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Review

Towards Artificial Intelligence in Sustainable Environmental Development

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Received: 15 February 2023; **Revised:** 4 March 2023; **Accepted:** 22 March 2023

Abstract: One of the most significant problems facing humankind now is environmental issues, which have harmed life on the planet. Research has been done continuously to lessen the effects of climate change on the local level and to manage its causes. Due to its indisputable rise in popularity, Artificial Intelligence (AI) will be used in a wide range of businesses and for several causes, such as environmental sustainability. Centers with significant ecological impacts may use AI's potential to alter the globe as the field expands. This article focuses on industries using AI applications for sustainable environmental development such as biodiversity, energy, water, transportation, air, agriculture, and resilience to extreme events. Next, some limitations are presented. To benefit both current and future generations, environmentally friendly AI should be developed.

***Keywords*:** artificial intelligence, environmental issues, applications, sustainable development

1. Introduction

The world is presently in a dire situation regarding the impacts of global warming and climate change [1], and effort should be taken to employ sustainable and ecologically friendly goods [2]. Sustainability has three interconnected dimensions: society, the economy, and the environment [3, 4]. According to the UN document "Our Common Future", also known as the "Brundtland Report", sustainability is introduced as "development that satisfies the needs of the present without jeopardizing the capability of future generations to meet the needs" [5]. Environmental sustainability is understood to mean that the resource and service demands of the current and future generations are met without compromising the ecosystem's capacity to support life [6].

Artificial Intelligence (AI) is recognized as a study field that is essential to addressing the majority of the present environmental sustainability issues because of the global environmental crises of the 21st century [2, 7]. For environmental sustainability, it may be useful in informing policy and practice development [8, 9]. Environmental degradation paired with climate catastrophe is one of the complex environmental issues that call for the required cutting-edge and original AI solutions [10]. According to Jha et al. [11], because of AI's durability throughout the last 50 years, environmental sustainability should be achieved via the development and application of this technology.

The literature on AI for a sustainable environment spans numerous fields, according to Nishant et al. [10]. Importantly, while many of these sectors have permeated every category and continue to develop, AI is used in

DOI: https://doi.org/10.37256/aie.4120232503

areas such as transportation, energy, water, and biodiversity to solve the majority of the present regional and global environmental challenges. In many developed countries, AI has been used in transportation and biodiversity [10] in practical ways, such as collecting e-waste using an advanced routing plan, protecting the ocean from pollution, using AI-driven autonomous garbage collection trucks, and wildlife conservation to increase biodiversity. However, there is a need to assemble the available literature on the use of AI in biodiversity and transportation [7]. It is important to highlight the lack of discussion around the use of AI to promote the sustainability of the environment in sectors like transportation, energy, water, and biodiversity [10]. This study focuses on the sectors engaged in, and potential problems with, AI applications in sustainable environmental development. Next, some limitations will be presented. To benefit both current and future generations, environmentally friendly AI should be developed. Following that, limitations and conclusions will be presented.

2. Role of AI in environmental sustainability

AI-based models are a useful tool for enhancing the efforts and processes of nations to attain the Sustainable Development Goal (SDG) (Figure 1). AI models may assist to providing people with food, fuel, fiber, water, and other ecosystem services while fostering a circular economy and other smart city resources [12]. AI can merge smart technology with low-carbon emission processes in an interconnected system, which might then notify and transmit the population's demands to the appropriate sectors. The application of AI in the detection of environmental issues and solutions gives a fresh perspective for comprehending the effect and severity of the world's environmental difficulties [13]. The application of machine learning and Artificial Neural Networks (ANN) in different environmental components is outlined below. Commonly, machine learning in ANN's form is utilized for problem evaluation and resolution in a variety of environmental sustainability components, such as plastic pollution [14], soil [15], and water quality [16], waste management [17], land degradation [18], and agriculture [19]. These issues may fall under larger SDG categories, such as "life on land" and "life below water", but they affect various social and economic sectors, including partnership objectives, sustainable cities, infrastructure development, poverty, and hunger [20, 21]. For instance, trash management creates significant problems. They contribute to climate change in the form of greenhouse gases, degrade natural resources through leachate and pollution [22, 23], and their disposal costs money, resources, and energy. Although trash management is not an essential SDG, every industry generates garbage, and its disposal is a burden. The circular economy is now being utilized to encourage trash reduction and generate money from waste. Circular economy concepts and their effects on the garbage and the environment demand data and technologies. ANN may be a valuable resource [24].

