Application of Systems Analysis in Monitoring the State of Land and Water Resources: Innovative Approaches

Sevda Jafarova
Department of Ecology and Nature Protection
Ganja State University
ORCID: 0009-0002-5587-8681
ceferovasevda1971@gmail.com

Annotation: This article is about new ways of tracking land and water resources using systems approach. The major technologies used are Geographic Information Systems (GIS), Remote Sensing (RS), Artificial Intelligence (AI) and Unmanned Aerial Vehicles (UAVs). These methods offer accurate data collection, analysis and presentation to help with the early detection of degradation, change prediction and the development of sustainable management plans for natural resources. This paper also focuses much on the integration of data from different sources to establish complex monitoring systems. Positive examples of technology application are also presented, such as the monitoring of coastal erosion and the current state of water bodies. The article highlights the necessity of an interdisciplinary approach, timely updates, and the application of new technologies to guarantee the protection of natural resources for the long term, which is crucial for sustainable development and environmental harmony.

Keywords: UAV, GIS, integration, monitoring, resources.

Introduction

On this day, when every possible aspect of our daily lives is concerned with the conservation and rational use of natural resources, land and water resources on which society is built are being urbanized, polluted and subjected to climate change, creating a dangerous problem for their sustainable management [2, p. 45–52]. New opportunities in ecosystem monitoring are opened up by systems analysis, the combination of geographic information systems (GIS), Earth remote sensing (ERS), artificial intelligence (AI) and unmanned aerial vehicles (UAVs). These technologies assist in capturing

the current state of natural objects, their changes, and the measures that can be taken for their conservation [1, p. 3–10].

- **Problem Statement**

Land and water resources, which form the foundation of human society, are increasingly threatened by urbanization, pollution, and climate change. These factors lead to ecosystem degradation, declining soil fertility, and deteriorating water quality, complicating their sustainable management and casting doubt on the prospects for long-term development.

Traditional monitoring methods often fall short—they fail to detect changes promptly or predict potential risks. The lack of data integration, low measurement accuracy, and insufficient adaptability to modern challenges slow down decision-making and hinder the development of effective, long-term strategies.

Addressing this issue requires a unified approach: the application of systems analysis and the integration of advanced technologies such as Geographic Information Systems (GIS), remote sensing, artificial intelligence (AI), and unmanned aerial vehicles (UAVs). However, the effective use of these methods demands interdisciplinary collaboration, continuous data updates, and innovative processing techniques.

The challenge lies in creating comprehensive monitoring systems capable of identifying changes early, predicting threats, and enabling informed decision-making to preserve natural resources in the face of modern environmental challenges.

- **Geographic Information Systems (GIS) and Remote Sensing**

GIS is a key tool for monitoring land and water resources [1, p. 3–10]. They provide for the collection, storage, analysis, and visualization of spatial data, integrating cartographic materials, remote sensing data, field research, and statistics. It helps in the analysis of the Earth’s surface and identification of the ecosystems’ latent patterns. Remote sensing provides accurate data on the state of the earth's surface [1, p. 3–10]. Modern remote sensing technologies provide satellite images for monitoring landscapes, vegetation, and water bodies. Application of remote sensing data in GIS enhances the speed of data collection and analysis of environmental processes. For example, monitoring of the Novosibirsk reservoir with geomonitoring has revealed the places of the coastal erosion and has put forth the

suggestions for strengthening of measures to prevent degradation of coast. AI powered information systems [3, p. 70–84] are used for predicting water quality, detecting pollution [4, p. 120–130], and environmental monitoring using UAVs. Autonomous UAVs increase the accuracy of tasks and reduce dependence on humans.

- **Unmanned aerial vehicles (UAVs) in monitoring**

An innovative approach to monitoring the state of land and water resources is the use of unmanned aerial vehicles (UAVs) [4, p. 120–130]. They are particularly useful for getting highly detailed images of areas or territories that are difficult to access or are large. The state of vegetation can be assessed, changes in the landscape can be detected and the state of water bodies can be monitored [1, p. 3–10]. The use of AI in the control of UAVs enables automation of the process of data collection and processing. Some of the applications of computer vision include object and anomaly detection, and use of machine learning algorithms to analyze the information received [4, p. 120–130]. Such integration increases the accuracy of monitoring and allows for a prompt response to identified problems.

- **Data integration and systems approach**

A key element of effective monitoring is the integration of various data sources into a single system. System analysis is a tool that helps in identifying the interconnections among the different components of the ecosystems leading to a more accurate assessment of the state of resources and the development of effective measures for their conservation and restoration [3, p. 70–84]. For example, the combined use of remote sensing data and GIS functionality enables prediction of the possible ways of degradation processes of reclaimed lands and the justification of the need to design new and reconstruct existing reclamation systems. This paper demonstrates how integration of data from various sources such as GIS, Remote Sensing, AI and UAVs is useful in developing complex monitoring systems that can give a complete analysis of the state of land and water resources. It therefore facilitates informed management decisions and development of strategies for sustainable development of territories [5]. The application of a systems approach to the monitoring of natural resources requires interdisciplinary cooperation and continuous data updating. Only the integrated use of modern technologies and methods will ensure the effective management and preservation of the environment for future generations [5].

Conclusion

Systems analysis in land and water monitoring has become a key tool for sustainable environmental management. The integration of technologies such as GIS, Remote Sensing, Artificial Intelligence and

Drones is to enable early identification of problems, forecasting of changes and informed decision making. These innovative approaches provide a comprehensive analysis of ecosystems, which helps in formulating strategies for their conservation and restoration. Some of the successful applications include monitoring of coastal erosion or water quality prediction because they display the effectiveness of these methods. In order to solve current problems and also to create the foundations for long-term resource management to ensure harmonious human-environment interaction, data integration and interdisciplinary collaboration are possible.

References

1. **Romanyuk Yu.A., Fazilova R.B.**Application of space imagery data for monitoring reservoirs in the Republic of Uzbekistan // Theory and practice of modern science. - 2024. - No. 12 (114). - P. 3-10.
2. **Fomin A.A., Mamontova I.Yu.**The state of land and water resources of the planet and methods of sustainable agriculture // Bulletin of the State University of Land Management. - 2023. - Vol. 58, No. 1. - P. 45-52.
3. **Potapov V.P., Schastlivtsev E.L., Yukina N.I., Bykov A.A., Kharlampenkov I.E.**Information and computing system for monitoring water resources // Mining information and analytical bulletin. - 2021. - No. 7. - P. 70-84.
4. **Ivanov P.P., Smirnova L.K.**Application of artificial intelligence for monitoring the ecological state of water resources // Economy and management: problems, solutions. - 2024. - Vol. 10, No. 12. - P. 120-130.
5. **FAO.**The state of the world's land and water resources for food and agriculture. Managing systems at risk.