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Concept, Principles and Tasks of Artificial Intelligence in Environmental Law

Abstract: This article examines the legal aspects of using artificial intelligence in environmental law and its areas. The principles and tasks of artificial intelligence for improving the environmental protection system are analysed, as well as the opportunities and benefits that can be obtained with the help of artificial intelligence in climate change, energy, biodiversity protection, waste management, etc. The study object is the social relations connected with using artificial intelligence in environmental protection and sustainable development. The study subject is international and European legislation that regulates the use of artificial intelligence in environmental relations. The study aims to analyse artificial intelligence's concepts, principles and tasks in environmental law. To implement the study, the ideas of foreign scientists were analyzed, namely Nehwal Ch., Piyselman M., Lytvynets V., Gomez Ch., Lhoumeau S., Pinelo J., Borges P., who considered individual aspects of the use of artificial intelligence in environmental protection and agriculture. It was determined that the EU has already developed strategies related to the need to use artificial intelligence, particularly to implement the environmental goals of the EU climate policy. The study concluded that it is necessary to develop legal and ethical principles for using artificial intelligence in environmental law.

Keywords: environmental policy, climate change, emissions monitoring, sustainable development, artificial intelligence.

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Поняття, принципи та завдання штучного інтелекту в екологічному праві

Анотація. У даній статті досліджено правові аспекти використання штучного інтелекту в екологічному праві та окремих його сферах. Проаналізовано принципи та завдання штучного інтелекту для покращення системи охорони навколишнього середовища, а також можливості та переваги, які можна отримати за допомогою штучного інтелекту, в сфері зміни клімату, енергетики, охорони біорізноманіття, управління відходами тощо. Об'єктом дослідження є суспільні відносини, які пов'язані з використанням штучного інтелекту у сфері охорони навколишнього середовища і сталого розвитку. Предметом дослідження є міжнародне та європейське законодавство, яке регулює питання використання штучного інтелекту в галузі екологічних відносин. Метою дослідження є проведення аналізу поняття, принципів та завдань

штучного інтелекту в екологічному праві. Для реалізації дослідження проаналізовано ідеї зарубіжних вчених, а саме Нехвал Ч., Пійсельман М., Литвинець В., Гомес Ч., Луме С., Пінело Х., Боргес П., які розглядали окремі аспекти використання штучного інтелекту в сфері охорони довкілля та сільського господарства. Визначено, що в ЄС вже розроблено стратегії, що стосуються необхідності використання штучного інтелекту, зокрема, для реалізації екологічних цілей кліматичної політики ЄС. В ході дослідження зроблено висновок про необхідність розробки правових та етичних принципів використання штучного інтелекту в галузі екологічного права.

Ключові слова: екологічна політика, зміна клімату, моніторинг викидів, сталий розвиток, штучний інтелект.

Abbreviations:

AI is artificial intelligence,

CODES is Coalition for Digital Environmental Sustainability,

GRI is Global Reporting Initiative,

IMEO is International Methane Emissions Observatory,

IoT is Internet of Things.

Introduction

The 21st-century global environmental challenges have highlighted the importance of artificial intelligence as a necessary condition for humanity's continued existence and for finding the most optimal ways to solve ecological problems.

Today, we can observe how artificial intelligence permeates the core spheres of human life: transport, energy, education, construction, and others. With the emergence of AI, human life has become simpler, allowing time and resources to be saved. At the same time, the application of AI in addressing environmental protection issues requires particular attention.

The study object is the social relations connected with using artificial intelligence in environmental protection and sustainable development.

The study subject is international and European legislation that regulates the use of artificial intelligence in environmental relations.

The study aims to analyse artificial intelligence's concepts, principles, and objectives in environmental law based on the analysis of European legal acts and international principles and standards for using AI in key ecological sectors.

In the study, general scientific and specialised legal methods of cognition were applied. The principal method used was the dialectical method, which enabled an analysis of the main aspects of developing artificial intelligence in environmental law. The formal logical method was employed to clarify the content of certain scientific concepts and notions (such as sustainable development, artificial intelligence, and ecological resilience). A comparative legal method was used to analyse the provisions of international treaties and European legal instruments regulating relations in the sphere of AI use in environmental law.

An analysis of recent research indicates the development of artificial intelligence technologies in various areas of environmental protection.

As noted in the works of Indian scholar Chaudhary Nehwal, particularly active research is being conducted into AI-based systems for environmental forecasting and monitoring of climate change, with the aim of adaptation and mitigation.

Foreign publications also discuss the application of AI technologies to address global environmental challenges such as climate change, energy security, and biodiversity conservation. For instance, M. Pieselman and V. Lytvynets have explored the ecological impact of artificial intelligence, legal frameworks, and approaches that support achieving AI's ecological sustainability.

