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AI and Public Administration at Environmental Protection: Modern Innovations for Sustainable Community Development

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Abstract **Review Article**

The article examines the essence of the categories of 'artificial intelligence', 'public administration' and 'balanced community development' in the context of environmental protection. The potential of using innovative artificial intelligence technologies to optimise environmental management processes at the local and national levels is considered. The author analyses modern digital tools that help to increase the efficiency of management decision-making, monitor environmental indicators and ensure transparency of interaction between environmental authorities and public environmental NGOs. Particular attention is paid to examples of the implementation of AI solutions in the field of environmental protection in public administration, as well as to the challenges arising in the processes of digital transformation of the environmental sector. The author concludes that an integrated approach to the implementation of artificial intelligence as a tool to support the balanced development of communities, taking into account environmental, social and economic factors, is necessary.

Keywords: Artificial Intelligence, Public Administration, Environmental Protection, Digital Technologies, Environmental Policy, Sustainable Community Development, Environmental Monitoring, Digital Transformation.

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INTRODUCTION

In today's environment of global environmental challenges and rapid development of digital technologies, there is an urgent need to find effective public administration tools that can ensure the balanced development of communities with due regard for environmental safety. Artificial intelligence (AI) may become one of these tools, opening up new opportunities for collecting, analysing and interpreting environmental data, predicting risks, optimising resources and supporting management decisions based on large amounts of environmental information. However, despite the rapid development of AI in various fields, its integration into the system of public environmental management remains fragmented and insufficiently researched, especially in Ukraine. The relevance of the problem is due to the need to develop effective approaches to the digitalisation of management processes, taking into account both technical and social aspects, including transparency, public access to information, and building trust in decisions made on the basis of data processing results by digital decision support systems. Thus, studying the potential of AI in the field of public environmental management is an important scientific and practical task that is in line with current trends in sustainable development.

Purpose of the Article

The purpose of the article is to study the potential of artificial intelligence in the system of public administration of the environmental sector to ensure the balanced development of communities. Achieving this goal involves theoretical substantiation and practical generalisation of modern innovative approaches to the digitalisation of the environmental sector, taking into account global and national experience. To achieve this goal, the following main tasks have been identified within the scope of this study:

- to analyse the current state and trends in the use of artificial intelligence mechanisms in environmental management at different levels - global, national and local;
- assess the benefits and risks of implementing AI solutions in public environmental management processes, in particular in the context of transparency, efficiency and public participation;

- to justify the feasibility of integrating intelligent systems into the practice of strategic planning and environmental monitoring;

- to formulate recommendations on the areas of application of AI as a tool for achieving sustainable development goals by territorial communities in Ukraine.

MATERIALS AND METHODS

The study combines various research methods. This approach was used to process data from national open data portals, government reports and international analytical publications, as well as to obtain data based on thematic content analysis of scientific sources. In addition, quantitative and qualitative indicators in the form of numerical and textual data presented in the paper were collected through online surveys of citizens, representatives of the expert community and civil servants. This study consists of the following stages: an overview, collection of empirical data, development of recommendations, and verification of the results, which allows us to speak about the reproducibility of the study's findings.

Analysis of Recent Research and Publications

The use of artificial intelligence mechanisms in environmental, socio-economic, military and defence, scientific, educational and other areas has been addressed by such Ukrainian researchers as S. Vorobiov, Y. Zaitsev, S. Kvitka, N. Novichenko, O. Bardakh, T. Tarasevych, H. Tatarenko and others.

The theoretical basis of the study is the fundamental and applied research works of A. Turing, P. Norvig, W. Wang, C. Xiayi, D. West, and J. Allen.

At the same time, a comprehensive approach to the integration of artificial intelligence mechanisms into the system of public administration of environmental protection activities at the community level remains insufficiently developed, which makes further research in this area relevant.

RESULTS AND DISCUSSION

In the XXI century, the transformation of public administration is associated with the need to respond to global challenges, among which environmental threats are among the leading ones, as the issue of a clean and safe environment for human life and health is extraterritorial and cross-border. Pollution and degradation of natural resources, climate change and other environmental problems require new, more effective governance mechanisms from the authorities that can ensure a balance of environmental, social and economic interests [1, P.149]. In this context, artificial intelligence (AI) is emerging as a tool not only for the digital transformation of the public sector, but also as a lever for improving the efficiency of management decisions in the field of environmental protection.

