The Role of Artificial Intelligence in Achieving the Environmental Goals of Sustainable Development

دور الذكاء الاصطناعي في تحقيق الأهداف البيئية للتنمية المستدامة

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Abstract :

Artificial intelligence (AI) is a rapidly evolving global technology. When used correctly, AI has the potential to boost productivity, eliminate human bias and error, and facilitate the achievement of the Sustainable Development Goals set out in the UN's 2030 Agenda.

This study reviews the potential of artificial intelligence to advance environmental goals in areas such as agriculture, renewable energy and environmental protection , etc... It also identifies the challenges hindering the adoption of AI as a tool for achieving these goals.

Keywords: Artificial intelligence; sustainable development; United Nations agenda; digital environment; environmental goals.

ملخص:

يعد الذكاء الاصطناعي مجال تكنولوجي عالمي سريع التطور. فإذا تم استخدامه بشكل صحيح، يمكن للذكاء الاصطناعي أن يزيد الإنتاجية، ويقضي على التحيز البشري والأخطاء البشرية، ويساعد في تحقيق أهداف التنمية المستدامة المحددة في أجندة الأمم المتحدة لعام 2030.

حيث تستعرض هذه الدراسة الدور الذي يمكن أن يلعبه الذكاء الاصطناعي في دفع عجلة التقدم لتحقيق الأهداف البيئية للتنمية المستدامة، بما في ذلك الزراعة والطاقات المتجددة، وحماية البيئة ...إلخ، كما تسلط الدراسة الضوء على التحديات التي تعوق اعتماد الذكاء الاصطناعي كأداة مساهمة في تحقيق أهداف التنمية المستدامة.

الكلمات المفتاحية: الذكاء الاصطناعي؛ التنمية المستدامة؛ أجندة الأمم المتحدة؛ البيئة الرقمية، الأهداف البيئية.

Introduction:

The world is witnessing an unprecedented boom in digital technologies, especially artificial intelligence (AI), which has become not only an advanced technology, but also a strategic factor that brings about important transformations in various aspects of life. In light of these developments, AI has emerged as an effective tool in supporting sustainable development efforts, due to its enormous potential in improving the quality of health services, expanding educational opportunities, enhancing environmental protection, achieving social and economic justice, etc.

Artificial intelligence (AI) has evolved from a specialised technological innovation into a powerful tool capable of solving complex, multidimensional problems in various sectors. Its applications in sustainable development are also promising.

Although AI has great potential to accelerate sustainable development, its application faces many challenges that have not yet been adequately addressed by existing research and studies. AI is a promising tool for accelerating progress towards the Sustainable Development Goals (SDGs), which were set by the United Nations in 2015 to address global challenges such as poverty, inequality, climate change, environmental degradation, and peace and justice.

For example, AI-powered applications in agriculture can predict weather patterns and optimise planting cycles, thereby enhancing crop yields and resilience to climate variability, etc…

=In recent times, the integration of artificial intelligence (AI) and sustainable development has also been the subject of extensive research, with numerous works highlighting AI's potential to advance environmental goals for sustainable development around the world. A systematic review of how AI affects all 17 sustainable development goals (SDGs) notes that, while AI has the potential to contribute to all SDGs, it can also pose risks that hinder progress if not carefully managed.

Despite these promising prospects, there is still a significant gap in the current body of research concerning the role of AI in tackling the world's unique social, economic and environmental challenges. Most existing studies rely on findings from different regions.

This paper aims to address this issue by Exploring the intersection of artificial intelligence with environmental goals for sustainable development, It identifies the opportunities and challenges posed by this collaboration and examines the extent to which AI contributes to achieving the SDGs from a legal perspective. The paper also emphasises the need to establish legal and ethical controls to ensure the fair and responsible use of this technology. Accordingly, we pose the following question: **In what ways can artificial intelligence technology contribute to the environmental goals outlined in the United Nations' Sustainable Development Agenda?**

The study will address the issue raised, and we have decided to adopt two main sections in order to answer it. The first section concerns the theoretical framework of the relationship between artificial intelligence (AI) and sustainable development. The second section analyses the legal challenges that arise from using AI to achieve sustainable development goals.

