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ENVIRONMENTAL MONITORING AND DECISION-MAKING SYSTEM BASED ON ARTIFICIAL INTELLIGENCE AND DIGITAL PLATFORMS

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Abstract. This article explores the development of environmental monitoring systems and decision-making processes based on artificial intelligence and digital platforms. The study analyzes the capabilities of real-time environmental monitoring, big data processing, and predictive analytics. Special attention is given to the use of artificial intelligence technologies for early detection of environmental risks, efficient resource management, and ensuring sustainable development. Digital platforms are considered essential tools for data integration, information exchange, and rapid decision-making. The findings contribute to improving environmental management systems and enhancing their overall efficiency.

Keywords: artificial intelligence, digital platforms, environmental monitoring, decision-making, big data, predictive analytics, sustainable development, digital governance, environmental safety.

Annotatsiya. Mazkur maqolada sun'iy intellekt va raqamli platformalar asosida ekologik monitoring tizimlarini shakllantirish hamda ular orqali samarali qaror qabul qilish jarayonlarini takomillashtirish masalalari yoritiladi. Tadqiqotda atrof-muhit holatini real vaqt rejimida kuzatish, katta hajmdagi ma'lumotlarni qayta ishlash va prognozlash imkoniyatlari tahlil qilinadi. Shuningdek, sun'iy intellekt texnologiyalaridan foydalanish orqali ekologik xavflarni erta aniqlash, resurslardan samarali foydalanish va barqaror rivojlanishni ta'minlash yo'llari asoslab beriladi. Raqamli platformalar esa ma'lumotlar almashinuvi, monitoring natijalarini integratsiyalash hamda boshqaruv qarorlarini tezkor qabul qilishda muhim vosita sifatida ko'rib chiqiladi. Tadqiqot natijalari ekologik boshqaruv tizimlarini modernizatsiya qilish va ularning samaradorligini oshirishga xizmat qiladi.

Kalit so'zlar: sun'iy intellekt, raqamli platformalar, ekologik monitoring, qaror qabul qilish, katta ma'lumotlar (Big Data), prognozlash, barqaror rivojlanish, raqamli boshqaruv, ekologik xavfsizlik.

Аннотация. В данной статье рассматриваются вопросы формирования систем экологического мониторинга и принятия решений на основе искусственного интеллекта и цифровых платформ. В исследовании анализируются возможности мониторинга состояния окружающей среды в режиме реального времени, обработки больших данных и прогнозирования экологических процессов. Особое внимание уделяется использованию технологий искусственного интеллекта для раннего выявления экологических рисков, повышения эффективности использования ресурсов и обеспечения устойчивого развития. Цифровые платформы рассматриваются как инструмент интеграции данных, обмена информацией и оперативного принятия управленческих решений. Полученные результаты способствуют совершенствованию систем экологического управления и повышению их эффективности.

Ключевые слова: искусственный интеллект, цифровые платформы, экологический мониторинг, принятие решений, большие данные, прогнозирование, устойчивое развитие, цифровое управление, экологическая безопасность.

INTRODUCTION

In recent years, the increasing relevance of environmental problems on a global scale—particularly climate change, air and water pollution, and the reduction of biodiversity—has intensified the need for effective environmental management. It is observed that traditional monitoring and management approaches do not always provide sufficient efficiency in addressing these complex and rapidly evolving processes. Therefore, the modernization of environmental monitoring systems and the scientific improvement of decision-making processes have become one of the most pressing areas of research.

The rapid development of modern information and communication technologies, especially the widespread

implementation of artificial intelligence and digital platforms, is elevating environmental management systems to a new level. Artificial intelligence technologies enable the rapid analysis of large volumes of data, modeling of complex environmental processes, and forecasting of potential outcomes. This plays a crucial role in early detection of environmental risks, efficient use of resources, and making well-informed management decisions.

Digital platforms, in turn, provide the capability to integrate data from various sources, unify them into a single system, and conduct real-time monitoring. Through such platforms, information exchange among government bodies, scientific institutions, and the private sector becomes more active, thereby enhancing overall management efficiency. In particular, digital platforms integrated with IoT (Internet of Things) devices, remote sensing technologies, and geographic information systems allow for more accurate and оперативный экологический мониторинг.

At the same time, the application of artificial intelligence in environmental monitoring and decision-making requires not only technological advancements but also institutional and organizational approaches. Factors such as data quality, reliability, information security, and the adequacy of the regulatory framework directly influence the effectiveness of these systems.

