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The role of artificial intelligence technologies in protecting the environment and enhancing its sustainability

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ABSTRACT

This study explores the role of artificial intelligence (AI) technologies in protecting the environment and enhancing its sustainability. AI technologies can perform specific environmental tasks to improve, preserve, and enhance the sustainability of environmental elements, and to provide effective environmental solutions. Hence, this study aims to reveal the essence of AI by explaining its concept, importance, and advantages. It also aims to explore its applications in environmental protection, as well as the ethics, risks, and balances associated with its use in the environment. To address this topic systematically, the study adopted a descriptive and analytical approach, because it is suitable for facilitating the process of examining the subject, and it leads to accurate scientific results that enhance understanding of the role of AI systems in protecting and enhancing environmental sustainability. The study concluded that AI is an effective tool for preserving the environment and supporting sustainability efforts by improving natural resource management, reducing emissions, and monitoring climate change with high accuracy. Finally, the study recommends strengthening environmental legislation and policies that regulate the use of AI technologies to ensure the protection of the environment and natural resources. It also recommends developing green, low-energy algorithms to reduce the carbon footprint of data centers and smart systems, in addition to integrating environmental ethics standards into the design and application of AI systems in order to ensure respect for privacy and social justice.

KEYWORDS: technology, sustainability, information, artificial intelligence, environment

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1. Introduction

Artificial intelligence (henceforth AI) represents a qualitative leap in the software world. Its primary goal is to build intelligent machines that can perform complex tasks such as protecting the environment and sustaining it, improving natural resource management, reducing carbon emissions, and accurately monitoring climate change. Therefore, this study is significant because it highlights the most prominent challenges and opportunities in environmental protection and sustainability. Furthermore, the study gains importance from addressing the ethical and environmental aspects of AI applications. It seeks to clarify how to achieve a balance between technological advancement and environmental preservation. In addition, this study provides an analytical framework to help decision-makers and researchers understand the implications of using AI technologies in environmental fields and to develop policies that ensure the safe and responsible use of these technologies. This contributes to enriching scientific knowledge about the complementary relationship between modern technology and the environment and supports efforts to build a sustainable future based on innovation and environmental awareness together.

Despite the rapid development of AI technologies and their growing role in supporting environmental sustainability efforts, the legislative vacuum that surrounds the regulation of these technologies raises several legal and ethical concerns. Current laws have failed to keep pace with the challenges posed using AI in environmental fields, whether in defining legal liability for environmental damage that result from decisions or activities that rely on intelligent systems, or in regulating energy consumption and emissions generated by technological infrastructure. So, the main legal problem lies in the following question: To what extent can current legal systems regulate the use of AI technologies in a way that achieves environmental preservation and sustainability, and protects natural resources from potential damage?

This problem can be addressed by answering the following research questions:

- What is the concept of environmental AI?
- What is the importance of environmental AI?
- What are the advantages of environmental AI?
- What are the applications of AI technology in environmental protection?
- What are the concerns and risks associated with using AI technology in the environment?

1.1 Study objectives

This study aims to explore the nature of AI by defining its concept, importance, and characteristics. It also analyzes AI's role in environmental protection and achieving sustainability through improved natural resource management and reduced pollution and emissions. Furthermore, it highlights the ethical challenges and concerns arising from the application of AI technologies in the environmental field.

1.2 Method

This study employs a descriptive-analytical approach, as it is the most effective method for describing and exploring the phenomenon to arrive at accurate scientific findings that enhance understanding of the role of AI systems in environmental protection and promoting sustainability.

2. What is Artificial Intelligence?

Research into the definition of AI reveals the difficulty in finding one comprehensive definition of this term. This is because of the difficulty in defining human intelligence itself, especially since psychologists, sociologists, and philosophers differed in defining it¹. This calls for examining the concept of AI on the one hand and the concept of environmental AI on the other.

2.1 The concept of Artificial Intelligence

Artificial intelligence is composed of two words: intelligence and artificial. Each has its own meaning².

1 Al-Da'aja, B. (2025). *The legal personality of artificial intelligence: A comparative study in civil legislation*. Dar Al-Thaqafa Publishing. P. 25.

2 Abu Bakr Khawaled. (2019). Artificial intelligence applications as a modern approach to enhancing

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Intelligence is a unique characteristic to the human mind, and it is distinguished by several qualities: awareness, perception, understanding, deduction, interpretation, reasoning, planning, and the ability to memorize and recall. Therefore, intelligence is defined linguistically as the ability to analyze, synthesize, differentiate, choose, and adapt to situations³. The word artificial, on the other hand, is an adjective derived from the verb “to make,” meaning something that is not natural but requires the intervention of an external element to create it⁴.

