The Application of Artificial Intelligence in Environmental Protection

Hayat GHELLAI*
University of Mostaganem, Algeria
Hayat.ghellai@univ-mosta.dz

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Abstract: With environmental challenges worsening and pressure on natural resources increasing, artificial intelligence has become one of the most important tools for managing environmental crises and achieving sustainable development.

In this context, AI stands out as a smart solution for monitoring environmental and climate change, predicting natural disasters, and improving energy and water management, making it an essential component in building a more sustainable future.

However, there is currently widespread debate about the environmental impacts of AI technology itself, in terms of how to store the enormous amount of data and the amount of natural resources consumed (water, energy, materials, etc.). All of this may require further scrutiny and research.

Keywords: artificial intelligence, environment, protection, technology, application.

***Corresponding author: Hayat GHELLAI**

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Introduction:

Environmental protection issues occupy a prominent place in contemporary global debates, with environmental challenges ranging from water pollution to biodiversity loss and climate change. In this context, artificial intelligence (AI) emerges as a key tool that enhances the effectiveness of efforts to protect the environment.

Artificial intelligence provides advanced technologies that enable the analysis of vast amounts of data and environmental patterns, contributing to better and more informed decisions on sustainability issues. Artificial intelligence contributes to the implementation of more sustainable environmental policies by improving our understanding of the impact of human activities on ecosystems. For example, AI-based environmental quality monitoring systems are capable of monitoring pollution levels in real time, enabling stakeholders to take immediate action to limit environmental damage in addition [1] .

The use of modern technologies in the field of the environment is an urgent necessity for achieving sustainable development, especially in light of accelerating climate change and increasing environmental threats. It is clear that artificial intelligence is not just a technical tool, but represents a comprehensive revolution in how we understand and interact with the environment. Integrating these technologies into environmental protection strategies enhances communities' ability to respond to environmental challenges, ensuring the continuity of ecosystems and the health of the planet for future generations.

Environmental protection is one of the most important issues facing humanity in the modern era, as the environment forms the basis for all forms of life. Environmental balance is essential for the continuation of life on Earth, as it contributes to providing the natural resources necessary for human survival and preserving the ecological systems that support biodiversity [2].

Climate change contributes to increasing the difficulties faced by many ecosystems, forcing human societies to reevaluate their practices and their impact on the environment as a whole. The importance of protecting the environment lies in the fact that it is a strategic necessity to protect biodiversity and ensure the sustainability of natural resources for future generations. Preserving different species of living organisms is a guarantee of a healthy and safe life, as biodiversity contributes to enhancing environmental resilience and resistance to negative environmental changes. In addition, a clean environment is a fundamental factor [3].

The question arises: how can artificial intelligence be applied to protect the environment?

To answer this question, we decided to divide our study into two sections. The first section focuses on artificial intelligence technology and the environment, while the second section discusses future trends in artificial intelligence in environmental protection.

TITLE 1 : Artificial intelligence technology and the environment.

Artificial intelligence technology is one of the most significant technological developments contributing to addressing multiple issues, particularly those related to environmental protection. Artificial intelligence reflects a set of systems and applications that can learn from data and perform complex analyses, enabling it to predict patterns and discover

[1] Fouad Ben Ghadban, Cities of Knowledge and Smart Cities, Dar Safaa Publishing and Distribution, Amman, Jordan, p. 215, 2017.

[2] Osama Salem, Artificial Intelligence and Water and Climate Issues, Artaq Publishing and Distribution, Vol. 1, 2013, Egypt, p. 2.

[3] Halim Hermouzi – Omar Bouzid Mohamed, The Contribution of Artificial Intelligence to Water Security: The Experience of the United Arab Emirates, Namaa Magazine for Economics and Trade, Volume 2, Issue 1, United Arab Emirates, 2012, p. 621.

environmental trends that may be hidden from traditional methods. This contributes to accurate analyses that help policymakers and urban planners make informed decisions [4].

