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Interrelation of state information systems for land management

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Abstract: State information systems play a significant role in information support of land management. Open state information systems and technologies are a modern mechanism of data collection, processing, analysis and publication for transparent, democratic, effective land resources management. Within the national Ukrainian context, land management activities are described by components presented in the article. The purpose of the study is to investigate the interrelation of different kinds of state information systems for land management. The following tasks are aimed at achieving the goal: to perform the analysis of types and forms of state information systems, to structure the information contained in the state information systems, and to research the interoperability of data of state information systems. Based on the results of the study, a structural model of effective land management is presented in the work. In the article, there is an example of the open data using regarding the state monitoring of surface water, which is open to users, as of March 2023, was used to make management decisions. The availability of complete open data regarding land and other natural resources provides the possibility of informed decision-making while ensuring effective land management in general and individual land plots in particular. The results of the study illustrate the need for further strengthening data interoperability in different state information systems.

Keywords: cadaster, geoinformation systems, land management, land use, state information systems

INTRODUCTION

Land management is the process whereby land resources are put to good effect. It foresees making decisions and implementing strategies to optimise land use for various purposes, such as agriculture, forestry, urban development, conservation and recreation. The United Nations (FAO, no date) defines sustainable land management as "the use of land resources, including soils, water, animals and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions".

TerrAfrica (FAO, no date) defines sustainable land management as, "the adoption of land-use systems that through appropriate management practices enable land users to maximise the economic and social benefits from the land while maintaining or enhancing the ecological support functions of the land resources".

The aim of the article is to investigate the interrelation of different kinds of state information systems for ensuring land management.

To achieve this goal, an analysis of components of land management was carried out, as the main state information systems for ensuring land management were determined; the analysis of types and forms of state information systems was performed. The information contained in some systems was structured. The research was carried out taking into account legal, spatial, social and technical aspects (Helbing, 2015; Krigsholm, Riekkinen and Ståhle, 2018). The analysis and synthesis, comparison and system methods were also applied during this study.

MATERIALS AND METHODS

WHAT IS LAND MANAGEMENT IN UKRAINE?

Land management is the practice of overseeing and controlling the use, development, and conservation of land resources. It encompasses all activities associated with the management of land and other natural resources required for the achievement of sustainable development. Effective land management aims to balance economic, social, and environmental considerations while ensuring sustainable use and long-term benefits (Bennett, Wallace and Williamson, 2008; Trehub and Trehub, 2017).

Organisational structure for land management varies widely between countries and regions throughout the world. Institutional arrangements may change over time to better support the implementation of land policies and good governance (Hens, 2010; ICSM, 2015; Auzins *et al*, 2022; Bennett, *et al*., 2023).

Within the national Ukrainian context, land management activities may be described by components presented in Figure 1 (Petrakovska and Mykhalova, 2018, Petrakovska and Dubnytska, 2019; Petrakovska and Mykhalova, 2020, Petrakovska and Mykhalova, 2022). In order to avoid controversial interpretations of terms, the next definitions given in the article are proposed by the authors.

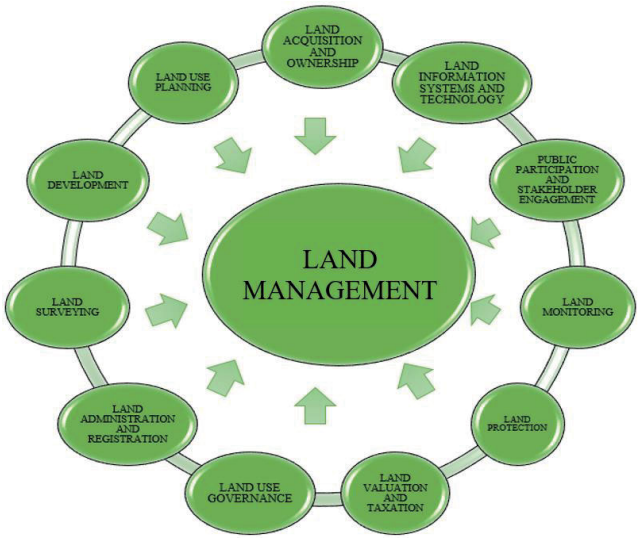

Fig. 1. Components of land management; source: own elaboration

Land use planning. This process regulates land use by developing various plans considering environmental, social and economic conditions for society's purpose and activity. There is also the land division into different zones with specific regulations and land use restrictions as a part of land use planning.

