative and environmental mechanisms is a key condition for ensuring sustainable land use. The study noted that improving the system of public administration in the field of land relations is a multifaceted task that requires close cooperation between the state, local government, business and the public. This approach encompasses the modernisation of the regulatory framework, the rationalisation of the distribution of powers, the introduction of modern technological solutions and a shift in the management paradigm towards public values and the principles of sustainable development.

S.V. Sharapova & V.A. Kashkina (2025) emphasised that information on the qualitative state of land is one of the key elements in the land resource management system. The study highlighted the significance of ensuring the interoperability and integration of state electronic information systems. This makes it possible to combine data from various sources, including the state land cadastre and other information resources, which contributes to updating information on land use and improving the efficiency of land resource management. Interoperability in this area is defined as the ability of different information systems to interact effectively, exchange geospatial data, analytical information and cadastral and monitoring results without loss of content or the need for manual intervention.

The issue of land monitoring remains relevant for the global scientific community. H. Azadi (2020) noted that despite growing interest among land use policymakers in defining indicators that measure changes in land tenure systems, there is little consensus on what structure can functionally analyse land tenure systems and how it should be developed. Existing indicators primarily address the measurement of the "consequences" of (in)security of land tenure and often neglect the "causes". The study analysed both the causes and implications of Strong Land Governance (SLG) and Weak Land Governance (WLG), which depend on the government's decision-making process. Land governance involves various stakeholders in government decisions and ensures the security of means of subsistence. According to the researcher's conclusion, SLG is a prerequisite for economic growth and poverty reduction in rural areas of developing countries.

R.P. Ndugwa & C.K. Omusula (2025) analysed the institutional structures and policies governing land governance and land tenure security in Kenya, Rwanda, Uganda and Zambia. The study examined how monitoring land rights and access to data can influence the achievement of the UN Sustainable Development Goals, particularly in the context of ensuring equal access to land resources and improving land governance. The study determined that the main problems in these countries are insufficient coordination between authorities, limited access to up-to-date data, and insufficiently transparent land tenure policies. At the same time, the article emphasised the importance of integrating modern technologies to improve data collection and use for sustainable development in these countries.

T.E. Boza Espinoza *et al.* (2024) investigated how Peru's land monitoring system contributes to the implementation of international environmental commitments, particularly under the Rio Conventions (UN on biodiversity, combating desertification, and climate change). The study demonstrated that reliable monitoring of land use change is key to developing and evaluating land management policies, but there are problems with policy coherence, data access and coordination between institutions. The authors found that although Peru has achieved some of the goals for sustainable land management, financial, institutional,

and technical constraints hinder the full implementation of international commitments. The study emphasised that improving land monitoring systems can strengthen management decisions and support national efforts to achieve environmental goals.

Most of the analysed studies emphasised the significance of integrating different data sources, such as geographic information systems and remote sensing technologies, but in practice this remains limited due to insufficient coordination between institutions, restricted access to up-to-date data and a lack of effective integration mechanisms. In addition, there is a lack of coordination between policies and institutions at the national and international levels, which complicates effective land resource management. Therefore, the study aimed to develop a conceptual framework for sustainable land management and build an effective monitoring system that includes the integration of modern technologies such as geographic information systems, remote sensing, and data automation. This will not only improve the effectiveness of management decisions on land use but also ensure social well-being and sustainable development of the country in the post-war period, in particular through the participation of all stakeholders. To achieve the research objective, it was necessary to analyse the current state of the land monitoring system in Ukraine, develop a conceptual framework for sustainable land resource management in the context of post-war reconstruction, and model a land monitoring ecosystem based on Agile principles with the involvement of stakeholders.

Materials and Methods

The study was conducted as conceptual and analytical work aimed at substantiating the possibilities of applying the Agile paradigm in modernising state land monitoring and land relations monitoring in post-war Ukraine. The main methodological tool of the study was a narrative review of the literature, due to the complexity and multidimensionality of land resource management issues in the context of war and post-war reconstruction. Standard models of land use change do not always cover contextual, institutional and social factors that are difficult to formalise quantitatively, whereas a narrative review provides a flexible and comprehensive synthesis of existing knowledge, management practices and challenges (Jorgensen *et al.*, 2025).