Combining the terms “intelligence” and “artificial” results in many ways to understand its meaning. Despite their diversity, they all focus to some extent on a single main idea, and this multiplicity can be attributed to the perspective from which AI is viewed, whether in terms of its characteristics, features, or operational mechanisms, or by comparing it to AI⁵. One such definition is the ability of machines and digital computers to perform specific tasks that mimic those performed by intelligent beings, such as the capacity for thought, learning from past experiences, or other processes requiring mental operations⁶. It is also defined as a branch of computer science concerned with studying and developing computer systems that exhibit some form of intelligence. These systems are capable of drawing very useful conclusions about the problem at hand. Furthermore, these systems can understand natural languages, comprehend human perception, and have other capabilities that would require intelligence if implemented by humans⁷.

Others view it as the science that enables machines to perform tasks that need intelligence if they are performed by humans⁸. It is also recognized as an interdisciplinary science and an important field in the lives of individuals, organizations, and society, which aims to provide intelligent software and create intelligent machines to perform tasks similar to those performed by humans, with the goal of making life and work better, easier, and less expensive. In other words, it is the science of enabling machines to perform tasks that require human intelligence. Finally, it is defined as the science that seeks to transfer human intelligence to devices and software, i.e., equipping computers with programs and capabilities that are similar to human intelligence, enabling them to perform intelligent operations⁹.

When we think of AI in relation to the environment, it involves developing systems capable of solving environmental problems, performing environmental functions by simulating mental processes, teaching machines how to solve environmental problems, enabling them to study environmental problems and determine how to solve them without human intervention, and allowing environmental machines to operate autonomously and act independently.

2.2 The importance of AI in protecting the environment and enhancing the sustainability of the agricultural sector

The importance of AI in protecting the environment and enhancing the sustainability of the agricultural sector

the competitiveness of business organizations. *Arab Democratic Center for Strategic, Political, and Economic Studies*. P. 11; Alhendi, N., & Salameh, M. H. (2022). The role of the public administration in protecting the environment from pollution. *Journal of Environmental Management and Tourism*, 13(7), 1835–1839

3 Al-Da’aja, B. (2025). *The legal personality of artificial intelligence: A comparative study in civil legislation*. Dar Al-Thaqafa Publishing. P. 23.

4 Al-Da’aja, B. (2025). *The legal personality of artificial intelligence: A comparative study in civil legislation*. Dar Al-Thaqafa Publishing. P. 23.

5 Madhkour, M., & Malika. (2021). Artificial intelligence and the future of distance learning. *Studies in Development and Society*, 6(3), p. 138; Alhendi, N., Baniamer, A., & Salameh, M. (2024). Legislative deficiency in moral authors’ rights in digital literature (international conventions and Jordanian law). *International Journal of Electronic Security and Digital Forensics*, 16(4), 520–532.

6 Al-Da’aja, B. (2025). *The legal personality of artificial intelligence: A comparative study in civil legislation*. Dar Al-Thaqafa Publishing. P. 25.

7 Sabaa, A. (2019). Applying artificial intelligence strategies at the international level: The United Arab Emirates as a model. *Al-Mayadeen Economic Journal*, 1(1), p. 33.

8 Abu Bakr Khawaled. (2019). Artificial intelligence applications as a modern approach to enhancing the competitiveness of business organizations. *Arab Democratic Center for Strategic, Political, and Economic Studies*. P. 26.

9 Al-Wali, A. (2021). *Civil Liability for Damages Caused by Artificial Intelligence*. Applications in UAE Law. United Arab Emirates: Dar Al-Nahda Al-Arabiyya. P. 29.

is difficult to fully discuss; however, some aspects can be highlighted¹⁰. The first is monitoring and analyzing environmental pollution through intelligent sensor systems that predict rising levels of air or water pollution, and this facilitates early intervention. Other aspects include enhancing the efficiency of natural resource management through predictive models that reduce water and energy waste, contributing to mitigating climate change by analyzing carbon emissions and proposing optimal strategies for reducing them, improving recycling processes using intelligent sorting systems capable of distinguishing between types of waste with greater accuracy than humans, monitoring biodiversity through algorithms that track the lives of endangered species and analyze the environmental conditions affecting them, improving crop productivity through models that predict diseases and pests before their spread, thus reducing pesticide use and preserving soil health, reducing agricultural losses through technologies that predict crop ripening times and identify optimal harvesting times, and reducing the environmental impact of agricultural operations by improving fertilizer and energy use and minimizing emissions from agricultural machinery.