3. Application of AI in environmental sectors

The majority of the present local and global environmental challenges are addressed via the use of AI in sectors including energy, transportation, biodiversity, water, etc that are discussed in this part. Table 1 summarizes some research on the use of AI in sustainable environmental development.

I. Energy: AI may be used to minimize natural resource usage and energy needs related to human activities. Some of the most important fields of study in the energy sector include pattern recognition, expert systems, neural networks, fuzzy logic models, and the management of energy generation, transmission, and consumption. To provide its users with the exact quantity of energy they need or have requested, smart grids employ AI algorithms to manage and control the many local power system components [25]. Smart meters and sensors may be put inside buildings to collect data, track, analyze, and improve energy use [26].

II. Air: AI is a useful method for controlling and reducing air pollution. AI might collect information from satellites and sensors and help scientists combine climate models. AI-driven simulations may be used to alert urban residents to the levels of pollution in their surroundings. The causes of pollution may be promptly and precisely identified using available methods. AI can decrease air pollution by using data from moving objects, cameras, and radar sensors. AI-enhanced air purifiers may continuously collect data about the surroundings and air quality and adjust the effectiveness

of the filters [27].

III. Water: Through the use of machine learning algorithms, water quality measurements and predicting stream flow can be analyzed. AI can help experts predict the weather and estimate water usage in a specific location, allowing them to make better management choices. Subsurface water, soil, and weather conditions may all be anticipated alongside droughts with the use of AI and satellite data. AI may assist water resource management save costs and improving efficiency, allowing them to have a smaller ecological footprint.

IV. Transportation: Environmentally friendly transportation may be obtained via AI applications. Computer vision methods may help with safety decisions and traffic management, mobility, and public transit. When AI-powered self-driving vehicles hit the market, strategies like shared transportation services, eco-driving algorithms, and route optimization will help to minimize the number of automobiles on the road and the carbon footprint.

V. Resilience to Extreme Events: Drones and cutting-edge sensor platforms, for example, may be used to monitor sea-level variations, windstorms, floods, earthquakes, and other natural calamities. Early evacuations may be made feasible by anticipating coming risks. Another application is the use of AI in conjunction with traditional physics-based modeling tools, which will aid many meteorological businesses in simulating the impact of catastrophic weather events on infrastructure and other frameworks, allowing them to advise on disaster risk management methods. Using geological data from research centers across the globe, AI can improve the early detection of wildfires, tsunami warnings, and earthquake prediction.

VI. Agriculture: By more effectively regulating agricultural production and environmental conditions, AI has the potential to revolutionize agriculture. Drones and satellite images may be used by farmers to evaluate crop yield and soil conditions.

VII. Biodiversity: AI can detect changes in forest cover, vegetation, land use, and the consequences of natural catastrophes when combined with satellite photography. Invasive species may also be monitored, identified, and recorded. Through the application of computer vision and machine learning, their detection, tracking, and elimination are made possible.