Section I: The conceptual dimension of artificial intelligence and sustainable development.

Artificial intelligence has become one of the most prominent features of the recent digital transformation that the world has witnessed, and is indeed one of the main drivers of societal development. It is no longer just a futuristic concept, but a tangible reality that is transforming the way we think, work and interact with our surroundings. At the same time, humanity is facing an increasing number of challenges relating to climate change, poverty, social justice and resource consumption. This highlights the urgent need to achieve comprehensive sustainable development.

We have therefore chosen to examine artificial intelligence and sustainable development separately, with the aim of developing a precise understanding of these core concepts of this study.

A) The conceptual framework for the use of artificial intelligence technology:

The emergence of artificial intelligence (AI) has clearly impacted the development of various areas of life. This has prompted researchers to define a conceptual framework for the use of AI technology, beginning with a definition of AI itself **(I)**, followed by a classification of its types **(II)**.

I. Definition of artificial intelligence: Artificial intelligence (AI) is defined as an information system that exhibits intellectual capabilities similar to those of humans, or a computer application or machine that performs operations typically carried out by human intelligence [1].

John McCarthy, an American scientist often referred to as the father of artificial intelligence, defined the term as 'the science and engineering of making intelligent machines, especially intelligent computer programs.' He also believed that artificial intelligence was linked to the task of using computers to understand human intelligence.

The United Nations also defines artificial intelligence as a specialisation in computer science that aims to develop machines and systems capable of performing tasks that are considered to require human intelligence, either with limited human intervention or without any human intervention[2].

From the above, it is clear that artificial intelligence encompasses software, technology and machines that mimic human intelligence in order to achieve a fundamental goal: to complete any task in the smartest, fastest way possible with the most accurate results[3].

Therefore, despite the multitude of definitions offered for artificial intelligence, it can be said that no comprehensive and widely accepted definition has been agreed upon. In general, artificial intelligence seeks to understand by creating computer programs capable of simulating intelligent human behaviour. These machines can make decisions or take certain positions based on descriptions of situations, finding solutions to issues by making decisions based on various inferential processes that have been programmed into the software[4]..

In Algeria, the legislator has regulated the use of artificial intelligence in various fields, particularly through Law No. 18-05 of 10 May 2018 on electronic commerce. This law allows for the use of modern technology, including intelligent software, in electronic contracting[5]. Additionally, Presidential Decree No. 21-323 of 22 August 2021 established the National Higher School of Artificial Intelligence[6].

The Scientific Council for Artificial Intelligence has been established as a scientific advisory body. Its tasks include overseeing the development of artificial intelligence applications, particularly in education, industry, economics and Environmental protection; assessing the available material and human resources in this field; and proposing a plan for establishing and monitoring opportunities for international cooperation[7].

II. Types of artificial intelligence:

The types of artificial intelligence are narrow AI **(1)**, general AI **(2)** and superintelligence **(3)**. This is because AI systems do not operate independently of their operators or programmers. Each type will be addressed separately:

1- **Specific or narrow artificial intelligence:** Artificial intelligence with a limited scope enables machines to understand, comply with and apply commands, as seen in facial and image recognition programmes. Its limited scope distinguishes it from other types of AI, as it cannot deviate from the tasks for which it was programmed. Therefore, its actions remain predictable and controllable[8].
2- **General artificial intelligence:** General artificial intelligence operates with a capacity similar to human thinking, enabling machines to think and plan independently in a manner similar to human behaviour. One application of this is in scientific research into the production of artificial neural networks for industrial robots, which involves creating a system similar to those found in the human body[9].
3- **High (superior) artificial intelligence:** Artificial intelligence (AI) is highly intelligent and can perform tasks and functions better than humans specialising in a particular field thanks to its learning technology. AI has many unique features, including the ability to learn, plan, communicate automatically and make judgements and decisions quickly and independently[10].