Maintaining soil fertility, predicting nutrient levels, and suggesting appropriate natural fertilizers are also some aspects. Finally, contributing to the achievement of sustainable environmental development goals is crucial¹¹. Article (2) of the Jordanian Environmental Protection Law No. (6) of 2017 defines sustainable development as development that achieves a balance between environmental safety, economic development, and social development, which ensure the use of natural resources while preserving them to achieve a decent life for future generations. The same article defines the environment as the medium that includes living and non-living organisms, its constituent materials, and its surroundings such as air, water, and soil, as well as the interactions between these elements, and any facilities or activities established or carried out by humans within it. Environmental protection is defined as the preservation and development of the environment's elements and components, and the prevention of their degradation or pollution.

2.3 Advantages of AI in environmental protection and sustainability

The development of AI technologies has brought many advantages to the environment¹². A study conducted by the International Telecommunication Union (ITU) shows that this technology, including its enormous potential, achieves economic benefits and accelerates progress in environmental protection and the achievement of the 2030 Sustainable Development Goals¹³.

2.3.1 Advantages of AI in environmental protection

The advantages of AI in environmental protection can be summarized in the high accuracy in collecting environmental data and analyzing it, as AI can monitor environmental changes with greater precision than traditional methods. This contributes to understanding environmental phenomena and making scientific decisions based on accurate data. It also provides the ability to predict environmental disasters. By analyzing climatic and geological data, AI can predict floods, droughts, forest fires, or pollution waves, which enables early preventative measures¹⁴. Furthermore, it improves the efficiency of natural resource management by helping

10 Al-Wali, A. (2021). *Civil Liability for Damages Caused by Artificial Intelligence*. Applications in UAE Law. United Arab Emirates: Dar Al-Nahda Al-Arabiyya. P. 29.

11 Al-Qahtani, A. (2022). The role of artificial intelligence in achieving sustainable development within the framework of the Kingdom of Saudi Arabia's Vision 2030. *Arab Journal of Informatics and Information Security*, 3(9). Arab Foundation for Education, Science and Arts. P. 105.

12 Khalifa, E. (2019). *Artificial intelligence: Features and repercussions of the dominance of intelligent machines in human life*. Future Studies, (6). Abu Dhabi. P. 20.

13 Al-Mulla, M. (2020). Employing artificial intelligence technology in combating corruption: Between the possible and the aspirational: A descriptive study in the field of criminal law. *Kuwait International Law School Journal*, (8). P. 101.

14 Al-Mulla, M. (2020). Employing artificial intelligence technology in combating corruption: Between the possible and the aspirational: A descriptive study in the field of criminal law. *Kuwait International Law School Journal*, (8), p. 102;

Alhendi, N., & Salameh, M. (2023). Environmental pollution crime. *Journal of Environmental Management and Tourism*, 14(1), 176–180.

to reduce water and energy waste through intelligent systems that rely on prediction and direct sensing¹⁵, in addition to its ability to respond quickly to environmental changes. This provides real-time monitoring systems capable of detecting any environmental disruption as soon as it occurs, which results in accelerating intervention to mitigate damage. Finally, AI works to reduce pollution by using AI models to monitor industrial emissions and provide immediate recommendations for reducing them¹⁶.

2.3.2 Advantages of AI in enhancing environmental sustainability

AI works efficiently to enhance environmental sustainability, as it can accurately predict diseases and pests at an early stage. Computer vision algorithms and big data enable the detection of agricultural diseases before they spread, reducing pesticide use and preserving the health of the environment and farms. AI also helps rationalize water use. Smart irrigation systems rely on analyzing weather and soil data to determine the ideal amount of water for each crop, which results in promoting water resource conservation. Furthermore, AI can improve crop quality and productivity by analyzing soil, crop type, and climate data. It helps in selecting the best farming methods and determining the optimal times for sowing and harvesting. AI reduces losses in the agricultural chain and helps in predicting production before harvest and managing storage and transportation efficiently, thus minimizing food loss and improving food security. It also reduces the environmental impact of agricultural operations by optimizing fertilizer and energy use and reducing emissions associated with agricultural machinery. In addition, AI supports agricultural decision-making by providing accurate reports on the best crops suited to climatic and environmental conditions, which makes it play active role in sustainable agricultural planning¹⁷.

