Journal of Information Systems Engineering and Management
2025, 10(4s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Artificial Intelligence for Environmental Protection: Opportunities and Challenges

Dr Shashikant Tripathi[1], Dr. Rahul Tiwari[2], Smriti Roy[3], Samarendr Chauhan[4], Divyansh Shulka[5], Prof.(Dr.) Aniruddha Ram[6]

[1]*Associate Professor, Department: Atal Bihari Vajpayee School of Legal Studies, University: Chhatrapati Shahu Ji Maharaj University Kanpur*
Orcid Id: 0009-0004-7873-2970
[2]*Assistant Professor, Department: Atal Bihari Vajpayee School of Legal Studies*
University: Chhatrapati Shahu Ji Maharaj University Kanpur
[3]*Assistant Professor, Department: Atal Bihari Vajpayee School of Legal Studies*
University: Chhatrapati Shahu Ji Maharaj University Kanpur
Orcid Id: 0009-0006-6201-0353
[4]*Assistant Professor, Department: Atal Bihari Vajpayee School of Legal Studies*
University: Chhatrapati Shahu Ji Maharaj University
[5]*Assistant Professor, Department Atal Bihari Vajpayee School of Legal Studies*
University: Chhatrapati Shahu Ji Maharaj University Kanpur
Orchid Id: 0009-0008-5623-2085
[6]*Professor & Associate Dean, Institution. School of law and Legal Affairs Noida International University, Noida*
Corresponding Email ID: drrahultiwari@csjmu.ac.in

ARTICLE INFO

Received: 14 Oct 2024

Revised: 06 Dec 2024

Accepted: 22 Dec 2024

ABSTRACT

Artificial Intelligence (AI) is emerging as a revolutionary force that can alter environmental protection efforts in the face of growing environmental issues. This study explores the profound potential of AI technology to safeguard our planet. Important ideas covered in the study are summed up in the abstract, including the use of AI in sustainable resource management, biodiversity preservation, and climate change mitigation. In order to fully utilize AI's potential for the good of our global environment, it also discusses ethical issues and the significance of interdisciplinary cooperation. The significance of AI solutions as vital instruments in the toolbox of politicians and environmentalists attempting to tackle the most pressing environmental issues of our day is emphasized in this paper.

Keywords: Artificial Intelligence, Environmental Protection, Climate Change, Sustainability.

INTRODUCTION

The use of artificial intelligence (AI) technology to protect the environment is growing. AI can help lessen the harm that the building sector does to the environment (1). In green buildings, it can improve climate and environmental adaptation, energy efficiency, and the prudent use of natural resources. A lack of subject morality and ethical dilemmas in decision-making are two more ethical issues that AI raises in the area of environmental protection (2). By highlighting the environmental aspects of AI and assessing the morality of new situations made conceivable by AI, environmental ethicists can support the field of AI ethics. By analyzing data, creating models, and anticipating and reducing emergencies, artificial intelligence (AI) can assist Health, Safety, and Environment (HSE) professionals in the oil and gas industry in resolving environmental issues (3).

For instance, environmental monitoring using convolutional neural networks can detect bloom patches and oil stains on water surfaces. Many industries are using artificial intelligence (AI) to support environmental sustainability. AI is currently being used in environmental preservation for land, ocean, and wildlife conservation (4). Technologies based on artificial intelligence are being used to track down illegal or unsustainable wildlife trade, protect endangered species, and track and forecast trends in animal behavior. Additionally, the oil and gas sector is using AI technologies to address environmental issues (5). Massive amounts of data may be analyzed by AI systems, which can also identify patterns, build models for event scenario analysis, and anticipate and reduce emergencies.

These AI-powered solutions contribute to clean air, water security, biodiversity preservation, waste reduction, ocean health, and climate change mitigation (6).

Artificial Intelligence and Environmental Protection

The application of artificial intelligence (AI) technology to environmental protection is expanding quickly. These technologies offer a wide range of features and uses in environmental monitoring, green building, and moral quandaries. Green buildings use artificial intelligence (AI) technologies like Building Information Models, Machine Learning, Deep Learning, and others to increase resource efficiency, energy efficiency, and resident safety and comfort (7). AI is also used in environmental monitoring, helping to analyze large amounts of data, identify trends, and predict and handle crises in the oil and gas sector. Additionally, by predicting the effects of climate change, monitoring the spread of illness, understanding human decision-making, and identifying areas that require attention, Civil Society Organizations (CSOs) employ AI to safeguard the environment. All things considered, artificial intelligence (AI) is emerging as a significant tool in environmental governance, from operational initiatives to policy formation (8).