Artificial intelligence is used in various fields related to environmental protection, including wildlife monitoring, climate change data analysis, and waste management. For example, deep neural networks are used to classify plant and animal species based on images, contributing to conservation efforts. In addition, machine learning models are used to predict extreme weather events, enabling preparedness and mitigation. In waste management, smart applications can use data to improve recycling processes .

It should be emphasized that the effective application of AI technology requires its integration with local and global ecosystems and regulations. Enhancing the technical skills of individuals and institutions is a vital step, as is emphasizing the importance of transparency and ethics in the use of this technology. Despite potential obstacles, Investing in artificial intelligence is a vital tool and can have significant positive impacts on the environmental future, reshaping how society interacts with current environmental challenges. The sustainable integration of these technologies enhances our ability to address global environmental challenges and is a key element in achieving sustainable development [5].

First Subtitle : Artificial intelligence applications in the field of the environment.

Artificial intelligence has many applications in the field of the environment, providing advanced tools for environmental data analysis, environmental monitoring systems, and natural resource management. In the context of environmental data analysis, artificial intelligence is used to extract patterns and insights from vast amounts of environmental data, such as air and water quality measurements and temperature readings. Through machine learning techniques, researchers can develop models that predict climate change or environmental disasters, leading to improved environmental response and planning. These processes help facilitate data-driven decision-making, resulting in more effective strategies for addressing environmental challenges.

With regard to environmental monitoring systems, artificial intelligence technologies are a vital tool for enhancing the ability of scientists and local authorities to monitor various environmental activities. This includes the development of systems that use drones and smart sensors to collect and analyze data in real time. These systems enable the monitoring of emissions, tracking of biodiversity, and prediction of changes in the ecosystem, thereby contributing to raising awareness of and protecting the surrounding environment. For example, these technologies are used to monitor forests in order to detect fires at an early stage, thereby reducing the resulting damage [6].

Natural resource management relies on artificial intelligence applications to provide effective and sustainable solutions. Through artificial intelligence models, management is optimized, such as water use technologies in agriculture that rely on climate and soil data analysis to determine optimal water requirements. Artificial intelligence is also used in fisheries management and sustainability by estimating allowable catch quantities and avoiding overfishing. By integrating these applications, it becomes possible to draw up comprehensive

[4] Osama Salem, op. cit., p. 43.
[5] Khalifi Abdelrazak, Artificial Intelligence Mechanisms for Analyzing and Disseminating Information on Food Security, Opportunities and Challenges, Ma'alim Journal of Global Studies and Communication, Volume 1, Issue 1, Algeria, 2010, p. 661.
[6] Karima Sultan, Agricultural Entrepreneurship in Southern Algeria and the Role of Artificial Intelligence Systems in its Development, Journal of Economics and Business Studies, Volume 9, Issue 1, Algeria, 2011, p. 921.

and effective plans that contribute to protecting the environment and ensuring the sustainable use of resources, which will have a positive impact on future generations.

1- Environmental data analysis:

Research in the field of artificial intelligence is increasingly turning toward environmental data analysis, as this analysis is considered the cornerstone for understanding environmental changes and the challenges facing planet Earth. Environmental data analysis involves the use of advanced techniques such as machine learning and deep learning. This helps extract patterns and trends from vast amounts of data collected from various sources such as satellites and ground-level sensors. These methods help accelerate the process of identifying environmental patterns, enabling researchers and decision-makers to take more effective measures to protect the environment.

Big data processing is used to analyze time series of environmental variables such as temperatures, air pollution levels, and precipitation rates. This data is extremely valuable, as it reveals the interrelationships between human activities and natural phenomena. By applying advanced algorithms, Accurate conclusions can be drawn that enhance understanding of how environmental changes affect biological systems. Furthermore, knowledge of historical patterns and statistical trends helps in developing predictive models that contribute to environmental crisis management and identifying areas most vulnerable to threats. Environmental data analysis also contributes to sustainability by providing evidence-based insights that support environmental policies [7].