3. AI applications in environmental protection and sustainability: Agriculture as a model

It is difficult to discuss all applications of environmental protection, and focusing only on specific applications may suffice, as agriculture is the core and foundation of the environment. Employing AI applications in agriculture represents a fundamental shift towards more precise and sustainable management of natural resources. These technologies enable advanced analysis of agricultural and environmental data, which leads to knowledge-based decision-making. With the development of smart forecasting, monitoring, and processing tools, agriculture has become more capable of addressing environmental challenges and enhancing production with high efficiency. Among these applications are:

3.1 Smart irrigation systems

AI enables farmers to use water more efficiently through smart irrigation systems. These systems rely on analyzing data collected by soil and weather sensors to determine the optimal water quantities needed for plants¹⁸. This means that automated sensors connected to AI systems are used to measure soil moisture in real time. Based on such data, the systems issue irrigation recommendations only when needed. Furthermore, weather forecasting can be predicted using advanced forecasting technologies, which helps prevent over-irrigation when rainfall is expected¹⁹.

3.2 Pest control using Machine Learning

15 Al-Mulla, M. (2020). Employing artificial intelligence technology in combating corruption: Between the possible and the aspirational: A descriptive study in the field of criminal law. *Kuwait International Law School Journal*, (8), p. 102.

16 Al-Mulla, M. (2020). Employing artificial intelligence technology in combating corruption: Between the possible and the aspirational: A descriptive study in the field of criminal law. *Kuwait International Law School Journal*, (8), p. 102.

17 Alhendi, N., & Salameh, M. H. (2022). The role of the public administration in protecting the environment from pollution. *Journal of Environmental Management and Tourism*, 13(7), 1835–1839, p.15.

18 Al-Darandali, K. (2020). *Artificial intelligence and the environment*. Zagazig University. P. 11.

Alhendi, N., Baniamer, A., Alsalamat, N., Salameh, M., & Alanazi, H. (2024). Emoji crimes on social media applications. *Cogent Social Sciences*, 10(1).

19 Zhao, L., Dai, T., Qiao, Z., Sun, P., Hao, J., & Yang, Y. (2020). Application of artificial intelligence to wastewater treatment: A bibliometric analysis and systematic review of technology, economy, management, and wastewater reuse. *Process Safety and Environmental Protection*, 133, 169–182.

Pest control using Machine Learning techniques is one of the most effective and sustainable applications of AI in agriculture. These techniques enable early pest detection through systems equipped with high-resolution cameras and image analysis algorithms. Because of these systems, pests can be detected in their early stages before they cause widespread damage, which gives farmers the opportunity to take appropriate preventative measures²⁰. Moreover, AI can target pesticides by analyzing data collected about infested crops. Based on this analysis, pesticides can be directed only to infested areas, reducing pesticide use on other crops and minimizing the negative impact of chemical use. This approach not only contributes to environmental protection and cost reduction but also helps improve the quality of agricultural products and promotes long-term agricultural sustainability²¹.

3.3 Precision agriculture

Precision agriculture relies on the use of AI to collect and analyze data from farmers. AI systems can identify areas that need improved fertility, which results in reducing the use of chemical fertilizers. AI technologies also help predict weather conditions more accurately, and this enables farmers to make better decisions about planting and harvesting times and to identify areas with climatic risks such as drought or flooding. These technologies also contribute to selecting suitable crops. By analyzing climatic conditions, AI systems can analyze soil data, determine its composition, salinity, moisture content, and other soil components, and then suggest the best and most suitable crops for these conditions to contribute to increased productivity²².

3.4 Smart robots in agriculture

Robots are an innovative tool for environmental conservation and achieving sustainability. They are used in beach cleanups, waste collection, and pollution control. Because of their intelligent capabilities, robots can perform a variety of tasks to preserve the natural environment and improve quality of life. It is worth noting that AI technologies enhance the performance of robots, and this helps them recognize their surrounding environment and make intelligent decisions based on data analysis. This contributes to using improved resources efficiently and reducing negative environmental impact. Also, robots and AI technologies can be used in large-scale environmental projects, such as waste management, water resource protection, and the promotion of sustainable agriculture. These technologies improve efficiency and accuracy, and they save time and effort in carrying out different environmental tasks²³.

AI-powered agricultural robots are experiencing rapid development, and this makes it play a prominent role in improving efficiency and reducing costs associated with agricultural operations. These robots use advanced technologies such as machine learning and computer vision, enabling them to perform many tasks that previously required significant human effort. Robots are used in crop cultivation by distributing seeds within the soil, and this reduces depth variations and increasing germination rates. AI-powered autonomous irrigation systems also contribute to adjusting water usage based on climatic and soil conditions, and this leads to reduced waste and improved water resource management²⁴.