The material basis of the study consisted of Ukrainian regulatory and legal acts governing land monitoring and the functioning of geospatial data (in particular, the Land Code of Ukraine, 2001; Resolution of the Cabinet of Ministers of Ukraine No. 474, 2023); scientific publications on land management issues. The Consensus platform was used to form a sample of elements for the study, which simultaneously searches several scientometric databases through a single interface. Search queries were based on the research topic by combining key concepts: land monitoring, land governance, Agile/adaptive management, post-conflict/post-war reconstruction, digitalisation and decision-making, which covered the interdisciplinary nature of the issue. The search covered the ScienceDirect, MDPI, Springer, JSTOR and ResearchGate databases. The analysis included publications in English and Ukrainian of at least three pages in length that corresponded to the research topic and were of an appropriate scientific level. The selection, duplication, removal and final inclusion of sources were conducted following the PRISMA protocol.

Methodologically, the study combined a systematic approach, qualitative analysis methods, and elements of the case method. At the first stage, content analysis and comparative legal analysis of the regulatory framework were conducted to identify gaps in the creation of geospatial data and metadata, as well as institutional and technological limitations of the current monitoring system. At the second stage, a narrative synthesis of the literature was applied to identify the key principles of Strong Land Governance, requirements for land management monitoring, and prerequisites for the digital modernisation of state land monitoring (SLM). The third stage involved benchmarking international post-conflict practices (Iraq, Syria), incorporating the principle of the impossibility of directly transferring models to the national context.

Conceptual modelling (Embley & Thalheim, 2011) was the key method used to obtain results, used to create a simplified, abstract representation of the land resource monitoring and management ecosystem. Based on the integration of theories of resilience, adaptive management and institutional change, the concept of Sustainable Agile Land Management was formed, and two visual models were developed: a conceptual framework for sustainable land management in post-war Ukraine and an Agile ecosystem for land resource monitoring and management with a stakeholder core and polycentric logic. The key components and mechanisms of the proposed approach have been summarised in the author's tables. The methodological approach used ensured logical consistency between the theoretical foundations, empirical observations and conceptual generalisations, which substantiated the potential of the Agile paradigm as an adaptive tool for modernising state land monitoring and supporting management decision-making in the post-war reconstruction process.

Results and Discussion

Land monitoring: Role in ensuring sustainable development, paradigms, practices and case studies

Effective land management is a key prerequisite for sustainable development, social justice and improved public governance, especially in the context of growing environmental and socio-economic challenges. In this context, the concept of Strong Land Governance, which combines the principles of transparency, accountability, fairness and public participation, is of particular importance. According to R. Hall *et al.* (2016), a land management system based on SLG principles is much more effective than the traditional one and can improve other aspects of social life, such as sustainable development, gender equality and

community viability. A substantial element for implementing these principles is state land monitoring, which provides an evidence base for management decisions, helps fight corruption, and integrates sustainable development goals into land policy practice.

Land monitoring for governance purposes involves the use of data and systems to track land access, its use and ownership to ensure transparency, accountability and fairness, combat corruption, and support sustainable development by providing evidence for policymaking, improving land governance (often in digital format) and securing the rights of individuals and communities. It assesses how land governance is implemented, from legal norms to actual implementation, prioritising principles such as equality, participation and effectiveness to build better systems. Key aspects of land governance monitoring are summarised in Table 1.

Table 1. *Key aspects of land resource management monitoring*

Aspect	Content
Data and technologies	Use of digital systems (such as the Agrarian Register in Ukraine or Copernicus in Europe) to collect and analyse land data, creating comprehensive overviews for planning and decision-making.
Transparency and audit	Monitoring demonstrates the actual state of land, reduces corruption and political speculation, and ensures accountability of authorities.
Security of land ownership (legal guarantees)	Assessment of tenure rights (who owns, uses or manages land) to prevent conflicts, especially for vulnerable groups such as women, and to ensure equal access.
Policies and reforms	Provision of a diagnostic tool (such as the World Bank's LGAF) to identify weaknesses in land governance and prioritise reforms for better governance.
Sustainable development	Connecting land monitoring to broader Sustainable Development Goals (SDGs) on food security, poverty reduction and environmental protection.