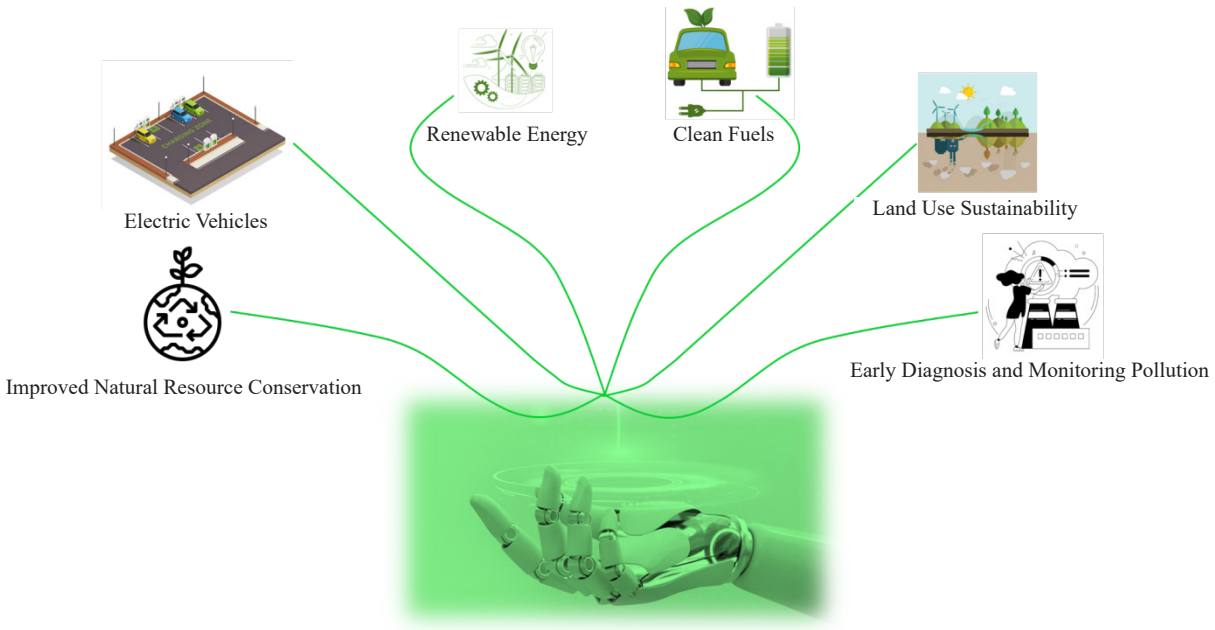

Figure 1. AI's ability for sustainable environmental development

Table 1. Some studies related to the applications of AI in sustainable environmental development

Application	AI System	Outcome	Reference
Biodiversity	Conservation Area Prioritization Through AI (CAPTAIN)	Even with the degree of precision typical in citizen science surveys, routine biodiversity monitoring enhances biodiversity outcomes.	[28]
Energy	AI-based useful Evaluation Model (AIEM)	The suggested approach may increase the energy efficiency to 97.32% and increase the use of renewable energy sources.	[29]
Water	The integrated Long Short-Term memory network (LSTM), using association rules and cross-correlation	Possible changes in water quality may be precisely tracked back to point sources using the LSTM.	[30]
Transportation	ANN models combined with spatial clustering techniques	A very high level of prediction accuracy for the transportation hubs with a high risk of crime.	[31]
Air	ANN	The model could provide an alternate strategy for forecasting NO_x emissions.	[32]
Agriculture	Convolutional Neural Network (CNN)	The proposed system opens up a broad range of smart applications in the Internet of Things framework that need intelligent and autonomous functioning from "things", proving that the system is both feasible and promising.	[33]
Resilience to Extreme Events	Advanced finite element analysis combined with computer vision and deep learning	Whether during or after a stressful event, computer vision may act as an intelligent, scalable agent to precisely monitor the structural reaction, detect various damage pathways, and suggest workable restoration techniques (i.e., fire, earthquake).	[34]

4. Limitations of employing AI for environmental sustainability

The rising application of AI technologies in organizational processes and humane practices confronts several hurdles [35], even though it is a strong and promising technology that may be used in attempts to achieve socio-environmental sustainability. Accessibility, privacy, liability, data accuracy, accountability, and responsibility, should be considered when using AI technology. Since AI models often use a lot of energy and resources, their advantages should exceed their disadvantages [36].

Environmental sustainability is advanced by monitoring and measurement of initiatives. The measurement is difficult and sometimes ineffective; as a result, AI's success in the sustainability of the environment depends on integrating analytical and technical performance in a comprehensive metric. While AI programs are just as brilliant as humans when it comes to making judgments, their emphasis on how decisions will affect people is quite different. Understanding behavioral responses may help prevent the rebound effects that are linked to technological advancement [10].

5. Conclusion

As a consequence of the worldwide environmental problems of the twenty-first century, Artificial Intelligence (AI) is presented as a topic of research that is vital to tackling most of the contemporary sustainability of environmental challenges. The degradation of the ecosystem combined with a global warming disaster is one of the most complicated environmental problems, necessitating novel AI solutions. This article focuses on the sectors using AI technology to promote sustainable development while also discussing any possible issues that may arise due to this trend. By detecting energy emission reductions and removing CO_2, assisting in the development of more environmentally friendly transportation networks, monitoring deforestation, predicting severe weather, etc., AI may speed up worldwide efforts

to safeguard the environment and conserve resources. Diversity, energy, water, transportation, air, agriculture, resistance to catastrophic events, etc. are some of the fields where it may be used. However, it is essential to address ethical considerations such as availability, privacy, liability, data veracity, accountability, and responsibility while working with AI. The lack of attention to these challenges will lead to compromised security, lack of openness, and lowered ethics. The current need is to develop environmentally friendly AI that can benefit the present and future generations.

Conflict of interest

There is no conflict of interest.

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