Robots are also used in automated harvesting operations to collect crops such as fruits and vegetables with high precision without damaging the products, which raises the quality of the harvest and speeds up its completion. Robots also rely on computer vision for visual analysis, which enables them to distinguish ripe crops and deal with them efficiently. In another step to improve the quality of production, robots sort crops based on criteria such as size, shape and color, which allows for the disposal of unripe or damaged crops. After that, these robots can carry out packaging operations accurately and safely, which reduces labor costs and

20 Yigitcanlar, T., Mehmood, R., & Corchado, J. M. (2021). Green artificial intelligence: Towards an efficient, sustainable and equitable technology for smart cities and futures. *Sustainability*, 13(16), 8952.

21 Bibri, S. E., Krogstie, J., Kaboli, A., & Alahi, A. (2024). Smarter eco-cities and their leading-edge artificial intelligence of things solutions for environmental sustainability: A comprehensive systematic review. *Environmental Science and Ecotechnology*, 19, 100330.

22 Al-Darandali, K. (2020). *Artificial intelligence and the environment*. Zagazig University. P. 11.

23 Al-Darandali, K. (2020). *Artificial intelligence and the environment*. Zagazig University. P. 11.

24 Al-Darandali, K. (2020). *Artificial intelligence and the environment*. Zagazig University. P. 11; Pachot, A., & Patissier, C. (2022). Towards sustainable artificial intelligence: An overview of environmental protection uses and issues. *arXiv Preprint*, arXiv:2212.11738.

speeds up delivery of products to markets. Drones, which are part of the agricultural robot system, are used to monitor crops from the air. These drones capture images and analyze them using AI to detect problems of water shortages or the appearance of agricultural pests, which enables farmers to take the necessary measures in a timely manner. These applications show how AI can radically transform agriculture, by increasing productivity and achieving sustainability while reducing reliance on traditional methods²⁵.

3.5 Analyzing big agricultural data

Big agricultural data analysis is one of the key agricultural tools that can be used to promote agricultural sustainability. AI can analyze big data related to the environment and various environmental challenges, extract valuable insights, make strategic decisions, and provide a comprehensive view of agricultural consumption patterns and environmental impact. Thus, organizations, governments, and individuals can take effective actions to reduce agricultural challenges and achieve environmental sustainability. Big agricultural data analysis can also identify effective agricultural practices and direct efforts towards innovation and sustainable agricultural development. These analyses can be used to achieve sustainability in a variety of sectors²⁶.

3.6 Data management and its role in environmental conservation

Data management can contribute to identifying areas that require urgent intervention to preserve biodiversity or reduce harmful atmospheric emissions. Furthermore, data management can be used to predict future environmental changes and develop adaptation strategies by analyzing historical data and predicting future trends. Intelligent systems provide important guidance for developing sustainable environmental policies and programs²⁷.

3.7 Recycling agricultural waste

Another area where AI contributes is in the handling and management of agricultural waste. It can improve recycling processes by identifying and classifying recyclable materials accurately, which result in reducing the amount of waste reaching landfills. It can also monitor and analyze pollution by monitoring air and water quality in real time using connected sensors and analyzing the data. In addition, it can assist in the early detection of agricultural waste and facilitate immediate action to treat and convert it into fertilizers and useful agricultural tools²⁸. For example, the United Arab Emirates, through its Environment Agency – Abu Dhabi (EAD), participated in the World Conservation Congress with an innovative pavilion showing the new technologies that are based on AI to support environmental protection and promote sustainability. The pavilion aimed to highlight pioneering projects in monitoring marine ecosystems and rehabilitating vegetation using advanced technological solutions. It featured a model of a sophisticated autonomous vehicle developed in collaboration with Micropolis Robotics, and it is specifically designed for environmental monitoring and vegetation rehabilitation programs. The reliance on AI represents a significant leap forward, as these technologies provide accurate and rapid data on the state of ecosystems, and this enables the efficient implementation of vegetation rehabilitation projects while minimizing human intervention and operational risks. The pavilion also showed the “Fish AI” project, which uses AI to identify fish species, sizes, and quantities, thus enhancing the accuracy and speed of fisheries censuses and supporting the sustainable management of marine resources.