Source: *compiled by the authors based on A. Lyusak & K. Nikolaichuk (2020), O. Ercan (2022)*

The modernisation of the state land monitoring system aims to improve the efficiency of land resource management through the introduction of digital technologies, the integration of data from various sources, the use of space monitoring and the creation of unified information platforms, in particular national spatial data systems, for the rapid detection of soil degradation, illegal use and changes in soil quality characteristics. Key areas include automating data collection, integrating data with other monitoring systems (environmental, agricultural) and creating interactive geoinformation portals for management decision-making (Reydon *et al.*, 2020).

Monitoring land relations covers a wide range of tasks, the implementation of which requires the involvement of various institutions and sectors. These tasks include monitoring the fulfilment of state obligations, supporting political advocacy, providing information on the use of financial resources, evaluating the results of the implementation of strategic and programmatic documents, stimulating public dialogue and democratic discussions, and actively involving stakeholders in effective land management practices. At the same time, no single institution is capable of institutionally ensuring the implementation of the entire range of these functions, just as there is no universal system capable of fully satisfying the needs of all participants in the process. In such conditions, cross-sectoral interaction and the development of inclusive approaches to monitoring become particularly relevant, while parallel and complementary initiatives should be seen not as duplication but as a substantial resource for improving the quality of land resource management. Therefore, in the process of modernising the state land monitoring system, it is advisable to introduce a stakeholder approach. The development of a comprehensive digital model for monitoring land relations can increase the effectiveness of state monitoring of land resources and contribute to social welfare, and support the implementation of sustainable development goals, particularly at the local level.

Land monitoring is an activity that involves the use of geospatial data, as defined by the Land Code of Ukraine (2001). The results of observations and measurements of the state of the environment and other ecosystem parameters are included in the list of geospatial data sets and types of the national geospatial data infrastructure. However, the content and procedure for land monitoring (Resolution of the Cabinet of Ministers of Ukraine No. 474, 2023) do not define the process of creating geospatial data and metadata. M. Malashevskyi *et al.* (2025) established that a "national, regional and local database on the state of land and soil" would be created based on a comprehensive national observation system. At the same time, ensuring the effective operation of a unified monitoring system remains a difficult task that requires addressing a wide range of organisational, technical and other challenges.

The current state of the land monitoring system in Ukraine is accompanied by several significant problems, among which the following can be highlighted: insufficient adaptation to wartime conditions, fragmentation between different agencies, limited technical resources, lack of a unified methodology for assessing damage, weak integration with international systems, and vulnerability in data storage. At the same time, the revitalisation of the land market, confirmed by data from the State Geocadastre on the transfer of 909,483 hectares of land plots (as of February 2025), creates new challenges for the monitoring system, as it requires enhanced control over compliance with the principles of rational land use by new owners in the context of growing risks of land degradation (Rybalko, 2025). The monitoring system should be improved by optimising the monitoring process methodology, strengthening coordination between the entities involved in this process, and effectively managing them within the state land monitoring

system in Ukraine. It is also necessary to ensure the integration of information resources.

The modernised LMS can ensure rapid response to land-related issues and provide a basis for sustainable land management, which is critical for agriculture, ecology and territorial development. The main areas of modernisation of the state land monitoring system include:

1) digitisation and automation: transition from paper media to digital databases and automated systems for collecting, processing and storing information on land status;

2) data integration: combining DMZ data with the results of space monitoring (space imaging), environmental monitoring, land management and cadastral registration;

3) creation of geographic information systems (GIS) – development of a national spatial data system that provides data visualisation, spatial information analysis and access to it through portals;

4) remote sensing of the earth (RSE): active use of satellite images for rapid detection of changes (flooding, erosion, pollution, disturbances);

5) forecasting and assessment: developing models to assess the current state of land and forecast negative processes such as desertification, waterlogging, pollution and soil degradation;

6) improving management efficiency: providing authorities with up-to-date and reliable information for making informed decisions on land protection and rational use.