By offering ways to mitigate environmental harm and address climate change, artificial intelligence (AI) plays a significant role in environmental conservation. Green buildings use AI technologies like machine learning and deep learning to increase resource usage, energy efficiency, and environmental adaptation (9). Numerous sectors apply AI-based environmental protection solutions, such as creating sustainable industrial methods and simulating climate change. To ensure long-term sustainability, it is crucial to take into account AI's detrimental environmental effects and create energy-efficient AI models. To address the environmental aspect of AI and ensure its ethical and sustainable use, algorithms must incorporate environmental indicators (10). By enhancing the capacity to control climate change and preserve the ecosystem, AI also supports sustainable urban development. AI is being utilized in China to promote sustainable energy production and increase the effectiveness of environmental governance.

Environmental Challenges and AI-based Solving to Environmental Issues

In the modern world, environmental concerns are a big source of worry. One of these obstacles is how rising temperatures affect the ecosystem and social factors, including water supply issues and extreme weather. Poisons, diseases, environmental stressors, and the processing and administration of health-informatics and medical data are additional problems (11). Another major worry is environmental conservation, which is exacerbated by factors including biodiversity loss, land degradation, and pollution of the air and water [17]. Additionally, research is being done on the utilization of nanomaterials as a possible remedy for environmental problems such contamination and pollution (12). Lastly, it is acknowledged that a significant problem is the need for durable, clean, and renewable energy devices, especially in view of the global warming brought on by carbon dioxide emissions. While AI can be used in a number of industries, such as biodiversity, energy, water, transportation, air, agriculture, and disaster resilience, it can observe and assess data in real time, resulting in it being more efficient in formulating plans and judgments than humans (13). Notably, humans should continue to make decisions based on the results of AI operations, and the data watched by AI needs to be calibrated to account for challenging weather conditions and increase accuracy (14). Artificial intelligence (AI) has the potential to help solve environmental problems by providing long-term solutions and aiding in climate change management.

Long-term sustainability of AI depends on the creation of ecologically friendly AI, and algorithms must incorporate environmental indicators. AI technology can assist in identifying and resolving environmental issues like climate forecasting, air pollution reduction, and wastewater management. The papers cover a wide range of environmental topics, such as climate forecasting, air pollution reduction, and wastewater management. This special issue of Environmental Science and Pollution Research focuses on environmental quality measures, pollution detection, remediation, prevention, management, monitoring, and modeling (15). The three-volume set on hydrology looks at new approaches, management strategies that are both quantitative and qualitative, and the impact of climate change.

A structural model for an automated system to maintain a microclimate in a biotechnological air purification filter is also presented by the authors. This model entails predicting air pollution levels for short- and medium-term forecasts. An intelligent air purification and environmental monitoring system can be constructed using these models (16).

AI's Possible Effect on Sustainability and Environmental Data Monitoring and Analysis

By encouraging environmental habits, combating climate change, and achieving the Sustainable Development Goals (SDGs), artificial intelligence (AI) has the potential to significantly impact sustainability (17). In several areas, such as agriculture, transportation, energy, water, biodiversity, and resilience to extreme events, artificial intelligence (AI) can support sustainable environmental development. However, as training AI models can result in significant carbon emissions, it is imperative to address the environmental impact of AI. The development of ecologically friendly AI that is transparent, energy-efficient, and socially conscious is essential to ensuring a sustainable future (18). A faster rate of innovation can be achieved by combining AI and data to forecast environmental impact factors, better plant design and management, optimize processes, and speed up the identification of eco-friendly materials. Intelligent environmental monitoring systems have been developed that monitor and assess a wide range of environmental parameters in real-time using communication technologies, AI algorithms, and multi-sensor data fusion. These systems employ various sensors to gather data, which is then transmitted to a gateway device or central controller (19). The collected data can be processed and examined using AI methods like machine learning and data fusion techniques to enhance the monitoring data's quality and dependability. Using AI algorithms, the system can categorize and identify locations with poor water quality or that surpass specified emission limitations. These systems can also give farmers access to real-time data and indications to aid in decision-making, including crop selection based on weather conditions. AI algorithms and multi-sensor data fusion technology are being used to create intelligent environmental monitoring systems that gather and analyze environmental factors in real time. Developments in crowd-sensing and the Internet of Things have also made it possible to gather vast amounts of urban data, which may be integrated with subjective information using AI models to improve human well-being in urban settings (20).