Through data analysis, best practices can be identified and effective strategies developed to conserve natural resources and reduce risks. Collaboration between various stakeholders, including governments, the private sector, and civil society, also allows for the consolidation of efforts to achieve sustainable development. Therefore, environmental data analysis is a key enabler of innovations in artificial intelligence that seek to achieve a more sustainable and secure environment for future generations.

2- Environmental monitoring systems :

Data is collected from these devices and analyzed using advanced algorithms, enabling patterns and trends to be identified over a given period of time. The smart environmental monitoring process involves multiple steps, starting with data collection via various sensors, whether fixed in specific locations or mobile using drones or satellites. Artificial intelligence systems then process this data, using techniques such as predictive analytics and deep learning to analyze factors affecting the environment, monitor climate change phenomena, and provide accurate predictions about potential environmental risks. This approach represents a major shift in how environmental issues are managed, allowing stakeholders to respond more quickly and effectively to emerging environmental threats and contributing to the development of strategies to mitigate their negative impacts [8].

AI-powered environmental monitoring systems enable improved natural resource management by providing real-time information on resource availability and in-depth analysis. With this integrated view, local authorities and environmental agencies can make decisions based on accurate data, contributing to enhanced environmental sustainability and ecosystem protection [9].

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[7] Blasel Bent Nabi Yasmine, Amrouch Al-Hussein, Artificial Intelligence and Its Role in Achieving Sustainable Development, Journal of Legal and Economic Studies, Volume 6, Algeria, 2011, p. 6612.

[8] Badri Jamal, "Artificial Intelligence: A Search for a Legal Approach," Algerian Journal of Legal and Political Sciences, vol. 59, no. 4, Algeria, 2022, 177.

[9] Balasil bint al-Nabi Yasmin, Amrush al-Hussein, previous reference, p. 6615.

3- Natural resource management:

Natural resource management is a vital field that requires innovative solutions to address the growing challenges posed by environmental changes and population growth. The importance of artificial intelligence applications in this context is evident in their ability to improve resource efficiency and reduce waste. AI-based systems can analyze vast amounts of data related to water, soil, and biodiversity, contributing to informed decisions that support the sustainability of these resources. Through machine learning technologies, researchers can advance the development of predictive models that help understand the impact of human activities on the environment. For example, data analysis models are used to identify climate patterns and assess how they affect water resources, leading to the development of effective strategies to mitigate the effects of drought or flooding. Similarly, artificial intelligence tools enable better control of irrigation systems by predicting crop water needs, increasing water use efficiency and reducing waste [10] .

Second subtitle : Applications of artificial intelligence in sustainable agriculture.

Artificial intelligence applications in sustainable agriculture are among the leading topics representing the future of modern agriculture, as this technology contributes to enhancing agricultural production efficiency and reducing environmental impact. One of the most prominent areas of application for artificial intelligence is precision agriculture, a technological system that seeks to optimize the use of agricultural resources by integrating geographic and climatic data with multiple sensing technologies.

Automated data processing can provide detailed information about agricultural phenomena, enabling farmers to make informed decisions about farming techniques, such as determining the optimal amount of water and fertilizer to reduce waste and increase yields. In addition, artificial intelligence technologies play a crucial role in soil and water analysis. Machine learning models can be used to analyze data extracted from soil and water tests. These analyses provide deep insights into soil properties, such as pH, organic content, and nutrient levels, making it easier for farmers to develop appropriate agricultural strategies that help promote crop growth By combining modern technologies such as satellites and drones with big data analysis, farmers can effectively monitor their land, thereby reducing negative impacts on the environment and promoting sustainability. Thanks to these applications, the use of artificial intelligence is a strategic tool to help address the challenges posed by climate change and population growth[11].

1- Precision farming:

Precision agriculture is one of the most prominent practical applications of artificial intelligence in improving agricultural productivity and promoting environmental sustainability. Precision agriculture relies on the use of a range of advanced technologies, such as remote sensing, geographic information systems, and advanced sensors, which contribute to the collection and analysis of data related to agricultural resources. By analyzing this data, more accurate agricultural decisions can be made to ensure increased crop yields while reducing environmental impact.