Land acquisition and ownership. This is the process of acquiring land through purchase, lease, or other means, and managing land ownership rights.

Land development. This multidisciplinary process involves the planning, engineering, construction and evaluation of improvements on a piece of land aimed at increasing its value and is based on legislation.

Land surveying. This is the practice of measuring and mapping the physical features and boundaries of land plots.

Land administration and registration. This is the implementation of land use and registration rules by means of organisational and coordination-administrative procedures by various regulatory agencies in the issues of land use and transfer of land rights.

Land use governance. This is the implementation and enforcing regulations and policies related to land use, management, development and conservation.

Land valuation and taxation. This involves assessing the value of land for different purposes and determining appropriate land taxes or fees.

Land monitoring. This is the regular observation and assessment of land conditions for economic effectiveness, ecology safety and social support of society to make informed decisions and improvements.

Land protection. This is the act of applying measures aimed at the preservation of land resources from exhaustion, pollution and other harmful anthropogenic damage.

Public participation and stakeholder engagement. This involves engaging the public and relevant stakeholders in decision-making processes related to land management to ensure transparency and inclusivity.

Land information systems and technology. Geospatial technologies, databases and information systems are utilised to gather, store, analyse and disseminate land-related data for effective decision-making and planning.

TYPES OF STATE INFORMATIONAL SYSTEMS

Objective and adequate information about the real state, land and other natural resources should be displayed in state information systems. State information systems (SIS) and technologies are modern mechanisms of data collection, processing, analysis and publication for transparency, democracy, and effectiveness of all components of land management. Graphical and attribute data are the main components of SIS all over the world (Liashchenko, 2004; Karpinskyi and Lazorenko-Hevel, 2018; Lazorenko-Hevel, Karpinskyi and Kin, 2021; Petrakovska *et al*., 2021).

There are more than 10 state information systems in Ukraine: State Land Cadastre (Ukr: Derzhavnyi zemelnyi kadastr), Urban Cadastre (Ukr: Mistobudivnyi kadastr), State Forest Cadastre (Ukr: Derzhavnyi lisovyi kadastr), State Water Cadastre (Ukr: Derzhavnyi vodnyi kadastr), State Cadastre of the Animal World (Ukr: Kadastr tvarynnoho svitu), State Cadastre of the Plant World (Ukr: Kadastr roslynnoho svitu), State Cadastre of Territories and Objects of the Nature Reserve Fund (Ukr: Derzhavnyi kadastr terytorii ta obiektiv pryrodno-zapovidnoho fondu), State Cadastre of Minerals Deposits and Occurrences (Ukr: Derzhavnyi kadastr rodovyshch i proiaviv korysnykh kopalyn), State Cadastre of Natural Territories of Resorts (Ukr: Derzhavnyi kadastr pryrodnykh terytorii kurortiv), State Cadastre of Natural Medicinal Resources (Ukr: Derzhavnyi kadastr pryrodnykh likuvalnykh resursiv), State Cadastre of Aquatic Bioresources (Ukr: Derzhavnyi kadastr vodnykh bioresursiv) etc. (Kodeks, 1995; Petrakovska and Tatsii, 2015).

Information from all the above-mentioned cadastres is accumulated and used by relevant ministries and other agencies for environmental protection.