The dissertation by K.V. Rybalko (2025) emphasises that the main obstacles to the implementation of public management tools are the institutional weakness of local self-government bodies (only 42% of communities have land management specialists), legal contradictions between the regulations of different agencies, the digital divide between levels of government (only 57% of communities have full access to electronic registries), and regional imbalances in access to resources. To overcome these problems, a comprehensive approach with differentiated management decisions is needed, considering the specifics of each region and its security situation. The study proposed theoretical and methodological foundations for an adaptive strategy for public management of agricultural land in conditions of uncertain truce. This strategy is based on a functional-spatial approach that includes the differentiation of territories according to security, environmental and socio-economic criteria. This approach facilitates a rapid response to changes in the security situation and can be used for the effective adaptation of management tools to local conditions. The strategy provides for the creation of a multi-level management system with mechanisms for rapid response to crises, the integration of specialised information systems for monitoring and analysing the state of land, and the introduction of methods for evaluating the effectiveness of tools, incorporating the specific features of each region. The implementation of this approach will ensure the sustainability of the land use system in conditions of instability, maintain the country's food security, and gradually restore agricultural potential in de-occupied and affected areas. All of these are key elements of the national strategy for Ukraine's post-war economic recovery.

Modelling an ecosystem of state land monitoring and land management based on the Agile paradigm and stakeholder approach

The strategy proposed by K.V. Rybalko (2025) is based on a synthesis of the theory of resilience (stability) of systems, the concept of adaptive management, the theory of institutional change, and the methodology of management in conditions of uncertainty. The theoretical basis is the concept of resilience (stability), which defines the ability of a public management system not only to withstand external challenges but also to effectively adapt and transform under their influence, while maintaining its basic functions. It is also necessary to consider the theory of adaptive management systems, which emphasises the process of continuous learning and improvement of mechanisms and tools for effective response to changes in the external environment.

However, there is a paradigm that unites the above theories into a single concept: Agile. Sustainable Agile Land Management (SALM) integrates the principles of Agile project management (adaptability, iterative work, stakeholder orientation) with SLM practices (soil health, water conservation, biodiversity) to create flexible, sustainable systems that balance environmental, social, and economic needs, addressing complex issues such as climate change and resource scarcity in agriculture and land use. Such management goes beyond rigid planning, ensuring rapid adaptation to changing conditions, ensuring long-term environmental health and community well-being, focusing on the principle of "People and planet over profit" (Matias *et al.*, 2025).

Agile land monitoring for sustainable development uses iterative, adaptive approaches (such as Agile/Kanban) with real-time data (Internet of Things, artificial intelligence) and community feedback to continuously adjust land use, conservation and management strategies, ensuring faster and more relevant responses to environmental changes (e.g., water, soil) and achieving better social, economic, and environmental outcomes than rigid traditional methods by integrating stakeholder knowledge and focusing on flexible, sustainable practices (Weith *et al.*, 2021). The conceptualisation of such an Agile land monitoring "ecosystem" is presented in Table 2.

Table 2. *Structural elements and logic of Agile-oriented land monitoring*

Key concepts
Agile principles. Applications of agile software development values (feedback loops, iterations, adaptability) to land resource management
Sustainable land management (SLM). Integration of environmental, social and economic objectives for long-term productivity, sustainability and equity

Table 2. *Continued*

Key concepts
Adaptive management. Flexible policies and management that respond to new information and challenges, transitioning from static plans
Emphasis on risks. By initially prioritising high-risk areas, Agile audits can provide timely and practical information, ensuring that critical issues affecting sustainable development are addressed promptly
Principles of operation
Data-driven iterations. Use of real-time data (sensors, satellite imagery) for continuous monitoring, enabling rapid adjustments (e.g., irrigation in agriculture)
Feedback loops. Introducing rapid feedback from local communities, farmers and stakeholders to improve interventions
Cooperation structures. Building partnerships between governments, communities and experts for joint decision-making
Technology integration. Using the Internet of Things for monitoring and AI for analysis to identify issues (such as rumours or risks) and develop adaptive strategies
Advantages of sustainable development
Resilience. Better readiness to overcome shocks (climate change, pandemics, armed conflicts) through adaptive strategies
Efficiency. Optimises the use of resources (water, soil) and reduces waste
Inclusiveness. Ensures that the needs of various stakeholders are met by involving them in the process
Improved results. Ensures more effective preservation and management by aligning with real-world conditions