As can be seen from the above, narrow artificial intelligence is the most common and abundant type in the current era. In contrast, superintelligence is a hypothetical concept that does not yet exist, remaining in the realm of limited theoretical and applied research in laboratories and scientific research centres.

B) The concept of sustainable development:

Human development projects in various economic, social, cultural, and political areas have brought about many changes and achievements, but have also caused environmental damage. In response to these environmental issues, several international conferences and meetings have been held, resulting in agreements on biodiversity conservation, climate change, forest protection and desertification. The importance of addressing environmental and development issues to preserve the future of humanity was emphasised. This gave rise to the concept of sustainable development, which ensures the rights of all generations to access natural resources[11].

I. Definition of sustainable development:

Sustainability is one of the most prominent concepts to emerge in recent years. It has sparked heated debate and prompted the organisation of seminars and workshops to define its meaning. At its core, sustainability is an environmental term that describes how biological systems remain diverse and productive over time[12].

The term 'sustainable development' was first coined by the Brundtland Commission and subsequently adopted in various fields, including transport, water, and tourism. It means 'the ability to meet the needs of the present without compromising the ability of future generations to meet their own needs'[13].

The term 'sustainable development' has been in widespread use since the World Commission on Environment and Development published its report, 'Our Common Future', in 1987. This report defined sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

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At the Rio de Janeiro Summit in 1992, the United Nations Conference on Environment and Development defined it as follows: "Managing economic resources in a way that preserves and improves the environment and resources so that future generations can enjoy a better, more dignified life."[16]

It endorsed Agenda 21, which established the concept of sustainable development, taking into account environmental, human and developmental aspects, and emphasising the interdependence of environmental protection, ecological restoration, development and poverty eradication[17].

As defined by the economist Robert Solow in 1991, sustainability is: 'not harming the productive capacity of future generations and leaving it in the same state as when the current generation inherited it'. Therefore, it does not solely focus on the resources consumed by the current generation and passed on to future generations; rather, it emphasises the quality and nature of the future environment. In his view, this encompasses the total productive capacity of the economy, including both physical resources (factories, equipment, etc.) and intellectual resources (knowledge structure...)[18]. It can also be defined as development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs[19].

II. The Algerian legislator's definition of sustainable development:

Algerian lawmakers have sought to enshrine the concept of sustainable development in environmental law, considering it to be the basis for environmental protection legislation worldwide. This concept involves reconciling economic and social development with the inclusion of an environmental dimension, ensuring that the needs of both present and future generations are met. Furthermore, according to Article 02 of the Environment Law, it is considered an objective to be achieved by the provisions of the same law.

The Algerian legislature followed the French legislature's example in adopting the concept of sustainable development as a goal for public authorities. This is reflected in Article 2 of Law No. 10/03 on environmental protection in the context of sustainable development, which states: 'The aim of environmental protection in the context of sustainable development is to achieve the following...'[20]

Therefore, sustainable development means ensuring there is solidarity between the current and future generations to guarantee the latter's right to environmental resources[21].

Accordingly, sustainable development can be defined as a system that meets human needs indefinitely. This means producing and manufacturing only what we need, while ensuring that enough is left for future generations to guarantee continuity[22].

In 2015, this vision was further realised through the adoption of the Sustainable Development Goals (SDGs) by all United Nations member states. These 17 goals provide a global blueprint for a better, more sustainable future for everyone[23], which can be summarised as follows:

- The human right to a healthy and productive life in harmony with nature.
- Development must be achieved in such a way that the developmental and environmental needs of present and future generations are met in an equitable manner[24].
- Eradicating poverty and reducing disparities in living standards around the world are essential to achieving sustainable development.

- Environmental protection is an integral part of the development process and cannot be considered in isolation from it[25].