Special mention should be made of the work of international scholars who investigate the use of AI in agricultural activities. For example, Ch. Gomes and J. Matushika examined the potential and benefits of using chatbots and neural networks to improve farm management systems.

Thus, we shall focus specifically on the issue of using artificial intelligence in certain areas of environmental protection that require particular attention.

Results

General Trends in the Use of Artificial Intelligence in Environmental Law

In recent years, AI has become a significant breakthrough across various areas of life, impacting both our daily activities and industry. Its practical application has become essential in many sectors requiring rapid and accurate analysis of large volumes of data, decision-making, and the resolution of complex problems (*Fox, 2024a*).

Climate change is causing various adverse consequences, such as global warming, rising sea levels, and biodiversity loss. In response, national and international authorities are adopting environmental programmes to tackle climate change and adapt to its effects. At the same time, modern technologies, particularly artificial intelligence programmes, are gradually being introduced as part of the strategy to manage climate change.

AI technologies offer considerable potential as tools for informed decision-making. AI can detect insights and patterns in unstructured data (e.g., data generated from videos, images, and social media) and combine computing power to solve complex problems.

AI applications, such as energy forecasting, smart grids, and climate change modelling, hold significant promise for managing adaptation processes. For instance, AI-powered autonomous vehicles could reduce greenhouse gas emissions by 50% by 2050, thanks to their ability to determine the most efficient routes. AI technology can also be used effectively in agriculture to increase crop yields. For example, farmers growing peanuts in India have improved their harvests by 30% through artificial intelligence (*Newal, 2023, p. 392*).

It is important to note that these technologies raise important legal and ethical questions that must be addressed. AI-driven data analysis can help identify areas affected by deforestation. It can also monitor emissions accurately and assess whether companies meet their primary pollutant emission targets.

Furthermore, AI can be deployed to develop innovative climate policies and address other environmental challenges—e.g., by creating predictive models that forecast the impact of climate change on ecosystems and inform conservation efforts. AI may become a vital tool in

environmental monitoring, enabling faster and more accurate environmental data analysis, identifying ecological risks and hazards, and detecting environmental violations.

European companies are actively implementing AI systems and technologies that are required to report greenhouse gas emissions in line with directive requirements. These innovative AI-based programmes assist in analysing and exchanging environmental data, including risk management and strategic planning. Similarly, the GRI provides a standardised framework for reporting on a broad range of topics within environmental reporting—including greenhouse gas emissions, occupational health and safety, human rights, and community impacts—thus improving transparency and governance practices worldwide (*Pijselman & Litvinets, 2024*).

The EU has already adopted the Artificial Intelligence Act (*Regulation EU, 2024*), which addresses sustainability issues related to AI development, training, and use. The methodology for assessing AI's environmental sustainability will be clarified separately by the AI Office and individual Member States through future codes of conduct and harmonised standards.

Meanwhile, the scientific framework of the National Institute of Standards and Technology includes environmental impact assessment and the management of model training practices. It focuses on establishing measurable baseline indicators of sustainability and assessing the reliability of AI systems by documenting key performance indicators such as resource usage and carbon footprint. While the new rules and standards aim to mitigate AI's environmental impact, they lack clarity on how to measure and allocate energy consumption within the complex AI ecosystem involving multiple stakeholders.

Thanks to the integration of AI into satellite systems, it will be possible to track changes in various agricultural sectors such as land use, crop production, and forestry. The use of AI in agriculture will allow for the early detection of plant diseases and associated issues. In our view, AI can be harnessed in agriculture to mitigate environmental risks arising from unsustainable agricultural practices, such as excessive pesticide use or uncontrolled irrigation that leads to fertiliser pollution. Examples of AI use in agriculture include farmer-support chatbots, intelligent systems for monitoring and protecting plant growth, and automated irrigation systems. Modern technologies enable achieving higher yields and transforming farms into environmentally safe and economically viable enterprises (*Gomes & Matushika, 2022, p. 12*).

Features of Using Artificial Intelligence Technologies in Certain Areas of Environmental Law

Artificial Intelligence and Climate Change

Artificial intelligence and emerging technologies are crucial for accelerating the implementation of the *2030 Agenda for Sustainable Development* (General Assembly, 2015), playing a key role in climate action, energy efficiency, green networks, and the circular economy. There is an urgent need for consistent governance of AI and other digital technologies by bringing together diverse stakeholder groups and experts. To address this challenge, the *CODES* is promoting a global movement for digital sustainability and advocating policies such as the *Global Digital Compact*, which is set to be signed by UN Member States at the forthcoming *Summit of the Future*. This event will engage participants in dialogue around the principle of environmental sustainability in the Global Digital Compact, including priorities, next steps for implementation,

and actions to promote the environmental sustainability of artificial intelligence (*UN Future Summit, 2024*).