AI-based systems can continuously monitor crop health and determine their water and fertilizer needs, helping to reduce the waste of natural resources. Investing in AI technologies for precision agriculture enhances farmers' ability to adapt to climate change. By analyzing

[10] Mohamed Dahmani, Uses of Artificial Intelligence in the Environmental Field, Journal of Environmental Law and Science, Volume 2, Issue 3, Algeria, 2023, p. 486.

[11] Tarek El Sayed, "The Role of Artificial Intelligence in Achieving Sustainable Development in Egypt," Al-Raya International Journal of Business Sciences, Issue 9, Volume 3, Egypt, 2024, p. 975.

climate data and weather forecasts, farmers can adjust their planting plans to meet anticipated challenges[12].

The benefits of precision agriculture go beyond the traditional boundaries of farming, leading to a better balance between meeting growing food needs and ensuring the sustainability of natural resources. Unlike traditional farming methods, which often lead to soil and water depletion, precision agriculture conserves the environment by improving resource use and reducing harmful practices. However, further research and development is needed to promote smart applications in agriculture, which will enable the full potential of artificial intelligence to be exploited in creating a sustainable and inclusive agricultural future[13].

2- Soil and water analysis:

Soil and water analysis technology is an essential part of AI applications in sustainable agriculture, as it effectively contributes to improving crop productivity and conserving environmental resources. Through the use of machine learning models, soil and water quality data can be accurately analyzed, enabling farmers to make decisions based on scientific information. Multiple data points are collected, including chemical composition and nutrition, as well as physical characteristics such as moisture and density. This data is analyzed using artificial intelligence algorithms to identify patterns and trends, providing comprehensive insight into the maintenance and management requirements for each crop type.

Remote sensing technologies are used to provide accurate information about environmental changes. This collected data, through artificial intelligence, helps develop predictive models that assist farmers in improving water and soil resource management. Smart systems can analyze variations in water and soil quality, leading to better allocation of fertilizers and pesticides and reducing water loss from inefficient irrigation.

In addition, AI systems conduct ongoing periodic assessments to ensure adaptation to climate change and its potential impacts on agricultural practices. AI-enhanced soil and water analysis mechanisms have a positive impact on environmental sustainability by reducing the identification of negative factors affecting productivity. When soil and water quality are assessed periodically and scientifically, opportunities for implementing effective and sustainable agricultural strategies increase. Therefore, the use of artificial intelligence in this context becomes a leading tool that contributes to enhancing food security and protecting the environment, which requires continuous research and development in this field to enhance sustainable agriculture capabilities [14].

TITLE 2 : Future trends in artificial intelligence in environmental protection.

Future trends in artificial intelligence in environmental protection are among the most prominent areas requiring sustainable innovation and strategic thinking. Artificial intelligence technologies are expected to increasingly contribute to addressing environmental issues by providing solutions based on accurate data and advanced analysis. Artificial intelligence can enhance the effectiveness of recycling efforts by improving sorting processes and identifying recoverable materials more efficiently, thereby reducing waste and directing resources toward optimal use. In addition, these technologies contribute to promoting smart agriculture that relies

[12] Karima Sultan, op. cit., 925.

[13] Rafaa Mahawi Hani, Saja Saad Ahmed, Characteristics of Smart Cities and Their Impact on Achieving Sustainable Development, Al-Mustansiriya Journal of Humanities, Faculty of Education, Al-Mustansiriya University, Volume 3, Issue 2, 2025, Egypt, p. 333.

[14] Imad Thayeb Al-Hafiz, The Environment (Its Protection, Pollution, and Risks), Dar Safa Publishing and Distribution, Amman, 1st edition, 2011, p. 148.

on data to improve productivity and reduce environmental impact through the use of weather monitoring and forecasting systems.