Section II: The contribution of artificial intelligence technology to promoting sustainable development

In light of the rapid development of technology, artificial intelligence is one of the most prominent innovations that will shape the future. It has applications in many different fields, such as education[26], health, economics and the environment[27]. At the same time, humanity is facing major challenges that require comprehensive, sustainable solutions. These challenges are encapsulated by the Sustainable Development Goals set by the United Nations, which aim to ensure a fairer and more balanced future for current and future generations[28] .

This highlights the importance of researching the complex relationship between artificial intelligence and sustainable environmental development, which offers many opportunities but also presents challenges. AI can be an effective tool in supporting sustainable development efforts, improving resource use, reducing pollution, enhancing service efficiency and achieving environmental justice. However, if it is not regulated, it could widen the digital divide, impact privacy, and lead to irrational energy use and pollution…[29]

In this regard, we will explore the synergies between artificial intelligence (AI) and the environmental goals of sustainable development. Our focus will be on the opportunities offered by this integration, as well as the challenges that must be addressed to ensure the responsible and ethical use of AI technology for the benefit of the environment in which humans live.

A) The Relationship Between Artificial Intelligence and Achieving Environmental Goals for Sustainable Development:

Artificial intelligence is one of the most significant technological developments of the modern era and has become an effective tool for supporting global sustainable development efforts. Thanks to its enormous analytical capabilities and potential for intelligent data processing, AI offers innovative solutions to environmental challenges, making it a strategic partner in achieving the environmental goals set out in the United Nations' 2030 Agenda for sustainable development[30].

We have identified and proposed four key points for artificial intelligence applications that contribute to achieving the environmental goals of sustainable development. These are as follows:

I. Artificial intelligence applications in achieving sustainable development goals:

We have attempted to crystallise and propose AI applications that contribute to the achievement of sustainable development goals through four key points, as follows:

1- **Using artificial intelligence to combat climate change:** Artificial intelligence has become a strategic tool in addressing the challenges of climate change, playing a key role in advancing efforts to achieve Sustainable Development Goal 13, relating to 'climate action'. This goal requires urgent action to combat climate change and its effects. This necessitates advanced technologies that can process and analyse large, complex data sets with a speed and accuracy beyond traditional capabilities[31].

The effectiveness of artificial intelligence hinges on strict regulatory frameworks that ensure data quality, protect privacy and promote transparency and accountability. At the forefront of these frameworks are the General Data Protection Regulation (GDPR)[32] and the Artificial Intelligence Act (EU AI Act), both of which were issued in 2024[33]. These acts

represent the cornerstone of the regulation of artificial intelligence, including its environmental and climate-related responsibilities and risks. This includes environmental impact assessments in line with the 'do no significant harm' (DNSH) principle of the European Green Deal[34]. The law also demands transparency and accountability in the development and application of AI technologies, emphasising respect for fundamental rights and striking a balance between innovation and environmental conservation.

In the context of climate action, AI technologies play a key role in monitoring environmental phenomena. They do this by analysing satellite images and sensor data to track deforestation, glacier melt and pollution, as well as providing accurate predictions of extreme weather events. AI technologies also help to improve the management of renewable energy and transport systems, thereby reducing greenhouse gas emissions[35].

Additionally, the law acknowledges the significant energy consumption and environmental impact of artificial intelligence technologies and proposes the adoption of sustainable energy usage standards for AI operations. It also encourages the implementation of strict reporting measures for these impacts within regulatory frameworks[36].

2- **Using artificial intelligence to explore and preserve underwater life:** Artificial intelligence helps to preserve the oceans by using machine learning to combat plastic pollution. This tackles one of the biggest challenges in this area by tracking and measuring exactly how plastic waste reaches bodies of water. Underwater robots can reach unexpected depths and reveal the wonders of the deep sea. AI also helps us to understand the complex interactions between climate impacts and our Earth system, and the effect of climate change on our oceans[37].