One of the UNEP-led initiatives within the *WESR* digital ecosystem is the *IMEO*, which uses AI to monitor and reduce emissions. This platform functions as a global public database of empirically verified methane emissions. IMEO technology enables the collection and integration of diverse data streams on methane emissions to create a global inventory with high accuracy and detail. Reducing methane emissions in the energy sector is one of the most efficient and cost-effective ways to mitigate climate change and achieve significant emission reductions (*How artificial…, 2022*).

Climate change presents a grave challenge, as it can lead to consequences such as droughts, wildfires, floods, and rising sea levels. These effects may become dangerous for humanity if global temperatures rise by 1.5–2.0°C, as outlined in the *Paris Agreement* (UN, 2015). Should climate change continue or be insufficiently mitigated, the global average temperature may reach 3°C by 2100.

AI-based programmes can support various climate mitigation and adaptation efforts. The EU's climate strategy sets out the goal of achieving climate neutrality by 2050 and reducing emissions by at least 55% by 2030 compared to pre-industrial levels. Accordingly, one of the top priorities of current European climate policy is the shift towards low-carbon development and economic decarbonisation.

In 2021, the European Commission adopted the new EU strategy *Forging a Climate-Resilient Europe* (*Forging…, 2021*), outlining the key directions of EU climate policy in mitigation and adaptation. This strategy aims to realise a vision of a climate-resilient Union by 2050 by making adaptation smarter, more systemic, and faster while intensifying international action. Adaptation measures will extend to every local authority, business, and household, aiming to involve all stakeholders.

It is important to note that science-based solutions can facilitate decision-making and action in climate uncertainty. We must develop effective and inclusive governance mechanisms that foster dialogue between policymakers and scientists, for instance, through the *European Climate Change Adaptation Conference*. We should promote using advanced digital technologies and climate services to support decision-making (e.g., remote sensing, smart weather stations, artificial intelligence). New tools such as *Destination Earth* and *Digital Twins* promise to enhance our understanding of present and future climate impacts at both global and local levels.

Monitoring, reporting, and evaluation are essential for establishing a reliable baseline to track progress in adaptation. Member States are developing climate adaptation plans by integrating them into their energy and climate policy frameworks. A key objective of these plans is to ensure the adaptation of European energy systems to climate change. Special attention must be paid to vulnerable areas, including river basins, mountainous regions, islands, and the most remote regions, which are particularly susceptible to the impacts of climate change.

AI-based adaptation measures should be implemented in energy efficiency, agriculture, and water management programmes. Artificial intelligence enables forecasting weather changes, which in turn allows for improved planning of agricultural activities, including the control and protection of crops from droughts and cold spells.

In conclusion, using AI offers broad opportunities for developing and planning climate change mitigation and adaptation measures through specialised AI-driven programmes and their integration into business operations.

Artificial Intelligence and Biodiversity Conservation

Intelligent systems can assess the environmental sustainability of various projects and develop strategies for biodiversity conservation. They can analyse diverse data on species and ecosystems, which helps to make informed decisions and ensure the preservation of life's diversity on the planet. Artificial intelligence holds great potential for species conservation and for addressing the planet's environmental challenges. Innovative AI-based technologies can assist ecologists and scientists in studying and monitoring various animal and plant species.

Forecasting biodiversity patterns and trends is a highly complex task that fundamentally depends on its variability. Long-term monitoring programmes are indispensable tools for tracking and observing changes in biodiversity over time. They can reveal ecological dynamics such as population cycles or responses to climate change. We believe the information gathered during monitoring is vital for developing effective biodiversity conservation strategies. Artificial intelligence technologies can be applied as a basis for ecological modelling and forecasting (*Lhoumeau et al., 2025*).

Neural networks are a promising modelling tool for studying complex temporal data. Due to the universal approximation theorem, they can approximate—i.e., simplify—any function. This makes it easier to identify species and analyse ecological interactions between them.

Artificial intelligence automates the processes of collecting and analysing data on various species. This significantly speeds up the work of experts and enables the collection of more information on species at risk of extinction. AI technologies can also be used to forecast environmental changes and detect patterns indicating threats to biodiversity. Through machine learning algorithms, AI can identify changes in ecosystems and provide timely alerts.

In addition, artificial intelligence contributes to developing new methods for nature conservation and restoring degraded ecosystems. By analysing vast amounts of data, AI can suggest practical approaches for restoring natural habitats and forests and propose innovative solutions for conserving rare plant and animal species. Thus, artificial intelligence, in combination with ecology, can become a powerful tool for species preservation. This technology will reduce the impact of human activity on the environment and ensure sustainable development (*Fox, 2024b*).