Artificial intelligence in the broadest sense is the ability of computer systems to reproduce the functions of human intelligence: perception, learning, decision-making, and adaptation to new circumstances. In the field of public administration, AI can be used for big data analysis, forecasting, automated decision-making, and identifying patterns in complex processes [2, P.74]. In the environmental sector, such capabilities are particularly valuable, as they allow working with data from sensors, satellites, environmental monitoring, meteorological services, as well as data coming from public initiatives or mobile applications created through C2G interaction [3, P.86].

Leading foreign researchers point to the significant potential of AI in the environmental sector. Thus, P. Norvig in his works repeatedly emphasises that intelligent systems are capable of analysing climate change, assessing the risks of natural disasters, and optimising environmental management [4, P.152]. D. Berg, in turn, considers AI as a mechanism for improving data-driven decision-making, which is especially important in the rapidly changing environment of environmental resource management [5]. D. Allen proposed a deep learning model for predicting local environmental changes that takes into account both anthropogenic and natural factors [6]. The results of such studies serve as a theoretical basis for the practical implementation of AI systems in public environmental management around the world.

In the Ukrainian scientific space, the issue of integrating AI into environmental protection is considered mainly through the prism of digitalisation of the state and society. For example, the introduction of AI technologies at the community level can become the basis for a fundamental change in management approaches, which today are limited to responding to certain environmental problems. Instead, AI mechanisms in environmental protection open up new opportunities for preventing environmental challenges and threats, thanks to the ability to quickly process large amounts of environmental data, analytics and forecasting.

Y. Zaitsev emphasises the importance of creating hybrid digital platforms that combine machine learning algorithms, elements of open governance and public involvement in decision making. Such approaches are especially important in the context of decentralisation, when a large amount of authority for the protection, conservation and reproduction of natural resources is transferred to the local level [7, P.233].

At the same time, we cannot ignore the risks and challenges that accompany the process of digital transformation of environmental management. In particular, T. Pshenychna emphasises the danger of a situation where an algorithm makes a decision without the user being able to understand its logic or mechanism of functioning [8, P.33]. This creates additional ethical challenges, especially in situations where the results of such decisions have an impact on citizens' rights, access to natural resources or spatial development of territories.

According to M. Barun, the effectiveness of AI implementation in management processes largely depends on regulatory and legal support [9, P.65]. In Ukraine, there is a fragmentation of legal regulation in the field of digital tools for environmental monitoring, which complicates the

legitimate and systematic use of AI algorithms at the municipal level. In addition, the issue of protecting personal data that can be used in environmental analysis remains open.

The works of K. Desyuz are also important for understanding the role of AI in the public administration system. The author emphasises the need to adapt governmental structures to the digital age, to form new institutional models of governance - from centralised to decentralised, data-driven [10, P.101]. His model envisages the creation of open, flexible and technologically equipped systems of interaction with citizens, which is especially relevant for public administration in the field of ecology and environmental protection at the local level.

H. Tatarenko studies the specifics of implementing digital ecosystems in communities facing environmental challenges, such as emissions from industrial enterprises or unauthorised landfills [11, P.10]. In view of the above, we emphasise that artificial intelligence-based platforms can become an effective tool for detecting violations of environmental legislation, promptly responding to citizen complaints, and formulating local environmental development plans not only for authorities but also for public environmental organisations.

Such approaches are also supported by S. Kvitka, N. Novichenko and others, who emphasise the role of civic initiatives, environmental volunteer movements and local start-ups in the development of ecosystem digital solutions [12, P.77]. The authors note that community involvement in the processes of collecting, processing and interpreting environmental data contributes to building trust in innovative tools and enhances the responsibility of public authorities.

Summarising the above, it can be concluded that the integration of AI mechanisms into public environmental management systems is interdisciplinary in nature and involves the study of a wide range of interactions between technological, legal, organisational and social components. An important role in this process is played by the concept of sustainable development, which considers environmental safety and efficient environmental management as the basis for community well-being. In this context, AI is not only a technical tool, but also an element of a new management culture - a culture of openness, data-driven, inclusive and long-term perspective.

The effective application of artificial intelligence technologies in public environmental management requires a profound rethinking of both the technological and managerial paradigms. Modern artificial intelligence systems are capable of not only processing large amounts of data, but also automatically detecting patterns that cannot be identified using traditional analysis. This is especially important in the environmental context, where data comes from a variety of sources: satellite monitoring, ground-based sensors, public observations, open environmental portals, and mobile applications.

In our opinion, one of the most promising areas may be the use of AI to detect changes in landscapes, predict environmental risks and identify points of potential environmental hazard. For example, the use of neural networks to detect negative phenomena in the field of land use, such as soil depletion and degradation, based on high-resolution satellite imagery, creates new opportunities for local authorities, land management and design organisations, as it allows them to timely identify and respond to negative processes that previously remained invisible until they became critical.