The purpose of this study is to examine the theoretical and practical aspects of improving environmental monitoring and decision-making systems based on artificial intelligence and digital platforms. Within the framework of the research, the role of modern technologies in environmental management, their advantages, and application possibilities are analyzed, and scientific and practical recommendations for forming an effective management system are developed.

The relevance of this topic lies in the fact that, under conditions of digital transformation, the development of environmental monitoring systems based on artificial intelligence is one of the key factors in ensuring sustainable development. The results of this research contribute to improving the efficiency of environmental management and optimizing decision-making processes.

LITERATURE REVIEW

In recent years, the digitalization of environmental monitoring and decision-making systems has become one of the key areas of scientific research. In particular, reports developed by the United Nations Environment Programme (UNEP) recognize digital technologies and artificial intelligence as major factors enhancing the effectiveness of environmental management [1]. UNEP studies emphasize that real-time monitoring and data integration play a crucial role in reducing environmental risks.

The issue of sustainable development is also supported by the Sustainable Development Goals (SDGs) adopted by the United Nations, which serve as an important theoretical foundation. These documents highlight the use of modern technologies, including artificial intelligence and digital platforms, as effective tools for addressing environmental challenges [2].

The role of artificial intelligence in environmental monitoring has been extensively studied by the World Bank and the Organisation for Economic Co-operation and Development (OECD). Their research indicates that the application of AI in processing large volumes of data, forecasting, and risk assessment significantly improves the efficiency of environmental management [3–4]. In particular, the ability to predict environmental processes using Big Data and analytical models is considered a major advantage.

The importance of digital platforms in environmental monitoring systems is also widely discussed in the studies of the European Environment Agency. These reports demonstrate that integrating geographic information systems (GIS), remote sensing, and Internet of Things (IoT) technologies enables accurate and real-time environmental monitoring [5]. Digital platforms consolidate data from multiple sources into a unified system, thereby optimizing the decision-making process.

Scientific research on AI-based decision-making systems has extensively explored the use of algorithmic models, machine learning, and neural networks. These technologies are highly valued for their accuracy and efficiency in modeling and forecasting environmental processes [6]. At the same time, some studies highlight challenges related to data quality, algorithm transparency, and ethical considerations [7].

At the national level, issues related to the digitalization of environmental monitoring and the use of artificial intelligence are also gaining increasing importance. In Uzbekistan, several programs have been implemented to modernize environmental management systems, introduce digital platforms, and strengthen environmental monitoring [8]. These studies emphasize the role of modern technologies in ensuring environmental safety and efficient resource utilization.

Overall, the analysis of existing literature indicates that the integration of artificial intelligence and digital platforms in environmental monitoring and decision-making systems has not yet been sufficiently studied in a comprehensive manner. In particular, there is a need for in-depth research on the interaction of these technologies and their impact on management efficiency.

RESEARCH METHODOLOGY

In this study, a comprehensive methodological approach was applied to evaluate the effectiveness of environmental monitoring and decision-making systems based on artificial intelligence and digital platforms. The research methodology is grounded in a combination of theoretical and empirical methods and incorporates systemic, functional, and integrative approaches.

The theoretical foundation of the study is based on the concepts of the digital economy, principles of sustainable development, and the practical application of artificial intelligence technologies. In particular, the approaches to digital transformation of environmental management proposed by the United Nations Environment Programme, as well as the principles for the use of artificial intelligence developed by the Organisation for Economic Co-operation and Development, served as the methodological basis.

The empirical base of the study consists of data from the World Bank, the United Nations, and the European Environment Agency, as well as national statistical sources and environmental monitoring results. Based on these data, the environmental condition and the effectiveness of decision-making processes were analyzed.

In addition, a system of indicators was developed to assess the effectiveness of environmental monitoring and decision-making. This system includes the following key indicators: data accuracy, decision-making speed, the level of environmental risk reduction, resource use efficiency, and the adaptability of the management system.

As limitations of the study, issues such as the insufficient development of digital infrastructure in certain regions, as well as challenges related to data quality and accessibility, were identified. Nevertheless, the applied methodology enables a comprehensive evaluation of environmental monitoring and decision-making systems and allows for the development of scientifically grounded conclusions aimed at their improvement.

This methodological approach ensures the reliability of the research results and contributes to the development of practical recommendations for the digital transformation of environmental management systems and their improvement based on artificial intelligence.

ANALYSIS AND RESULTS

In the context of the digital economy, the implementation of environmental monitoring systems based on artificial intelligence (AI) and digital platforms is of critical importance for effectively managing environmental challenges and ensuring sustainable development. These systems enable scientifically grounded decision-making by collecting, processing, and analyzing data in real time.