Besides, there are (a) additional registers that record ownership/use rights and their restrictions, for example, State

Register of Real Property Rights (Ukr: Derzhavnyi reiestr rechovykh prav na nerukhome maino), State Register of Mortgages (Ukr: Derzhavnyi reiestr ipoteky), Unified Register of Prohibitions on Alienation of Real Estate Objects (Ukr: Yedynyi reiestr zaboron vidchuzhennia obiektiv nerukhomoho maina) and (b) registers which fix different data about objects and subjects, such as Unified State Register of Legal Entities and Individual Entrepreneurs (Ukr: Yedynyi derzhavnyi reiestr yurydychnykh osib ta fizychnykh osib-pidpryiemtsiv), Inheritance Register (Ukr: Spadkovyi reiestr), Register of VAT Payers (Ukr: Reiestr platnykiv PDV), State Register of Immovable Monuments of Ukraine (Ukr: Derzhavnyi reiestr nerukhomykh pamiatok Ukrainy), State Register of Potentially Dangerous Objects (Ukr: Derzhavnyi reiestr potentsiino nebezpechnykh obiektiv), (c) Register of Administrative Decisions (Ukr: Reiestr administratyvnykh rishen), Unified State Register of Court Decisions (Ukr: Yedynyi derzhavnyi reiestr sudovykh rishen), Register of Sanitary-Epidemiological Conclusions (Ukr: Reiestr sanitarno-epidemiolohichnykh vysnovkiv) (Petrakovska and Tatsii, 2015).

In Ukraine, the mechanism of interaction between state information systems is defined at the legislative level Postanova (2013).

Realisation of this mechanism is aimed at ensuring of effective economic, environmental and social decisions and is achieved by taking next measures:

- provision of mutual data replenishment of information systems;
- ensuring the objectivity, reliability, and completeness of data in information systems;
- prevention of duplicating works on filling information systems;
- improving state information systems;
- provision of necessary up-to-date geospatial data for state authorities, local self-government bodies, owners/users and business entities.

In order to ensure effective land management, the analysis of objects and information about them, which is contained in information systems, was carried out in the work.

The first step is to define the objects of information systems. The main objects are land/water/forest resources, soils, other natural resources, animals and plants. Information systems where animals and plants are objects are not considered in the work.

The next step is to define the subjects. The participants in the process of ensuring effective land management, who have a certain interest in obtaining a specific result, are land owners/users, governments and municipal authorities, business entities and non-governmental groups. It should be noted that all four groups of participants are directly involved in making decisions about ensuring effective land management.

Based on the results of the study, the structural model of effective land management is developed and presented in the work (Fig. 2).