Equally important may be the use of digital AI tools to support the decision-making processes of local governments. Due to their ability to analyse data in real time, these tools are able to assess the level of air and water pollution, noise pollution and other environmental parameters, automatically offering optimal management solutions in accordance with the set criteria, taking into account not only actual quantitative environmental indicators, but also building predictive models in terms of social change, which allows for the creation of an integrated model of sustainable community development.

At the local government level, the introduction of AI is particularly relevant in the context of the development of smart communities. This approach involves the creation of ecosystems where digital technologies are used to improve the quality of life of residents, optimise public services, reduce emissions, and manage resources efficiently.

In practical terms, Ukraine is already piloting a number of projects to introduce AI into environmental management.

For example, Ukrainian scientists have developed an online system called Deep Green Ukraine to detect illegal logging. The system uses satellite and radar imagery, as well as artificial intelligence algorithms to timely detect and respond to deforestation. The pilot project is being tested in Kyiv, Lviv, Zakarpattia, and Odesa regions [13].

The Hydrometeorological Institute of Ukraine, in cooperation with IBM Research and Texas Agrilife Research, has introduced two online platforms that allow for drought forecasting, water management and statistics on Ukrainian agriculture. These tools help farmers, environmental experts, and local authorities make objective decisions to protect agriculture and water resources [14].

At the same time, we agree with the opinion of A. Matseruk, who notes that at present, the issue of innovative application of artificial intelligence in the context of sustainable community development is still under development, which necessitates further theoretical and empirical research in this area, in particular, the analysis of innovative ways and options for the use of artificial intelligence to ensure sustainable community development [15, P.116].

Therefore, it seems appropriate to consider the following related scientific problem, which is the lack of a clear methodology for integrating AI into the management processes of local authorities. This issue is especially relevant for the local level, as self-government bodies are often unable, and even unwilling, to adapt internal processes to new, innovative tools, including digital tools based on the use of AI models. This applies to both staff who do not have a sufficient level of digital competence

and institutional structures that are not ready for flexible and rapid change. An additional challenge is posed by a bureaucratic culture dominated by administrative rather than analytical thinking. This phenomenon has been described in the scientific literature as "technological inertia", which manifests itself in the inability to introduce innovative practices into management structures due to traditional resistance to change as a result of the existence of established practices, low levels of digital competence of staff, and limited financial and organisational resources.

An equally important aspect of the use of artificial intelligence by local governments to achieve the goals of sustainable community development is to build trust in digital intelligent systems among local residents, which requires the creation of an ethical framework for their operation. This requires constructive interaction with citizens and local environmental NGOs.

Open environmental data plays a special role in shaping the new governance model. The principles of openness and transparency enshrined in international documents, such as the Aarhus Convention [16], provide for public access to information on the state of the environment. In this case, AI algorithms can not only facilitate access to such data, but also automate the processes of structuring it, visualise models, and provide a high-quality interpretation of the analytical data obtained.

AI can also serve as an analytical tool for adapting environmental policies to climate change. Predictive AI models that use climate and hydrological data can predict scenarios of flooding, forest fires, droughts, and other risks. As a result, local governments can develop mitigation and adaptation strategies in advance.

Alongside this, AI can also be used as a mechanism to combat corruption in the environmental sector. Automated algorithms are able to quickly analyse public procurement, emission permits, and environmental assessments, identifying suspicious actions, which allows not only to detect violations but also to create preconditions for preventing corruption by automating the processes of such ongoing monitoring.

Equally important is the prospect of using AI in environmental education and raising environmental awareness. Interactive systems, chatbots, augmented reality, personalised recommendations on environmental behaviour - all of these can form a new type of human relationship with the environment. For example, S. Vorobyov points to the potential of gaming platforms that model the consequences of various decisions for the ecosystem and help citizens understand the importance of environmental choices [17].

Thus, the effective use of AI in public environmental management requires a comprehensive approach: technological, institutional, legal, ethical, and social. Artificial intelligence has the potential to become a key element in transforming environmental policy, shaping a new management culture, and ensuring the achievement of sustainable development goals at the community level.

Successful implementation of artificial intelligence (AI) technologies in the environmental sector requires not only appropriate technical infrastructure, but also a strategic vision on the part of public authorities focused on the long term. The basis for such transformations can be the creation of an adaptive communication environment (digital ecosystem) to ensure the inter-integration of digital innovations with national, regional and local environmental policies.