Source*: compiled by the authors*

Remote sensing technologies demonstrate high efficiency as tools for detecting changes, observing and mapping territories. At the same time, in many cases, additional sources of information are needed to reliably confirm the results, interpret them correctly and determine the nature of the damage. When remote sensing capabilities are limited or are unable to provide a full assessment of the situation, it becomes advisable to use alternative or complementary research methods, including field surveys, mobile laboratories, unmanned aerial vehicle data, local monitoring tools, eyewitness accounts, the participation of local volunteers, and analysis of secondary impacts (Kopecká *et al.*, 2025). In such conditions, the application of the stakeholder approach becomes relevant.

In addition, auditing and managing land resources in post-conflict territories is related to the need to establish clear, fair and secure land tenure regimes in situations of mass population displacement, loss or destruction of registration data, and transformation of power relations. This requires comprehensive approaches that combine formal legal norms with traditional institutions, focus on restitution and compensation mechanisms, promote the development of state institutional capacity for transparent governance, and provide for conflict resolution through dialogue with communities and reliance on an effective legal framework, which is critical for peacebuilding and preventing the recurrence of violence.

The land tenure system, in turn, should reflect all land transactions and potential changes related to land use and disposal, as interested parties need to be able to inform the relevant institutions about such transformations promptly. Discrepancies between actual land tenure patterns and existing land institutions can significantly weaken rights protection mechanisms and create conditions for instability. At the same time, there are at least two areas in which it is advisable to apply the Agile framework in parallel. First, it can be used as a methodological basis for monitoring flexible, rule-based policy reform indicators, incorporating a wide range of participants in the process, including non-governmental organisations, private sector representatives and the scientific community, in compliance monitoring with the adopted recommendations. This creates a system for further oversight of resource use and respect for the rights of vulnerable groups.

Secondly, alongside flexible indicators, this approach prioritises a range of dynamic and rapidly changing areas, which necessitate the development of empirical indicators for more frequent and timely monitoring of land resource management. Key areas of such analysis include: (1) principles of land management system functioning (in particular, from the perspective of primary and secondary rights registered both for individuals and groups, with an emphasis on the gender dimension); (2) the situation of poor segments of the population, who are often deprived of access to reliable information; (3) historical trajectories of land relations development; (4) the scale and typology of conflicts that fall within the formal legal field.

In this context, auditing and managing public land resources based on a stakeholder approach involves various groups (citizens, communities, organisations) in assessing and overseeing land use, exceeding the scope of traditional top-down control to increase transparency, fairness and outcomes by incorporating local knowledge, improving accountability and balancing competing interests for sustainable development, often using tools such as stakeholder analysis and public participation frameworks. This approach uses auditing not only for financial checks, but also to assess management, effectiveness and stakeholder satisfaction, seeking “win-win” solutions by integrating diverse needs and influences. The systematisation of the main approaches, tools and expected effects of applying stakeholder logic in the audit and management of state land resources is summarised in Table 3, which can be used for a comprehensive assessment of the potential of this approach to improve the quality of public administration.

Table 3. *Key concepts and principles of auditing and managing state land resources based on a stakeholder approach*

Key concepts and principles
Identification of stakeholders. Recognition of all parties affected by or affecting land management (government, developers, local communities, indigenous groups, future generations)
Participatory management. Involvement of citizens and stakeholders in decision-making to improve legitimacy and environmental outcomes
Effective governance. Managing public lands for long-term economic, social and environmental benefits, with an emphasis on transparency and sustainable development
Stakeholder analysis. A tool for identifying interests, power and needs to determine dynamics and develop fair policies
Principles of operation
Engagement methods. Use of surveys, online platforms (such as social networks for citizen science), consultations and workshops to gather different points of view
Balance of interests. Active determination and prioritisation of conflicting stakeholder interests (e.g., economic development versus nature conservation) to obtain balanced solutions
Improved results. Using local expertise to obtain better data, promote community engagement and increase resilience to environmental challenges
Benefits and risks
Benefits. More democratic, transparent, fair and efficient land management, improving environmental and social outcomes and ensuring social well-being
Risks. Managing the numerous, sometimes conflicting, interests of stakeholders, ensuring meaningful (not just symbolic) participation and overcoming legal/administrative barriers