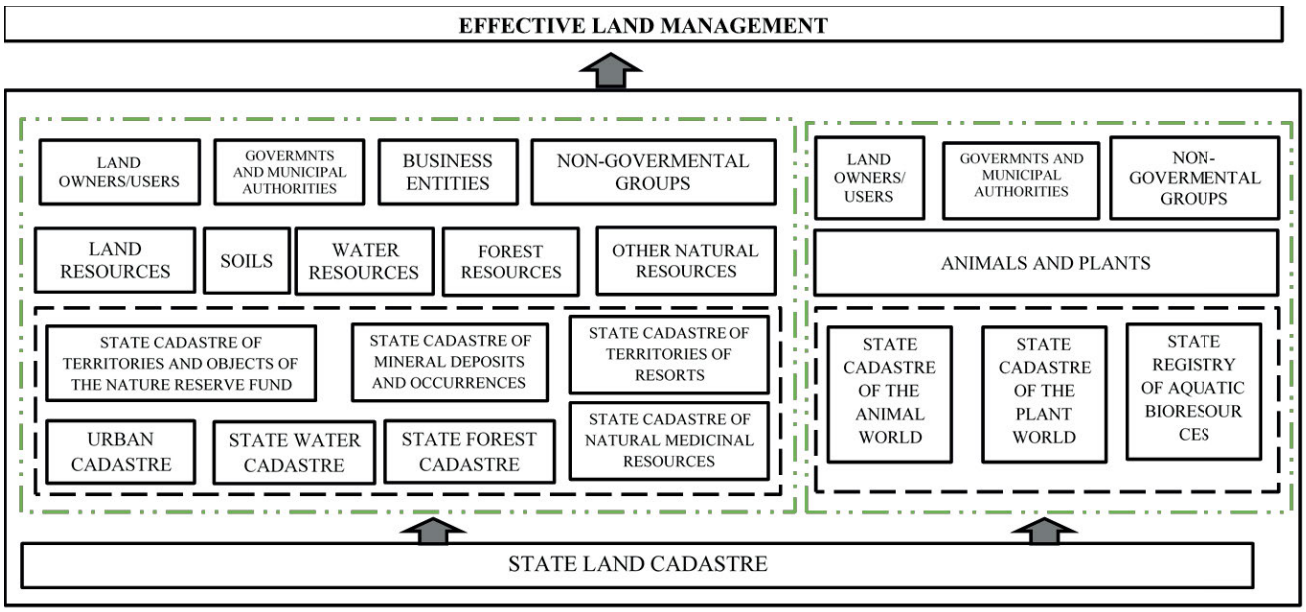

Fig. 2. Structural model of effective land management; source: own elaboration

- geospatial data storage;
- determining the degree of their accuracy;
- providing the possibility of automated data exchange between geographic information systems in real time;
- elimination of discrepancies and ensuring the reliability of geoinformation systems.

The advantages of objective and adequate interaction between state information systems are:

- formation of a unified cartographic basis for geo-information systems;

RESULTS AND DISCUSSION

INFORMATION SYSTEMS FILLING

Ukraine is following the global practice of building a national system of geospatial data on the basis of the land cadastre, when information about the subsoil, engineering networks, water and forest resources etc. will be superimposed on the land cadastre (Zakon, 2011; Zakon, 2020). In 2021, a legal framework for the creation, operation and development of the national infrastruc-

ture of geospatial data was formed in Ukraine. Regional governments and municipal authorities are obliged to publish geospatial data and metadata on their official websites and geoportals and display them using access services on the national geoportal. Geospatial data placed on the portal are divided into basic and thematic geospatial data. Research of basic data and the diversity of thematic ones made it possible to establish systems, which are the information source for creating and updating sets of geospatial data. As a result of the data analysis, the authors proposed examples of the possibility of obtaining data for filling the portal and making management decisions (Tab. 1). For the analysis, the State Land Cadastre and Urban Cadastre were chosen as the most complex and multi-purpose information bases, and the State Water Cadastre as the sectoral and thematic information source. At the same time, the peculiarity of the influence of water resources on the ecological state of the territories was taken into account.

USING AND PRESENTING OPEN DATA

Open data is the basis of anti-corruption and transparent work of state and local authorities. Every interested person has the right to access public information about the work of authorities and other state institutions. In 2020 Ukraine entered the Open Data Maturity Report, European rating, for the first time. In 2021 Ukraine took 6th place and became a trendsetter in the digital sphere. Ahead of Ukraine were France, Ireland, Spain, Poland and Estonia (EU, no date).

It is important to note that the significance of open data on natural resources goes beyond the boundaries of cities, regions and even countries. If the question of economic efficiency and social security is important at the local, regional, and state levels, then environmental protections have no boundaries. The possibility of getting acquainted with the data of all interested parties will make it possible to make weighted decisions regarding the preservation of all components of the environment and overcoming and preventing possible negative consequences.

In connection with the full-scale military invasion of the Russian Federation, martial law has been introduced in Ukraine since February 24, 2022. As a result, in order to prevent threats of using information for enemy targets, state authorities as holders of state information systems suspended their work and temporarily limited access to open data (Tomchenko *et al.*, 2023).