Applications of AI in the Monitoring and Defense of Endangered Species and the Conservation of Flora and Fauna

Applications of AI have become increasingly significant in wildlife conservation and in identifying and protecting endangered species. More effective animal and habitat monitoring has been made feasible by the advent of smart technology, such as drones and unmanned aerial vehicles (21). Among other AI technologies, convolutional neural networks and machine learning algorithms were employed to evaluate the gathered data and offer important insights for conservation initiatives. However, using AI for animal conservation comes with restrictions and moral dilemmas that need to be resolved. Increased access to big data and digital technologies can help overcome these barriers, although adoption of AI technology in this business has been delayed in some places, including India.

Conservation, Monitoring, and Preservation of Endangered Flora and Fauna

Applications of artificial intelligence could make a big difference in the preservation and conservation of endangered plants and animals. Monitoring and the implementation of conservation programs can be aided by the use of remote sensing data and algorithms to identify habitat loss and changes in land cover (22). Meeting conservation goals and expanding terrestrial coverage can be facilitated by the establishment of site safeguard protocols and the growth of protected area networks. Vulnerable bird species' sustainable habitats under future climate and land-use change scenarios can be predicted using the species distribution model Maxent. When combined with GIS and satellite remote sensing, precise point-location data can provide valuable insights into the status and distribution of fragile species and their ecosystems (23).

Keeping an eye on and stopping illegal poaching

Detecting and tracking illicit poaching activity can be greatly aided by the use of artificial intelligence (AI). Law enforcement and conservation organizations can detect and battle poaching with the use of AI systems that can scan images and identify patterns of criminal conduct (24). Patrolling subsystems, fixed point detection subsystems, and monitoring centers have all been used as anti-poaching monitoring techniques and systems. AI may also be used to predict and model poacher behavior, which would allow for more efficient use of patrols and resources. By integrating AI with surveillance devices like cameras and sensors, poaching can be identified and prevented more successfully (25).

AI-Powered Predictive Models for Climate Change Impacts and Mitigation

Apps that help reduce greenhouse gas emissions, get ready for the effects of climate change, and advance climate research can be made with AI. The energy and carbon footprint of AI systems must be assessed, though, as well as

any potential drawbacks for climate action, such as accelerating the use of fossil fuels that release greenhouse gases. Designing effective AI models that put sustainability first at every stage of their lifecycle—from data collection to model deployment—is essential to ensuring the ethical and significant application of AI in combating climate change. Moreover, integrated assessment models' capacity to direct climate change control strategies can be enhanced by addressing uncertainty and value-laden assumptions (26).

Predicting and Responding to Natural Disasters and Optimizing Renewable Energy Systems using AI

By forecasting solar radiation and wind power output, maximizing energy storage, and ensuring grid stability, artificial intelligence (AI) has become a valuable tool for enhancing renewable energy systems. By enhancing controllability, energy efficiency optimization, cyber-attack prevention, big data management, and predictive maintenance control, it can also be used to increase the energy sector's sustainability and efficiency (27). AI can help emergency management operators prepare for and respond to disasters by integrating with traffic management systems and climate modeling in the realm of natural disaster prediction and response. AI approaches are used in geothermal, wind, ocean, solar, hydro, bio, hydrogen, and hybrid energy sources (28).

While tackling the challenges presented by growing populations and human-caused emissions, we can create an energy infrastructure that is more robust, safe, and effective. Smart networks, smart energy systems, and the integration of renewable energy sources like geothermal, solar, and wind power can all help achieve this. Moreover, energy conservation measures and measurement and verification techniques can be made more accurate, efficient, and consistent through the use of contemporary sensor technology and artificial intelligence algorithms (29). Energy systems can be protected against cyberattacks using frameworks based on hash functions and elliptic curve encryption.