Source: *compiled by the authors*

There is already a range of best practices that can be used to develop a modernised system of public land monitoring in post-war Ukraine. In particular, sustainable land management in post-conflict Iraq included overcoming significant land degradation, water scarcity and pollution through projects aimed at restoring wetlands with the support of the Food and Agriculture Organisation of the United Nations and the Global Environment Facility (FAO/GEF), the introduction of a socially oriented domain model for land rights registration (Social Tenure Domain Model, STDM) within the framework of the United Nations Human Settlements Programme (UN-Habitat), and the identification of pollution hotspots with the participation of the World Bank, which made it possible to simultaneously address the problems of weak governance, mass population displacement and climate change to ensure sustainable livelihoods and environmental restoration. Key strategies included agroecology, conservation agriculture, capacity building for local authorities, and innovative land use solutions for returnees and vulnerable groups that exceed the scope of traditional systems (Aoki *et al.*, 2014). The main approaches to management were identified as follows:

- comprehensive assessment: combining digital mapping of land rights with environmental data (pollution, water);
- community-oriented solutions: empowering local communities and authorities through training;
- policy and practice: adapting land management, promoting sustainable agriculture and restoring ecosystems;
- climate resilience: building adaptive capacity to water scarcity and rising temperatures.

In post-war Syria, land registry management underwent both local transformations and demonstrated considerable stability. With the destruction of state institutions and the emergence of new non-state governance structures, the old land registry system collapsed, and existing gaps between official records and property rights deepened, with significant implications for the possibility of establishing lasting peace in the country (Alsamar *et al.*, 2023). The proposed actions emphasised the importance of prioritising agricultural land in master plans, which was achieved through the recultivation of these lands after the end of the conflict. This also included restrictions and limits on construction, especially on productive agricultural land, which helped to create a healthy and adequate environment, self-sufficiency and employment opportunities for residents. Increasing public green spaces was also identified as a priority.

Covering these cases and the theoretical arguments described above, a conceptual framework for sustainable land management in post-war Ukraine can be proposed (Fig. 1). The proposed framework combines elements of equitable sustainable response, land management and post-conflict recovery strategies, and reflects opportunities for improvement through polycentric and multi-level approaches aimed at ensuring social cohesion, food security and sustainable development. The approach to land management developed by UN-Habitat (Enemark *et al.*, 2016) is based on three basic and closely interrelated principles, summarised in Table 4. Within this approach, the land management system in each country, including Ukraine, should cover four key components: land ownership, land value, land use and land development. The implementation of these functions requires interdisciplinary cooperation and the involvement of specialists from various fields, including land surveyors, engineers, lawyers, appraisers, planners, and developers.

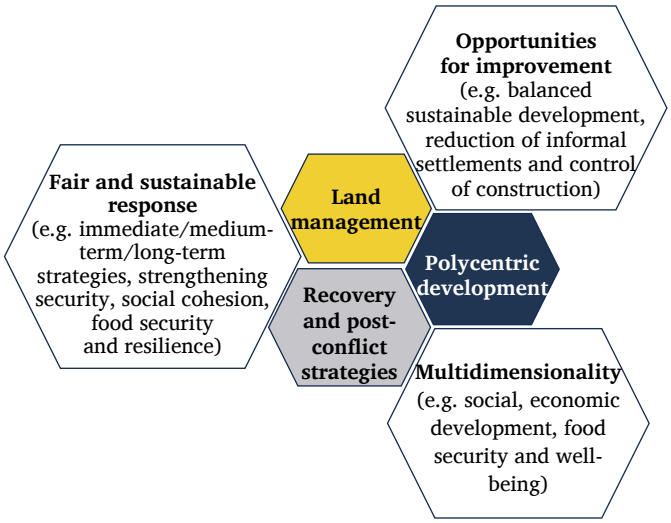

Figure 1. *Conceptual framework for sustainable land management in post-war Ukraine*
Source: *compiled by the authors*