The essence of this system lies in continuous monitoring of environmental processes, integration of data within digital platforms, and forecasting through artificial intelligence algorithms, which significantly enhances management efficiency. Compared to traditional monitoring approaches, this method is distinguished by its higher speed and accuracy.

Artificial intelligence serves as the primary analytical tool within environmental monitoring systems. Through AI, large volumes of data (Big Data) are processed to generate forecasts of environmental conditions, identify potentially hazardous trends, and develop optimal management decisions. This contributes to ensuring environmental safety and promoting the rational use of natural resources.

Digital platforms, in turn, create a unified information environment for the collection, storage, and exchange of environmental data. These platforms facilitate interaction among government bodies, business entities, and the public, thereby increasing the transparency and efficiency of the management system. As a result, decision-making processes become faster, more accurate, and well-grounded.

In Uzbekistan, the public-private partnership (PPP) mechanism has entered an active development phase following the adoption of the Law “On Public-Private Partnership” in 2019. Through this mechanism, major projects have been successfully implemented in sectors such as infrastructure, energy, healthcare, and transportation. Specialized agencies and project offices have been established to manage PPP projects, ensuring effective investment management and monitoring.

Environmental monitoring systems based on artificial intelligence and digital platforms are emerging as important tools for improving management efficiency, reducing environmental risks, and achieving sustainable development goals (Figure 1).

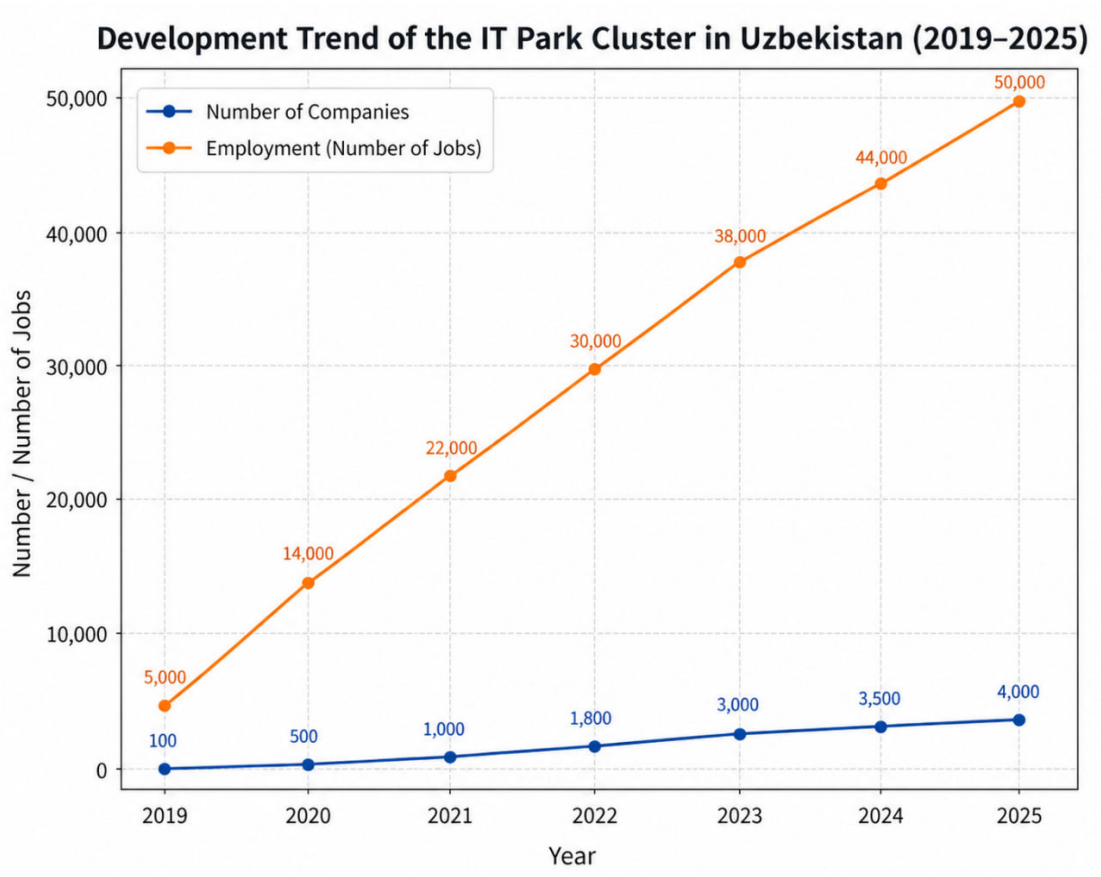

Figure 1. The impact of IT Park cluster development on employment in Uzbekistan (2019–2025)[1]

The figure illustrates the dynamics of employment growth resulting from the development of the IT Park cluster in Uzbekistan. According to the graphical data, employment in the IT sector was approximately 5 thousand jobs in 2019, while by 2023 this figure had reached 38 thousand. During this period, the increase in the number of companies from 100 to 3,000 had a direct and significant impact on employment growth. This indicates that the IT Park cluster is emerging as an important driver in the economy, generating new jobs with high value added.