Sustainable Development Goal 14 sets out a wide range of targets for improving the management of ocean resources, including the management of large and small-scale fisheries, the protection of key marine resources, and the sustainable development of small island states. Emerging technologies can also help governments manage fisheries more effectively[38].

Unmanned aerial vehicles patrolling the oceans provide an effective and cost-efficient way of assessing fish stocks and patrolling remote areas. Real-time reporting enables the dynamic management of fishing activities, helping to reduce the overfishing of protected and endangered species[39].

3- **Using artificial intelligence technology to protect life on Earth and preserve it from pollution:** With regard to Sustainable Development Goal 15, 'Life on Land', artificial intelligence (AI) is proving to be a vital tool in the fight against desertification, the preservation of biodiversity, and the effective and sustainable management of forests and land[40]. AI applications facilitate the proactive monitoring and thorough analysis of substantial environmental data, whether derived from satellite imagery or ground sensors. This enables the early identification of environmental changes and the prompt implementation of measures to prevent degradation and desertification, while also enhancing environmental rehabilitation and biodiversity conservation programmes[41].

Furthermore, the Convention on Biological Diversity (CBD) and the United Nations Convention to Combat Desertification[42] (UNCCD) establish binding rules that require member states to adopt innovative, technology-enabled solutions to address biodiversity loss and land desertification. Artificial intelligence (AI) is an integral part of these solutions,

supporting monitoring, management, and environmental planning while enhancing the climate resilience of ecosystems.

AI-based environmental governance strategies support the "precautionary" principle of international environmental law. This principle requires taking precautionary measures even when complete scientific information is lacking, in order to minimize potential risks to ecosystems and wildlife resulting from new technologies[43].

4- **Artificial intelligence and environmental goals within the Sustainable Development Agenda:** The use of artificial intelligence (AI) in the environmental sector is expanding rapidly, with applications in energy systems (especially smart grids), agriculture, and environmental monitoring. This progress has been made possible by recent advances in Internet of Things (IoT) technologies and advanced AI algorithms in the areas of computer vision and sensor fusion[44].

In the context of smart cities, smart cities are advanced, technology-driven communities. The interplay between artificial intelligence (AI) and blockchain technology is transforming cities' digital infrastructure, creating sustainable and efficient urban ecosystems[45]. Adopting electric vehicles and smart appliances has great potential to improve the efficiency and reliability of electricity generation.

AI can facilitate the integration of renewable energy sources into smart grids by intelligently managing operational risks and optimizing the balance between supply and demand. It is expected that ICT-induced electricity consumption will reach 20 percent of global needs by 2030, up from the current one percent. These figures underscore the urgent need for green growth strategies, including the development of more efficient data centers powered by renewable energy and the integration of human knowledge into AI models, such as physics-based deep learning models[46].

These technological developments require strong environmental governance frameworks from an organizational and legal standpoint. International environmental law instruments, such as the 2015 Paris Agreement and the United Nations Sustainable Development Goals (SDGs)—particularly Goals 7 (clean energy for all), 13 (climate action), and 11 (sustainable cities and communities)[47] —provide guidelines for the responsible use of AI technologies while minimizing negative environmental impacts. As part of regulatory oversight, environmental impact assessment procedures, renewable energy efficiency standards, and emissions reporting requirements should be adhered to[48].

Furthermore, the principle of state responsibility under international law requires governments to regulate AI technologies in order to prevent transboundary environmental damage and protect vulnerable populations disproportionately affected by the environmental degradation associated with AI infrastructure[49]. Private actors, including technology developers and data center operators, have legal obligations under national and international environmental laws to ensure transparency and accountability and to minimize the carbon footprint of AI-based systems.[50] The precautionary principle plays a key role in decision-making by requiring precautionary measures when there is scientific uncertainty about the long-term environmental impacts of AI[51].

In conclusion, integrating AI into environmental management requires a multidisciplinary legal approach that balances technical innovation with regulatory controls in order to achieve sustainable development and environmental justice[52].