Table 4. *Key principles of the "Fit for purpose" approach*

Spatial framework	Legal framework	Institutional framework
▪ visible (physical) boundaries, not fixed; ▪ aerial/satellite images, rather than field studies; ▪ accuracy related to the objective rather than technical standards; ▪ requirements for updating and opportunities for modernisation and continuous improvement	▪ a flexible framework developed according to administrative rather than "legal" principles; ▪ continuity of ownership, not just individual ownership; ▪ a flexible accounting system, not just registers; ▪ ensuring gender equality in land and property rights	▪ proper management of land resources, rather than bureaucratic barriers; ▪ integrated institutional structure, rather than isolated sectoral structures; ▪ a flexible approach to ICT, not just high-tech solutions

Source: *compiled by the authors based on S. Enemark et al. (2016)*

To illustrate the interrelationships between the key elements of adaptive land resource management, a schematic model of the Agile ecosystem for land resource monitoring and management has been proposed (Fig. 2). At the centre of this model is the integrative involvement of stakeholders in combination with the principles of polycentric development, which determines the logic of the entire system's functioning. Interrelated processes of land monitoring and auditing, management decision-making in the field of land management, as well as the achievement of sustainable development, social well-being and justice are formed around the central core. This structure emphasises the iterative nature of the interaction between data, management decisions and social goals in a dynamic environment. Therefore, integrated spatial polycentric land use management is a key tool for recovery, peacebuilding and reconstruction strategies in Ukraine, as well as for achieving the Sustainable Development Goals. When benchmarking, it is impossible to fully adapt approaches from different cases; there is no one-size-fits-all approach, as each country has its own circumstances. Nevertheless, international and common standards can provide a general framework for research. Therefore, by combining benchmarking with local practices and experiences, key indicators of land management can be identified and evaluated to determine which aspects of the land management process need improvement.

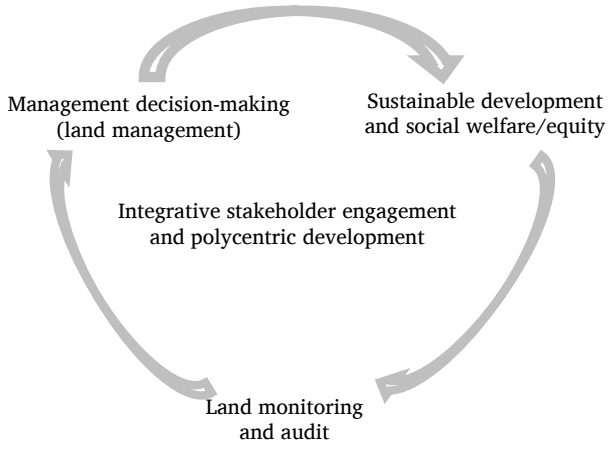

Figure 2. *Agile (iterative) ecosystem for monitoring and managing land resources with stakeholder involvement*
Source: *compiled by the authors*

The results of the study confirm the feasibility of applying the Agile approach in the land relations monitoring system, which is consistent with current scientific developments in the field of adaptive land resource management. In particular, H. Azadi (2020) emphasises the need to move from static indicators to flexible, process-oriented monitoring models that consider the causes of changes

in land ownership and provide effective feedback loops between data and management decisions. Similar conclusions are presented in the studies by Th. Weith *et al.* (2021) and M. Matias *et al.* (2025), which demonstrate the effectiveness 2f iterative, co-design and digital approaches to land use management in conditions of high uncertainty and dynamic change.

A substantial theoretical basis for interpreting the results of the study is also the article by O.V. Lazareva & V.V. Yuzva (2024), which substantiates a synergistic approach to land use in the post-war period, based on the combined action of data, institutional mechanisms and stakeholder interaction. In this context, Agile monitoring of land relations can be seen as a practical tool for achieving synergy, ensuring flexible integration of information, prompt adjustment of management decisions, and coordination of environmental, economic, and social goals. This is consistent with the conclusions of T.E. Boza Espinoza *et al.* (2024), emphasising that it is adaptive, inter-institutional and data-driven monitoring systems that can improve the quality of land resource management in post-crisis and post-conflict conditions. Thus, the results of the presented study expand existing approaches, demonstrating the potential of the Agile ecosystem as a tool for implementing synergistic principles in the practice of post-war land relations management.