The integration of artificial intelligence into biodiversity management represents a promising future, as it can be used to monitor endangered species and analyze environmental patterns in real time. Machine learning techniques are used to identify environmental changes and monitor various influencing factors such as pollution and habitat loss. This is a significant benefit for developing effective protection strategies and promoting the sustainability of ecosystems. In the same context, it is important to establish strategic partnerships between governments and the private sector to stimulate innovation in this field. By sharing knowledge and resources, stakeholders can promote investment in artificial intelligence technology and data systems, opening up new avenues for improving the response to global environmental crises [15].

First Subtitle : Challenges facing the application of artificial intelligence.

The challenges facing the application of artificial intelligence in the field of environmental protection are complex issues that require special attention. Among these challenges, ethical considerations stand out as a key element that must be taken into account during the development of intelligent systems. This includes issues such as privacy, Artificial intelligence models can collect and analyze vast amounts of personal data about individuals, posing a potential threat to individual rights. In addition, questions arise about how AI is used in environmental decision-making, as misguided programming could lead to unintended consequences that conflict with environmental conservation principles.

Financial costs play an important role in the process of integrating artificial intelligence into environmental protection projects. AI technologies require significant investments in technological infrastructure, personnel training, and software development. This can be a barrier for governments and large organizations, especially in developing countries, which often suffer from a lack of resources[16].

Limited budgets may restrict the ability of these entities to leverage AI technologies in resource allocation, environmental data analysis, and appropriate policy guidance. Data scarcity is also one of the most significant challenges facing the application of AI.

The availability of reliable and comprehensive data is a prerequisite for training AI models efficiently. Data related to the environment is often intolerant and its dominance is often within certain ranges, which can cause a lack of diversity in the dataset. Apart from this challenge, data related to certain environmental indicators can be misleading or inaccurate. This negatively affects the inputs of AI models and the results obtained. Therefore, there is an urgent need to develop standards for data collection and maintenance, which will contribute to enhancing the ability of AI to effectively achieve environmental protection goals.

1- Ethical considerations:

Ethical considerations are key elements that must be taken into account when applying AI in environmental protection. AI, as an effective tool for analyzing big data and identifying patterns, carries with it potential risks related to ethical issues such as privacy, transparency, and fairness. The use of artificial intelligence systems to collect environmental data may involve

[15] Tarek Al-Sayed, op. cit., p. 975.

[16] Springer International Publishing AG, (2017) "The Rise of the Smart City" L.G. Anthopoulos, Understanding Smart Cities: A Tool for Smart Government or an Industrial Trick? Public Administration and Information Technology 22, http://www.springer.com/978-3.

gathering information about individuals and communities without their knowledge or consent, thereby increasing the rates of privacy violations.

Complex models, which rely on deep learning techniques, can lead to what is known as a "black box," where it becomes difficult to explain how certain results were reached. This raises questions about the accountability of such systems, especially in environmental crisis situations that require a rapid and effective response. The data used to train AI models should be fair and unbiased, as bias in data can lead to unfair outcomes that may harm some groups more than others, necessitating the adoption of strict ethical standards in the data collection process and the use of models[17].

The impact of artificial intelligence on human jobs and skills cannot be overlooked either. With the increasing reliance on AI solutions, some traditional jobs in the field of environmental protection may disappear, requiring effective strategies to retrain workers and equip them with the skills necessary to work alongside AI technologies. Therefore, ethics in this context is a complex issue that requires a delicate balance between technical benefits and human consequences, necessitating the development of clear policies that encourage innovation while preserving the well-being of society and the environment[18].

2- Financial costs:

Financial costs are one of the decisive factors in determining the applicability of AI technologies in environmental protection. The introduction of these technologies requires significant investments, including software development costs, advanced technological infrastructure, and specialized human resources salaries. This includes the purchase or upgrade of necessary computer equipment and ongoing maintenance and operating expenseThis may place a financial burden on institutions operating in this field, whether governmental or private.

The application of artificial intelligence involves education and training costs, as the teams involved must acquire advanced skills to deal with smart systems and their applications. This step may require costly training programs, which increases the financial burden. Large operations also require the processing of huge amounts of data, which means additional investment in storage technologies and digital security to protect sensitive data when it is collected and analyzed[19].