For Ukraine, it is extremely important to create an environmental data ecosystem that integrates not only official data but also public monitoring data, satellite imagery from international projects, and other available research data. In this context, machine learning algorithms will be able to process multidimensional data sets, identify correlations, and create predictive models. For example, AI models will be able to detect patterns in the spread of invasive species, allowing local authorities to respond quickly to potential threats.

Separately, we believe it is advisable to pay attention to the role and place in the field of public environmental management of the concept of "Participatory AI", which is the involvement of citizens in decision-making processes using artificial intelligence. In particular, within the framework of Citizen Science models, citizens can collect environmental data (e.g., through mobile applications or sensors), which are processed by AI systems and used to generate analytical reports. This approach not only ensures transparency, but also stimulates citizens' social responsibility on environmental issues [18].

It is also worth paying attention to the adaptability of AI models to local ecosystems, as universal algorithms that work well in large urbanised regions may be ineffective in sparsely populated areas due to differences in data structure and the dynamics of natural processes. This means that the issue of creating specialised models that take into account regional features of the landscape, climate, anthropogenic pressure, etc. is becoming more relevant.

We should not ignore the issue of power consumption of artificial intelligence models' hardware, as complex machine learning systems, especially those related to processing satellite images or video streams, require significant computing resources, which may create a certain environmental dilemma regarding the feasibility of using AI to protect the environment, as it entails an increase in electricity consumption. In addition, in the context of Russia's unprovoked aggression against Ukraine and, as a result, constant missile attacks on local energy facilities, the above problem is significantly exacerbated. However, to solve it, it is possible to adapt the concept of "Green AI" to modern realities, which aims to minimise the carbon footprint of digital technologies through the use of energy-efficient algorithms and renewable energy sources (wind, solar power plants, etc.) to provide computing power.

Alongside this, AI systems can perform an auxiliary function in disaster management, assessing the risks of floods, forest fires, droughts, or landslides in advance. An example is Japan's early warning system, which has been operating for a long time, but today analyses seismic activity and predicts earthquakes with a high level of accuracy using AI, allowing for timely evacuation of the population [19]. Similar algorithms can be adapted to Ukrainian realities, in particular, such tools

can be extremely useful in the Carpathian region or probable flood zones in southern Ukraine.

Given the analysis, it can be concluded that the application of modern AI models in public environmental management has an extremely wide scope for implementation - from data analytics and climate change forecasting to citizen engagement and the development of ethical environmental standards. In our opinion, Ukraine has all the prerequisites for the active integration of AI into the natural sector management system, but this process should be based on an interdisciplinary approach, balanced planning, and constant adaptation to technological changes and changes in the dynamic environment.

International support and cooperation can play a significant role in the above integration process, as leading environmental institutions in the European Union and the United States are already actively using change detection algorithms to respond quickly to forest fires, flooding, illegal development of coastal zones and other environmental problems and violations of environmental legislation. Therefore, with their considerable practical experience and relevant expertise, international partners will be able to help with the high-quality organisational and technological implementation of these innovations.

Thus, the use of AI technologies in the field of public environmental management opens up completely new opportunities for prompt, large-scale and objective monitoring of the environment, and in combination with a deep institutional management reform, these technologies can become the basis for a global, fundamental environmental transformation of Ukraine.

CONCLUSIONS

This study has shown that AI is increasingly being integrated into the public administration system, particularly in the environmental sector. The results of the analysis demonstrate the high potential of these technologies in environmental monitoring, forecasting environmental risks, managing natural resources, and shaping environmental policy at both the local and national levels.

The use of machine learning methods based on environmental data, satellite image analysis and the implementation of management decision support systems, together, can improve the efficiency and accuracy of responding to the challenges of climate change, environmental pollution and ecosystem degradation.

At the same time, a number of problems that need to be addressed urgently have been identified and highlighted within the scope of this topic. In particular, these are ethical issues (transparency of algorithms, protection of personal data, etc.), insufficient institutional capacity of local governments, and a limited level of digital literacy of both public officials and the population.

Special attention should be paid to the issue of harmonisation of legal and regulatory frameworks in the field of artificial intelligence, which is a key to creating a secure technological environment.

In view of the above, we see prospects for further research in an in-depth study of the applied use of AI mechanisms in the environmental sector, the development of recommendations for the creation of transparent decision-making mechanisms focused on sustainable community development, as well as a more thorough analysis of the phenomenon of "technological inertia" described in this paper, which negatively affects the processes of introducing innovations to ensure the balanced development of territorial communities in Ukraine.

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