In the article, as an example of the open data use, information from the "Diya" portal (the only portal of public

Table 1. Information sources for obtaining data

Geospatial data	State Land Cadastre	Urban Cadastre	State Water Cadastre
Basic data			
Coordinates and heights reference systems	bank of geodetic data		
The state border of Ukraine	+	–	–
Boundaries of administrative-territorial units	+	–	–
Boundaries of territorial communities	+	–	–
Hydrographic objects and hydrotechnical structures	+	–	+
Settlements, including their street and road network	+	+	–
Buildings and structures	–	+	–
Highways	–	+	–
Railways	–	+	–
Engineering communications	–	+	–
Airports, sea and river ports	basic state topographic map		
Land cover and soils	+	–	–
Land plots	+	–	–
Registers of streets and addresses of objects	+	–	–
Geographical names	state register of geographical names		
Digital terrain model	digital terrain model		
Orthophoto plans	orthophoto plans/maps		
Thematic data (as example)			
Hydrography. Water bodies (inland sea waters and territorial sea, rivers, streams, lakes, reservoirs, ponds, canals, aquifers), swamps, catchment basins	–	–	+
Buildings of aquaculture. Meliorative systems, greenhouses	–	–	+

Source: own study.

services) regarding the state monitoring of surface water, which is open to users, as of March 2023, was used to make management decisions (Derzhvodahentstvo, 2020).

The data set contains primary information (observation data) for monitoring. The data are presented in terms of monitoring posts and search dates.

The set includes 16 key monitoring indicators regarding the chemical composition of water, biochemical and chemical oxygen demand, the presence of synthetic surface-active substances etc. Observation data for a certain period are displayed in the table. The authors modelled a surface water quality map of Ukraine as of March 2023 based on open data from the State Agency for Water Resources (Ukr: Derzhavne ahenstvo z vodnykh resursiv), and created an ArcGIS dashboards control panel based on it (Fig. 3).

The chart is configured so that the *Y*-axis displays three chemical indicators of water quality: chemical oxygen demand (*COD*), biochemical oxygen demand in 5 days (*BOD*5), and dissolved oxygen (*DO*). The results of the water quality monitoring analysis are presented on Figure 4.

COD – the amount of oxygen required for the chemical oxidation of inorganic and organic substances. A sharp increase in *COD* of water indicates pollution of the reservoir. The quantity of *COD* is an important hygienic characteristic of water, which allows judging the contamination of water with oxidised substances but does not provide information about the composition of pollution. *BOD* is the amount of oxygen used for biochemical oxidation by a unit volume of water at a given temperature during a certain time. *BOD* is an indicator of the degree of organic pollution of water. Dissolved oxygen is the amount of oxygen dissolved in a water stream, river, or lake, and is an indicator of health and the ability to maintain a balanced aquatic ecosystem.

The given example illustrates the possibilities of open data use for interested persons. They on their own can select the necessary data and analyse them to solve concrete applied tasks and model the situation.