For the period 2023–2025, employment is projected to grow from 38 thousand to 50 thousand jobs, which can be explained by the expansion of IT clusters and the deepening of the digital economy. At the same time, it is observed that the growth rate of employment exceeds the growth rate of the number of companies, indicating an increase in the average number of jobs per enterprise. As a result, the IT Park cluster not only contributes to the growth in the number of entities but also strengthens employment efficiency through the expansion of existing companies.

The analysis shows that the development of the IT Park cluster is one of the innovative and sustainable sources of employment growth in Uzbekistan. In particular, jobs created within the digital economy not only attract highly qualified specialists but also play an important role in ensuring youth employment. In the future, expanding IT clusters will become one of the strategic directions for increasing employment, promoting economic growth, and developing human capital.

Empirical evidence also indicates that public-private partnerships (PPP) and cluster mechanisms have become important instruments for improving management efficiency in Uzbekistan. While large-scale infrastructure and investment projects are being consistently implemented through PPP, the cluster system contributes to accelerating production and innovation activities. The integration of these mechanisms creates a foundation for forming a comprehensive management model that ensures economic growth, environmental sustainability, and institutional development (Table 1).

1 Author's development

Table 1

Indicators of Improving Management Efficiency in Uzbekistan through PPP and Cluster Mechanisms (Based on Real Data)[2]

No.	Area	Indicator	Actual Data (Figures)	Analysis (Scientific Interpretation)
1	PPP	Legal Framework	2019 – Law on PPP	The PPP system has gained an institutional foundation
2	PPP	Investment Volume	$1.6 billion in 2023	Private sector participation is increasing
3	PPP	Projected Volume	2025–2030: $30+ billion	PPP has become a strategic investment instrument
4	PPP	Number of Projects	6 major projects in 2023	Large-scale infrastructure projects are expanding
5	PPP	Sector Coverage	Energy, transport, healthcare	Multi-sector management efficiency is improving
6	Cluster	IT Park Companies	2,800+ residents	An innovative ecosystem has been established
7	Cluster	Employment	38,600 jobs	Social efficiency is increasing
8	Cluster	Export Geography	90 countries	Global integration has strengthened
9	Cluster	Sector Coverage	Agriculture, industry, IT	Systematic economic development is observed
10	Integration	PPP + Cluster Impact	Investment + innovation synergy	Management efficiency significantly improves

The table presents the development indicators of PPP and cluster mechanisms in Uzbekistan based on real data, comprehensively illustrating their impact on the management system. The provided figures confirm the economic and institutional significance of these mechanisms and demonstrate their practical effectiveness.

With the help of artificial intelligence (AI) and IoT technologies, environmental indicators are monitored in real time. This enables prompt control over key parameters such as air pollution, the condition of water resources, and waste volumes. Within this system, decision-making is carried out based on a data-driven approach. Various scenarios are generated using AI algorithms, and the most optimal option is selected among them.

A monitoring system based on AI and digital platforms significantly improves management efficiency. This is because decisions are made quickly, accurately, and on a scientific basis, which expands opportunities for the rational use of resources. At the same time, such a system contributes to the early detection and prevention of environmental problems. As a result, waste volumes are reduced, carbon emissions are effectively controlled, and the level of environmental protection increases.

At the regional level, AI-based monitoring systems provide local authorities with accurate and timely information. This enables the development of more well-grounded regional development strategies and their effective implementation.

This system also plays an important role in long-term strategic planning and accelerates the transition to a green economy. As a result, it enhances the ability to ensure a balance between economic growth and environmental sustainability (Table 2).