Moreover, the EAD pavilion presented the “Dalma Fish” project, which is a marine cage aquaculture system for local fish. This project is the first of its kind in the Middle East to use AI for monitoring water quality, fish behavior, and improving the efficiency of aquaculture operations. These projects also reflect the Environment Agency – Abu Dhabi’s vision of using innovation and modern technologies to protect the environment and

25 Al-Darandali, K. (2020). *Artificial intelligence and the environment*. Zagazig University. P. 11; Zhao, L., Dai, T., Qiao, Z., Sun, P., Hao, J., & Yang, Y. (2020). Application of artificial intelligence to wastewater treatment: A bibliometric analysis and systematic review of technology, economy, management, and wastewater reuse. *Process Safety and Environmental Protection*, 133, 169–182.

26 Alhendi, N., & Salameh, M. H. (2022). The role of the public administration in protecting the environment from pollution. *Journal of Environmental Management and Tourism*, 13(7), 1835–1839.

27 Al-Shawabkeh, I. (2020). Legal guarantees for objective performance evaluation of the federal public employee in UAE legislation. *Lawyer Quarterly*, 10(3), 217–229.

28 Al-Darandali, K. (2020). *Artificial intelligence and the environment*. Zagazig University. P. 6.

enhance marine sustainability, while supporting the UAE's goals for the sustainable management of natural resources. This pavilion is part of the Environment Agency's efforts to raise environmental awareness and highlight the role of modern technology in supporting sustainability, in line with the UAE's vision for preserving the environment and enhancing natural resources for future generations.

4. The ethics, risks, and balances of applying environmental AI

AI represents a revolutionary tool for protecting the environment and achieving sustainability, but it also presents challenges and risks that must be addressed wisely. Proactive steps can be taken to confront these challenges and ensure that this technology becomes a driving force towards a sustainable future without harming the environment or communities.

4.1 The ethics of using technology in environmental protection

The ethics of AI play a crucial role in ensuring its responsible use, and here, many key points must be considered. First, individual privacy is a concern, as AI systems require very big amounts of data for analysis. Collecting such data can sometimes infringe upon the privacy of individuals or communities²⁹. For example, satellite-based monitoring of agricultural land could violate the privacy of farmers if these operations are not legally regulated. This is reflected in the principle of respecting human autonomy, which mandates that the producers and developers of these systems adhere to democratic standards, the rule of law, and respect for individual rights. This includes enabling individuals to conduct their activities without any coercion or restriction that contradicts these standards. The goal of the manufacturers and developers of these systems is to make them available to support and enhance the cognitive, cultural, and social skills of users. Individuals should have the freedom to choose whether or not to participate, accepting or declining based on a request that informs them of all processes and their implications.

It is worth noting that the Jordanian legislator, in Article (2) of the Personal Data Protection Law No. (24) of 2023, defined personal data as any data or information relating to a natural person that could identify them directly or indirectly, regardless of its source or form, including data relating to their identity, family status, or location. Furthermore, the principle of preventing harm must be observed. This principle stipulates that AI systems must not cause harm to individuals or exacerbate their effects, whether in the personal or work environment. These tools must guarantee their safety and protect them from any violations that infringe upon their dignity. Preventing harm is not limited to individuals but extends to protecting the environment and living organisms. Preventing harm necessitates the development of these systems be carried out by teams with experience and knowledge in the field of system automation and its suitability for use. It is also essential to inform individuals of any risks inherent in the nature of the system and the mechanisms for mitigating its impact to ensure accountability and transparency³⁰.

Furthermore, AI applications must ensure they do not exacerbate socioeconomic inequalities, as might occur with smart farming technologies that boost productivity for large farmers at the expense of small farmers. This is expressed through the principle of fairness and equity, which dictates that the use and development of AI systems must guarantee a fair distribution of benefits and costs in terms of living standards, ensure impartiality and non-discrimination among individuals, achieve social justice, and promote equal opportunities in education, goods, services, and technology. Therefore, these systems must be trained to respect proportionality and competition between means and ends. This, in turn, requires, procedurally, enabling individuals to challenge automated decisions made by AI systems that affect them.

Moreover, decisions made by AI systems must be understandable and explainable. In the context of environmental protection, assigning responsibility can be difficult if systems cause environmental damage.

29 Leal Filho, W., Wall, T., Mucova, S. A. R., Nagy, G. J., Balogun, A. L., Luetz, J. M., & Gandhi, O. (2022). Deploying artificial intelligence for climate change adaptation. *Technological Forecasting and Social Change*, 180, 121662.

30 Khalifa, E. (2019). *Artificial intelligence: Features and repercussions of the dominance of intelligent machines in human life*. Future Studies, (6). Abu Dhabi. P. 21

Alhendi, N., Baniamer, A., Alsalamat, N., Salameh, M., & Alanazi, H. (2024). Emoji crimes on social media applications. *Cogent Social Sciences*, 10(1).