Conclusions

The study aimed to justify the possibility of modernising state monitoring of land relations in post-war Ukraine based on the Agile paradigm and stakeholder approach. The study analysed the role of land monitoring as a tool for implementing the principles of Strong Land Governance and achieving sustainable development goals through increased transparency, accountability and fairness in governance. Existing gaps and challenges in the landscape of state land monitoring in Ukraine were identified in the context of the need to form vectors of sustainable development in the period of post-war reconstruction. In particular, the analysis showed that current approaches do not sufficiently define the processes of creating geospatial data and metadata, which complicates the integration and reuse of information. An assessment of the state of the LMS revealed systemic limitations, including fragmentation between agencies, a shortage of technical resources, a lack of a unified methodology for assessing damage, weak integration with international systems, and risks to data preservation during the war/post-war period. Based on benchmarking of international post-conflict cases, practices relevant to the Ukrainian context were summarised, and a conceptual framework for sustainable land management in post-war Ukraine was developed. As a result of the study, a conceptual model of an Agile ecosystem for land resource monitoring and management was proposed, with a stakeholder core and polycentric logic that closes the cycle of "data → monitoring/audit → management decisions → sustainable development and social well-being". Polycentric development and active stakeholder engagement can promote better land use practices through proper land resource management that supports decision-making. As a result, land use can be optimised and, consequently, a more effective land resource management system can be achieved, contributing to the achievement of the Sustainable Development Goals. The study conceptualised the Agile approach as a tool for transitioning from "static" control to adaptive, data-driven and inclusive land relations management, which is critical for post-war reconstruction where risks and conditions are rapidly changing. The proposed model provides a framework for the integration of geodata, institutional coordination and stakeholder participation, increasing the soundness of management decisions and the system's ability to support the achievement of SDGs. Promising areas for further research include the development of measurable Agile indicators for monitoring land relations, testing the model through pilot projects in communities of different security categories, and empirical assessment of data interoperability and the effectiveness of polycentric management mechanisms.

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Модернізація системи державного моніторингу земель як основа для прийняття управлінських рішень у процесі післявоєнної відбудови

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Анотація. Актуальність дослідження зумовлена необхідністю модернізації системи державного моніторингу земель в Україні в умовах повоєнної відбудови, коли від якості, оперативності та адаптивності управлінських рішень безпосередньо залежать сталий розвиток територій, продовольча безпека та соціальна згуртованість. Метою роботи є обґрунтування можливостей застосування Agile-парадигми як концептуальної основи для оновлення державного моніторингу земель і моніторингу земельних відносин у повоєнний період. У дослідженні використано наративний огляд наукових джерел, аналіз нормативно-правової бази, елементи кейс-методу та концептуальне моделювання. У результаті встановлено, що чинна система державного моніторингу земель в Україні характеризується фрагментарністю, обмеженою інтеграцією даних, недостатньою адаптацією до умов воєнного та післявоєнного періоду й слабкою інституційною координацією, що знижує ефективність управлінських рішень. Обґрунтовано, що поєднання принципів Strong Land Governance, цифровізації, стейкхолдерського та поліцентричного підходів створює передумови для переходу від статичних моделей моніторингу до адаптивних ітеративних систем. Запропоновано концепцію Sustainable Agile Land Management, яка інтегрує резильєнтність, адаптивне управління та інституційні зміни й орієнтована на використання геопросторових даних у режимі наближеному до реального часу. Розроблено концептуальний фреймворк сталого управління земельними ресурсами у повоєнній Україні та модель Agile-екосистеми моніторингу й управління земельними ресурсами зі стейкхолдерським ядром, що демонструють логіку взаємодії моніторингу, аудиту та прийняття управлінських рішень. Показано, що Agile-підхід дозволяє оперативно реагувати на ризики деградації земель, враховувати локальний контекст і забезпечувати узгодження екологічних, економічних і соціальних цілей розвитку. Практична цінність результатів полягає в можливості використання запропонованого підходу та моделей як методологічної основи для модернізації державного моніторингу земель і підтримки управлінських рішень у процесі повоєнної відбудови України

Ключові слова: публічне управління; управління земельними ресурсами; соціальне благополуччя; сталий розвиток; землекористування