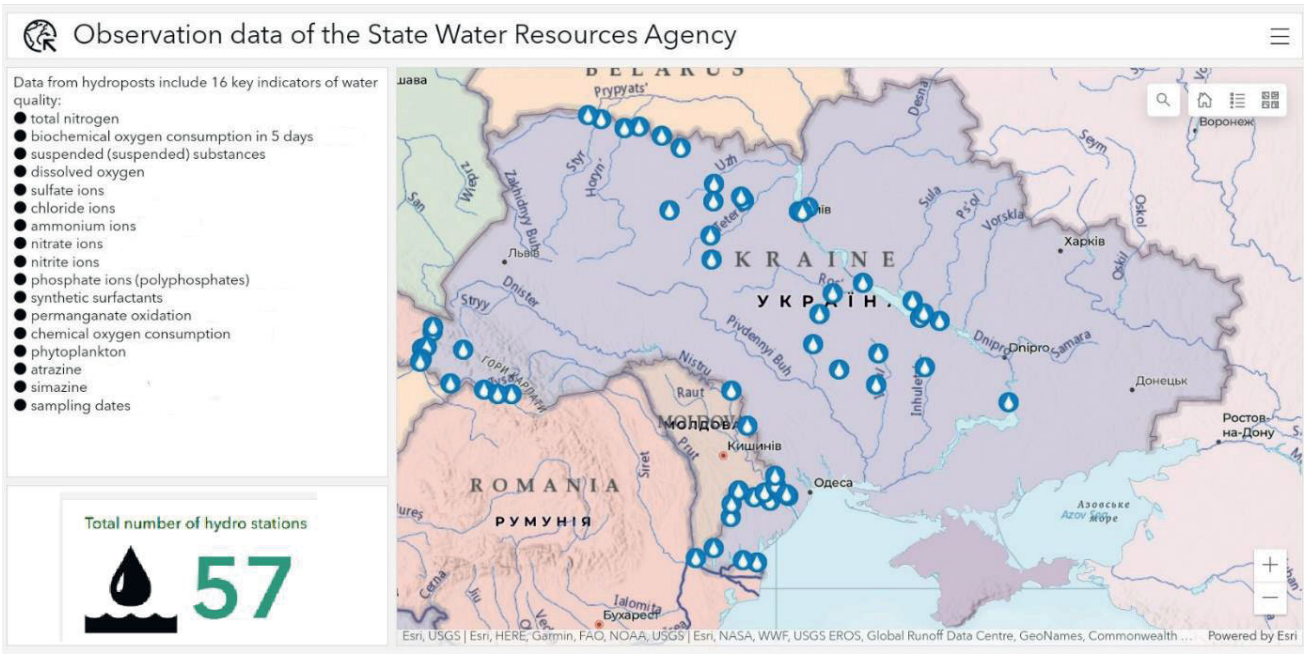

Fig. 3. Surface water quality map of Ukraine; source: own elaboration based on data from State Agency for Water Resources

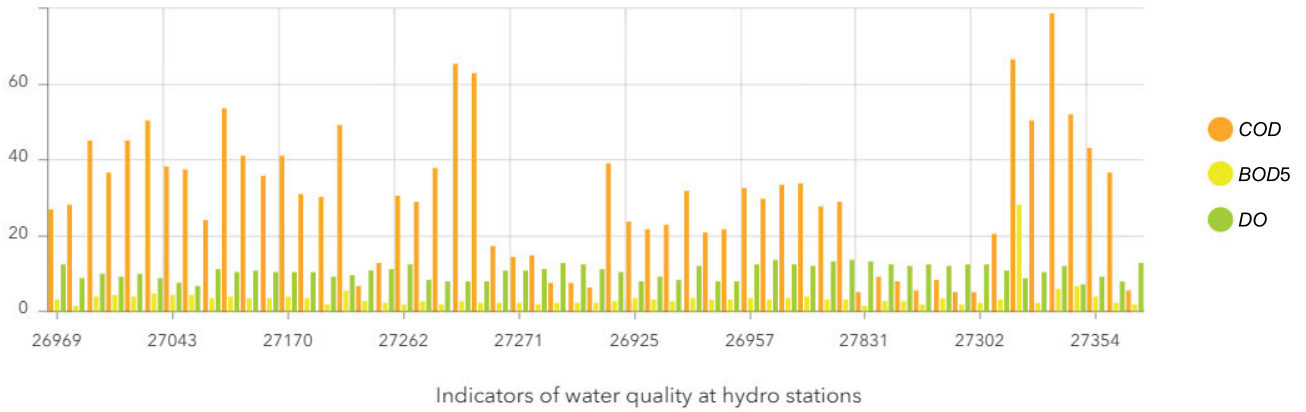

Fig. 4. Analysis of chemical indicators of water quality; *COD* = chemical oxygen demand, *BOD*5 = biochemical oxygen demand in 5 days, *DO* = dissolved oxygen; source: own study

CONCLUSIONS

Open state information systems and technologies are modern mechanisms of data collection, processing, analysis and publication for transparent, democratic, effective land resources management. The main objects of state information systems are land/water/forest resources, soils, other natural resources, animals and plants. The main participants in the process of ensuring effective land management are land owners/users, governments and municipal authorities, business entities, and non-governmental groups. The availability of complete open data regarding land and other natural resources provides the possibility of informed decision-making while ensuring effective land management in general and individual land plots in particular.

CONFLICT OF INTERESTS

All authors declare that they have no conflicts of interests.

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