Artificial Intelligence and Waste Management

To regulate legal matters concerning waste management in the European Union, Directive 2008/98/EC is applied (*Directive…, 2008*). According to the Directive, the core principles of European waste management policy include pollution prevention, extended producer responsibility, recycling, and secondary processing. The European policy is focused on reducing waste generation and implementing recycling technologies.

The application of AI in waste management encompasses several modern trends. This involves using machine learning algorithms for waste sorting to classify and separate recyclable materials to reduce pollution during the recycling process. AI technologies are also used to

optimise collection routes, resulting in more efficient resource allocation and collection procedures. In addition, AI-based robotics are being introduced to enhance the efficiency of waste processing, particularly during sorting (*Revolutionizing…, 2024*).

AI also plays a vital role in waste recycling by optimising various stages of the recycling process. AI-driven identification and sorting technologies enable the accurate detection and separation of recyclable materials, thereby contributing to resource recovery and reducing pollution from waste. AI-based quality control and inspection systems ensure the production of high-quality recycled materials by detecting defects, contamination, and inconsistencies. Furthermore, robotics and automation of recycling processes guided by AI optimise recycling operations, thus improving their overall efficiency.

Waste monitoring is another area for AI technology applications. Real-time monitoring systems integrated with IoT devices and sensor networks collect and analyse waste generation, collection, and disposal data. AI algorithms analyse and process this data, providing valuable insights for optimising recycling and disposal operations. This enables real-time forecasting of waste generation patterns, optimisation of resource distribution, and data-driven decision-making in waste management.

What AI technologies are used in the waste management sector? The primary AI methods widely applied in waste management include collection, sorting, recycling, and planning. Key methods in the field include linear regression, support vector machines, decision trees, and artificial neural networks (*Olawade et al., 2024, p. 250*).

Recently, supervised machine learning algorithms have gained popularity due to their relevance for analysing large volumes of data. These algorithms identify and sort waste by type, determine bin fill levels, optimise collection routes, and more. These technologies employ advanced sensors, such as X-ray fluorescence, to analyse waste's physical and chemical properties. AI algorithms then process the data obtained to determine the material composition and sort the waste accordingly. Current trends in automated sorting technologies focus on integrating machine learning methods, such as deep learning and neural networks, to identify and sort a wide range of waste, including plastics, metals, paper, glass, and organic matter.

Applying AI technologies in waste management requires ethical considerations and responsible approaches. AI-driven decision-making must be accurate and transparent to avoid errors and unintended outcomes. Efforts are ongoing to establish ethical practices and guidelines for optimal AI-based waste-handling decision-making. Continuous research and collaboration are crucial for further enhancing AI algorithms and developing ethical principles ensuring fair waste management outcomes.

Developing legal frameworks and industry standards is essential to ensure AI's responsible and ethical use in waste management. Legislation should address key concerns such as data privacy, security, fairness, and transparency. Governments and regulatory bodies should lead the development and adoption of regulations that balance innovation needs with protecting ethical principles and societal values.

The regulatory framework must adapt to evolving AI technologies, ensuring they foster innovation while promoting public welfare and environmental sustainability. As AI advances, governments and regulators must remain proactive in updating legislation and standards to address emerging risks and opportunities in AI-powered waste management.

Discussion

Further areas of research into the application of artificial intelligence in environmental law may include the development and analysis of ethical and legal principles governing the use of AI, which is currently a highly relevant issue. The use of "smart technologies" necessitates the adoption of digital codes of conduct and standards for the safe use of data. Another debated issue is the principle of the environmental sustainability of artificial intelligence, which requires detailed study and analysis in terms of introducing innovations into environmental decision-making processes.

Conclusion

This study has provided an in-depth analysis of how artificial intelligence can significantly contribute to ensuring environmental sustainability in such critical areas as climate change and energy, agriculture, waste management, and biodiversity conservation. As we have seen, monitoring plays a significant role in harnessing the potential of artificial intelligence and advancing environmental sustainability. In particular, we have examined the capabilities of AI in monitoring greenhouse gas emissions to improve environmental reporting and forecasting systems, as well as its application in waste management monitoring, which offers several advantages for waste sorting and recycling.

Future research must focus on specific issues related to AI technologies and the effectiveness of their implementation to achieve environmental sustainability and fully harness artificial intelligence's benefits for present and future generations. The actual value of AI in the environmental field lies in its ability to support more accurate and sustainable environmental decision-making. We can conclude that AI offers benefits such as improved environmental governance, optimisation of environmental performance in production and agriculture, reduction of environmental risks, and a general decrease in pollution.

Conflict of interest

The author declares that there is no conflict of interest.

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