Hence, algorithms must be open source to ensure transparency and accountability³¹, which is expressed through the principle of explainability. This principle stipulates the need to explain the processes of AI systems in order to build user trust in them. These processes should be transparent and clear in terms of their results as well as the terminology used in those processes³².

4.2 Environmental risks resulting from using AI technologies

Despite the important benefits that AI offers in addressing environmental challenges, there are environmental risks that may arise from the unplanned use of this technology. Operating AI systems requires large amounts of energy, especially in data centers that rely on intensive computations for data processing and model training. According to scientific reports, training a single AI model can consume a very large amount of energy, which leads to significant carbon emissions³³. The increasing reliance on sensors and the Internet of Things (IoT) for collecting environmental data also leads to an increase in electronic waste³⁴. If this waste is not managed properly, it can cause soil and water pollution due to the leakage of toxic materials. Reports indicate that the world produces more than 50 million tons of electronic waste annually. Sometimes, AI systems may be used to accelerate industrial or agricultural processes in unsustainable ways, which can lead to the depletion of natural resources. For example, smart irrigation applications may lead to the overexploitation of groundwater resources if not carefully managed, as happened in parts of India where groundwater levels have negatively declined³⁵.

There are risks and concerns associated with the increasing reliance on AI systems in environmental protection and enhancing the sustainability of the environmental sector. This sector is vulnerable to cyberattacks because it is based on the continuous collection and analysis of data that could disrupt irrigation processes, manipulate environmental data, or damage crops and production. Hence, the importance of linking the features of AI with cybersecurity law becomes clear. Such law provides legal and technical protection for agricultural and environmental data and systems, ensuring the continuity of smart technologies and safeguarding their role in achieving sustainable development and protecting natural resources.

The Hashemite Kingdom of Jordan has enacted a special law dedicated to protecting the Kingdom's security, called the Cybersecurity Law No. (16) of 2019. The Jordanian government justified this approach in the reasons that prompted the codification of cybersecurity in Jordan, including protecting the Kingdom from cybersecurity incident threats, building national cybersecurity capabilities to counter threats to information systems and infrastructure, raising the level of overall national security for institutions and individuals, and developing deterrence, monitoring, early warning, and incident response capabilities.

Other reasons include mitigating the damage caused by cyberattacks, creating a safe and attractive investment environment, and stimulating the national economy, especially given the rapid development of information systems and infrastructure, the growing volume of government services, and finally, monitoring, tracking, and documenting cybersecurity incidents within the national cyberspace. Article (2) of the beforementioned law defines cybersecurity as the measures taken to protect information systems, networks, and critical infrastructure from cybersecurity incidents, and the ability to restore their operation and continuity, whether due to unauthorized access, misuse, failure to follow security procedures, or exposure to deception that leads to such incidents. The same article also defines a cybersecurity incident as an act or attack that poses a risk to data, information, information systems, the information network, or related infrastructure, and it requires a response to stop it or to mitigate its consequences or effects.

4.3 Balancing technological progress and environmental sustainability

31 Al-Darandali, K. (2020). *Artificial intelligence and the environment*. Zagazig University. P. 42.

32 Al-Mulla, M. (2020). Employing artificial intelligence technology in combating corruption: Between the possible and the aspirational: A descriptive study in the field of criminal law. *Kuwait International Law School Journal*, (8), p. 138.

33 Galaz, V., Centeno, M. A., Callahan, P. W., Causevic, A., Patterson, T., Brass, I., & Levy, K. (2021). Artificial intelligence, systemic risks, and sustainability. *Technology in Society*, 67, 101741.

34 Al-Darandali, K. (2020). *Artificial intelligence and the environment*. Zagazig University. P. 41.

35 Chen, C., Hu, Y., Karupiah, M., & Kumar, P. M. (2021). Artificial intelligence on economic evaluation of energy efficiency and renewable energy technologies. *Sustainable Energy Technologies and Assessments*, 47, 101358.

The pursuit of technological progress must go hand in hand with maintaining environmental sustainability, and this can be achieved by taking steps that contribute to this balance. Data centers and AI systems should rely on renewable energy sources such as solar or wind power to reduce carbon emissions. For example, Google has relied on renewable energy to power all its data centers. AI systems can also be designed to be more energy-efficient, such as by improving machine learning algorithms to reduce the required computations, which results in lowering energy consumption. Furthermore, governments play a key role in regulating the use of AI. This can be achieved through legislation that requires companies to assess the environmental impact of their technologies before implementation.