Table 2

Structural Elements and Effectiveness of Environmental Monitoring Systems Based on Artificial Intelligence and Digital Platforms[3]

No.	AI Technology	Digital Platform (Infrastructure)	Result (Effectiveness)
1	Machine Learning (ML)	Big Data platforms	Improved accuracy of environmental forecasting
2	Deep Learning	Cloud systems	Rapid processing of large-scale data
3	Computer Vision	Video monitoring systems	Detection of air and water pollution
4	AI Analytics	Environmental dashboards	Real-time analysis and visualization

2 Author's development
3 Author's development

5	Predictive AI	GIS (Geographic Information Systems)	Early identification of environmental risks
6	IoT + AI integration	Sensor networks	Real-time monitoring systems
7	NLP (Natural Language Processing)	E-government platforms	Analysis of public requests and feedback
8	Expert Systems	Decision Support Systems (DSS)	Optimal management decisions
9	AI Simulation	Digital Twin platforms	Modeling of environmental scenarios
10	Autonomous AI	Smart city platforms	Automated environmental management

The table systematically illustrates the interrelationship between artificial intelligence technologies and digital platforms within the environmental monitoring system. Each AI technology operates in integration with a specific digital platform, contributing to the enhancement of environmental management efficiency.

The analysis indicates that the integration of AI and digital platforms elevates environmental monitoring systems to a qualitatively new level. As a result, it expands the possibilities for real-time monitoring, accurate forecasting, and optimal decision-making. This becomes a key factor in improving management efficiency within the context of a green economy.

The AIMI model represents an integrated mathematical framework designed to evaluate the effectiveness of environmental monitoring based on artificial intelligence and digital platforms. This model combines real-time monitoring, forecasting, and optimal decision-making processes, thereby significantly improving management efficiency (Table 3).

Table 3

System of Indicators and Weight Coefficients for the AIMI (AI Monitoring Index) Model[4]

No.	Component (Index)	Notation	Key Indicators	Weight (w_i)
1	Machine Learning Efficiency	ML	Forecast accuracy, model training quality	0.12
2	Deep Learning	DL	Speed of large-scale data processing	0.10
3	Computer Vision	CV	Monitoring accuracy (air, water)	0.10
4	Predictive Analytics	PA	Level of environmental forecasting	0.12
5	IoT Integration	IoT	Real-time monitoring through sensors	0.14
6	NLP Technology	NLP	Analysis of public requests	0.08
7	Expert Systems	ES	Quality of decision-making	0.10
8	Digital Twin	DT	Level of environmental modeling	0.12
9	Smart Automation	SA	Level of automation	0.12
	TOTAL			1.00

The table systematically reflects the key components of the AIMI model and clearly demonstrates the role of artificial intelligence technologies within the environmental monitoring system. The highest weight assigned to the IoT component (0.14) indicates that ensuring real-time monitoring is one of the most critical elements of this system.

The analysis shows that the AIMI model enables a comprehensive evaluation of artificial intelligence technologies. This system of weights contributes to improving the effectiveness of environmental monitoring, strengthening real-time control, and providing a scientific basis for management decisions. As a result, the accuracy, responsiveness, and overall efficiency of the environmental management system are significantly enhanced.

4 Author's development

CONCLUSION AND RECOMMENDATIONS

The results of this study demonstrate that the implementation of environmental monitoring and decision-making systems based on artificial intelligence and digital platforms represents one of the most effective directions in modern environmental management. Compared to traditional monitoring approaches, this method enables real-time data collection, processing, and analysis, thereby ensuring accurate and timely assessment of environmental conditions.

The use of artificial intelligence technologies expands the possibilities for forecasting based on large-scale data, early identification of environmental risks, and their prevention. This enhances the scientific validity of management decisions and contributes to the efficient use of resources as well as the strengthening of environmental safety.

Digital platforms, in turn, improve management efficiency by integrating data from multiple sources into a unified system and enabling rapid information exchange among stakeholders. In particular, systems integrated with IoT, GIS, and remote sensing technologies elevate environmental monitoring to a more advanced level.

The study also reveals that the integration of artificial intelligence and digital platforms significantly increases the accuracy, responsiveness, and adaptability of environmental monitoring systems. This, in turn, optimizes decision-making processes and enhances the ability to effectively address environmental challenges.

At the same time, the research identifies the need to improve data quality, technological infrastructure, human capital, and the regulatory framework when implementing such systems. Taking these factors into account, the digital transformation of environmental management systems requires a comprehensive and systematic approach.

In general, the development of environmental monitoring and decision-making systems based on artificial intelligence and digital platforms is a key factor in ensuring sustainable development, reducing environmental risks, and improving management efficiency. Therefore, the widespread adoption of innovative technologies, deepening of scientific research, and improvement of practical mechanisms in this field remain highly relevant priorities.

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