II. Towards Adopting Sustainable Artificial Intelligence (Legal challenges)

Artificial intelligence (AI) has proven to be an effective and sustainable way to address environmental issues. However, AI faces legal and technical challenges due to its heavy reliance on historical data for training machine learning models. The dynamic and unpredictable nature of AI makes accurately representing all human behaviors within these models difficult. Additionally, historical data often reflects times and climates prior to significant human activity, which limits these models' ability to predict future climate changes accurately[53].

Furthermore, those developing machine learning models must consider reducing variance and bias when using previous and new data. Imbalance can lead to overgeneralization, resulting in incorrect predictions. This is known as variance-bias compensation[54].

Cyber threats pose a significant obstacle to applying artificial intelligence for environmental sustainability because effective management of cybersecurity risks is required to ensure the integrity of the data used in these systems. The growing number of cyber threats, including attacks and breaches, creates legal and technical risks that hinder the protection of vital environmental monitoring data, especially since current measures are inadequate for warding off these risks[55].

From a legal perspective, the absence of performance standards and the unpredictability of human responses present additional challenges. Nevertheless, evaluating and monitoring the performance of AI systems is essential to achieving sustainable environmental goals[56]. Despite the difficulty and complexity of such measurement, it is crucial to integrate technical and analytical indicators into a comprehensive framework for measuring the purposes of AI use, especially given the variability of human responses to AI decisions[57].

In this context, it is crucial to understand human behavioral interactions with AI systems while avoiding rebound effects that could diminish the benefits of technological progress. Clear legal frameworks are required to govern the use of AI and ensure its environmental and social sustainability[58].

Conclusion:

In the context of twenty-first century global environmental challenges, artificial intelligence (AI) is a vital and fundamental area of research for addressing most contemporary environmental sustainability issues. The degradation of ecosystems coupled with the global warming crisis is one of the most complex environmental issues and requires innovative technological solutions. AI plays a central role in accelerating environmental protection efforts by contributing to emission reductions, carbon dioxide removal, the development of environmentally friendly transport networks, monitoring deforestation, and predicting severe weather. AI has applications in areas such as biodiversity, energy, water, transportation, air quality, agriculture, and disaster resilience.
Nonetheless, it is imperative not to overlook the legal and ethical considerations linked to AI usage, particularly regarding the accessibility of technologies, privacy protection, liability determination, data integrity, and the reinforcement of accountability principles under applicable laws. Neglecting these facets may adversely affect legal security, diminish transparency, and erode public trust in these technologies.

Both international and domestic legislation play a pivotal role in this regard. This includes, but is not limited to, the following:

- The General Data Protection Regulation (GDPR), which imposes stringent standards for the protection and secure processing of personal data, setting a global benchmark for privacy protection.

- The European Union Artificial Intelligence Act (EU AI Act), which comes into effect in 2024, establishes a comprehensive regulatory framework for classifying AI system risks. It emphasises the necessity of environmental impact assessments and enforces the principles of responsible innovation and transparency, aligning with the Sustainable Development Goals (SDGs).

- The 'Do No Significant Harm' (DNSH) principle, enshrined within the European Green Deal framework, ensures that AI activities do not cause disproportionate environmental damage, integrating environmental protection into technology deployment strategies.

- The Precautionary Principle in international environmental law mandates precautionary measures to avoid environmental harm, even in the face of scientific uncertainty. This principle is essential for balancing innovation with natural resource conservation.

These legal frameworks should be strengthened further by adopting governance systems that pay attention to ethical values, improving cybersecurity and ensuring transparency and accountability in the development and application of AI systems, particularly in sensitive sectors such as healthcare and environmental protection.

Ultimately, realising the environmental and societal benefits of AI requires close integration of legislative policy, responsible technological development and rigorous adherence to sustainable development objectives. This positions AI as an effective tool that bridges innovation with sustainability and environmental stewardship for present and future generations.

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