Raising awareness among engineers and scientists about the importance of environmental sustainability can also positively influence the design of future technologies³⁶. Several important steps can be taken to ensure the optimal use of AI technologies. These include encouraging research and development in AI algorithms to improve their energy efficiency, raising awareness among engineers and developers about the importance of environmental sustainability to help design technologies that consume less energy, fostering international cooperation between governments and global organizations to develop comprehensive strategies that balance technology and the environment, enacting laws that require companies to assess the environmental impact of their technologies before deployment, and developing effective systems for recycling electronic waste by establishing specialized centers for recycling devices used in AI technologies³⁷.

With the continuous advancement of AI technologies, it has become essential to anticipate the future and identify ways to improve these technologies to promote sustainability and protect the environment. Future AI innovations focus on innovative technologies that reduce environmental impact and achieve efficiency. For example, developing environmentally friendly processors and algorithms based on simple learning techniques that require less data and energy can be crucial. Sustainable smart cities are also witnessing remarkable progress when they rely on AI systems to improve resource management such as public transport networks, reduce energy consumption in buildings, and monitor air quality, and this makes them more sustainable and livable. AI will also develop to predict environmental disasters such as floods, earthquakes, and forest fires, and this allows for proactive measures to protect lives and reduce damage using historical data and advanced simulation models³⁸.

5. Conclusion

After examining the role of AI technologies in environmental protection and sustainability, the study concludes that AI is an effective tool for protecting the environment and supporting environmental sustainability efforts by improving natural resource management, reducing emissions, and monitoring climate change accurately. It also demonstrated that environmental AI applications contribute to developing innovative solutions for complex environmental problems such as air and water pollution, desertification, and energy consumption. Furthermore, the results showed that the absence of specialized legislation in Jordan and other Arab countries poses a major challenge to the safe and regulated use of AI technologies in environmental fields. While existing Jordanian laws (such as the Personal Data Protection Law No. 24 of 2023 and the Cybercrime Law No. 17 of 2023) represent a step towards regulating digital technology, they still require updates specifically addressing AI and the environment.

The results also highlighted the importance of developing a comprehensive legislative framework to

36 Al-Darandali, K. (2020). *Artificial intelligence and the environment*. Zagazig University. P. 42; Khan, A. A., Laghari, A. A., Rashid, M., Li, H., Javed, A. R., & Gadekallu, T. R. (2023). Artificial intelligence and blockchain technology for secure smart grid and power distribution automation: A state-of-the-art review. *Sustainable Energy Technologies and Assessments*, 57, 103282.

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37 Al-Darandali, K. (2020). *Artificial intelligence and the environment*. Zagazig University. P. 42.

38 Al-Darandali, K. (2020). *Artificial intelligence and the environment*. Zagazig University. P. 45; Javaid, M., Haleem, A., Khan, I. H., & Suman, R. (2023). Understanding the potential applications of artificial intelligence in the agriculture sector. *Advanced Agrochem*, 2(1), 15–30; Kar, A. K., Choudhary, S. K., & Singh, V. K. (2022). How can artificial intelligence impact sustainability: A systematic literature review. *Journal of Cleaner Production*, 376, 134120.

regulate the use of AI in environmental issues and ensure a balance between innovation and environmental protection. Finally, the findings indicated that societal and ethical awareness is a crucial factor in the responsible use of AI for environmental benefit. Finally, the study concluded that achieving environmental sustainability requires a comprehensive legal approach that combines legislation, technology and public policies to ensure a balance between technological development and environmental preservation. In addition, the study emphasized that AI is a double-edged sword: while it contributes to environmental protection on one hand, it also causes negative environmental impacts on the other, such as increased energy consumption and a rise in electronic waste.

Based on the findings and analysis above, the following are some recommendations that we hope will be taken into consideration:

- Strengthening environmental legislation and policies that regulate the use of AI technologies to ensure the protection of the environment and natural resources.
- Developing low-energy, green algorithms to reduce the carbon footprint of data centers and smart systems.
- Integrating environmental ethics standards into the design and implementation of AI systems to ensure respect for privacy and social justice.
- Encouraging scientific research on the role of AI in achieving the Sustainable Development Goals, particularly in the areas of clean energy and smart agriculture.
- Promoting international cooperation to exchange expertise and experience in employing AI to serve the environment and developing joint strategies to address climate change.
- Expanding awareness and education programs on the use of AI in environmental protection to contribute to building a societal culture aware of modern technologies and their impacts.
- Establishing specialized centers for recycling smart devices to reduce electronic waste generated by rapid technological development.
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