3- Data deficiency:

Data scarcity is one of the main challenges facing the application of artificial intelligence in the field of environmental protection. Artificial intelligence technologies, such as machine learning and deep learning, require large amounts of high-quality data to train systems and achieve the desired results. In the context of environmental protection, data on biodiversity, pollution measurements, water resources, and climatic factors are essential for developing effective models. However, researchers and scientists often face significant difficulties in accessing comprehensive datasets covering all environmental variables. One of the key obstacles to data collection is the lack of investment in environmental studies, which leads to limited recording of important data. In addition, some areas, especially remote or disadvantaged ones, lack adequate monitoring technologies, making it difficult to obtain accurate and reliable data. From here, the move towards open data and community participation becomes essential,

[17] Imad Thayeb Al-Hafiz, op. cit., p. 150.
[18] Evren TOK, Maha Al MEREKHI, Hanaa Al GHAISH , Fatima MOHAMED ALI(2014)"SMART CITIES IN QATAR AND UNITED ARAB EMIRATES , A COMPARATIVE ANALYSIS " The Journal of Academic .
[19] Manour Ousserir, Environmental Economics, Vol. 1, Dar Al-Khaldounia Publishing and Distribution, Algeria, 2010, p. 64.

as open data initiatives can enhance access to vital information and stimulate cooperation between different stakeholders[20].

Second subtitle: Raising awareness about artificial intelligence and the environment.

Education and awareness about artificial intelligence and its impact on the environment are key factors in promoting understanding and awareness among individuals and communities. Through innovative educational programs, knowledge of how to use smart technologies to protect the environment can be promoted, from waste recycling to improving energy efficiency. Different educational curricula should include content that focuses on AI applications such as machine learning and big data analysis, and guide discussions on how they can be used to solve the problem of climate change by providing solutions for resource management and sustainable use.

Trainees can learn how to use artificial intelligence models to analyze energy consumption data or predict the environmental impacts of specific activities. Through this type of training, individuals become better equipped to understand the opportunities and challenges they face when integrating AI into environmental practices. Raising public awareness about AI and its impact on the environment is a vital tool in advancing environmental policies. This involves emphasizing the importance of legislation governing the use of AI technologies, taking into account environmental impacts. Informed public support for such policies can promote innovations that contribute to sustainable development, ensuring a balance between technological progress and environmental conservation. Educational and research institutions should also encourage studies and research that explore the potential for using AI in ways that increase the effectiveness of environmental efforts [21] .

Conclusion:

The application of artificial intelligence in environmental protection heralds a new revolution in environmental conservation strategies, reflecting the importance of technological innovation in addressing contemporary environmental challenges. By integrating artificial intelligence into areas such as air quality monitoring, environmental data analysis, and natural resource management, a high level of efficiency in decision-making and forecasting future climate change trends can be achieved.

The benefit of these applications lies in their ability to process vast amounts of data and analyze patterns, thereby enhancing the accuracy of environmental understanding and observation.

The use of artificial intelligence contributes to the development of sustainable solutions that promote resource efficiency and reduce waste. AI-based models also enable policymakers to predict how different ecosystems will respond to environmental pressures and provide accurate insights that contribute to the formulation of effective strategies.

It is clear that artificial intelligence is not just a technological tool, but goes beyond that to become a strategic partner in achieving environmental sustainability and the well-being of the planet. Societies and countries must recognize the pivotal role of technology in addressing growing environmental problems and invest in research and development to expand the scope

[20] Imad Thayeb Al-Hafiz, op. cit., p. 151.

[21] Bassam Samir Al-Ramidi, Egypt's New Administrative Capital as a Leading Model for Smart Cities in Africa, Proceedings of the First International Maghreb Conference on Sustainable Development 2021, Egypt, 2021, p. 348.

of AI applications. Dedication to using these smart tools will open new horizons for innovation and enhance the ability to meet global challen .