AI in Early Warning Systems and Earthquake, Flood, and Other Disaster Response and Recovery Activities

AI has found widespread use in several phases of disaster management, such as early warning systems and earthquake, flood, and other disaster response and recovery activities. In order to handle disaster-related data and create efficient management solutions, artificial intelligence techniques have been applied (30). AI can automate processes, guarantee quick recovery plan implementation, and offer insights to handle difficult circumstances in the context of disaster recovery planning. Emergency management operators can improve their readiness for and response to natural disasters by integrating AI with traffic management and climate modeling systems (33). To identify the most effective AI technologies for application in Disaster Resilience Management Support Systems (DRMSSs), prospective AI research have been conducted.

AI for resource management and water and energy optimization

Numerous applications of AI technology have been made to improve resource management, including the utilization of energy and water. These technologies include wireless network systems, cloud computing, Internet of Things, optimization systems, and reporting systems (33). In order to optimize crop yields, water and fertilizer use efficiency, and insect and disease management in smart greenhouses, artificial intelligence has been applied in the agricultural sector [85]. Mult objective optimization algorithms have been created to address the complexity of the Food, Energy, Water (FEW) Nexus to achieve sustainable resource production and consumption (34). Additionally, AI-based models for conserving and allocating water resources have been created, which reduces energy and water use. Water professionals, data scientists, social scientists, and humanities specialists must work together to implement responsible AI techniques in the water domain, which include decision support, modeling, prediction and forecasting, operational management, and optimization (35).

AI-Powered Farming Methods, Precision Agriculture, and Waste Management

Computer vision, artificial intelligence, machine learning, and deep learning are some of the cutting-edge technologies used in precision agriculture and AI-driven farming methods, which have revolutionized the agricultural industry. Crop and animal monitoring, yield optimization, crop grading and sorting, pest and disease diagnostics, and pesticide spraying are just a few of the farming applications that have made use of these technologies (36). Additionally, by identifying problem areas and offering remedies, artificial intelligence (AI) technology—such as seasonal forecasting models, AI sensors, and AI camera-enabled drones—has been used to enhance agricultural certainty, reduce pesticide use, and boost crop yields. Additionally, by harvesting crops,

detecting and eliminating weeds, and improving agricultural management, AI bots have been developed to augment the human labor force (37). Together with waste management strategies, these precision farming methods can support sustainable farming and guarantee food security in the future.

Governance of Environmental Policy and Decision-Making

Decision-making processes pertaining to the environment and natural resources that involve a large number of actors at the regional, subregional, and national levels are referred to as environmental governance. In order to promote ecologically sustainable development, it integrates values like accountability, efficacy, transparency, equity, and involvement. Examining the application of sustainable development principles, assessing national and international environmental laws, and working to build a strong basis for global environmental standards are the main objectives of the Rio + 20 conference. For the purpose of managing the environment and natural resources, environmental governance includes both official and informal processes and organizations as well as a range of laws, regulations, and policies (38). Stakeholder inclusion, openness, handling ambiguity, and striking a balance between science and values are all essential to environmental governance policy and decision-making.

Successful AI Applications in Environmental Protection in the Real World
A wide range of environmental preservation initiatives have successfully employed artificial intelligence (AI). By addressing environmental issues and promoting biodiversity conservation, artificial intelligence (AI) has been essential in achieving the Sustainable Development Goals (SDGs). AI has been applied to heavy metal pollution to identify sources of contamination, evaluate risk, and direct remedial methods. AI techniques have been employed by environmental scientists and engineers since the 1950s to address issues like image processing, climate estimate, weather forecasting, and optimization. Applications of AI have also been applied in fields like agriculture, transportation, energy, water, biodiversity, and resilience to extreme weather.

Emerging Developments and Trends in AI for Environmental Protection
A wide range of environmental preservation initiatives have successfully employed artificial intelligence (AI). By addressing environmental issues and promoting biodiversity conservation, artificial intelligence (AI) has been essential in achieving the Sustainable Development Goals (SDGs). AI has been applied to heavy metal pollution to identify sources of contamination, evaluate risk, and direct remedial methods. AI techniques have been employed by environmental scientists and engineers since the 1950s to address issues like image processing, climate estimate, weather forecasting, and optimization. Applications of AI have also been utilized in fields like agriculture, transportation, energy, water, biodiversity, and resilience to extreme weather. Furthermore, with an emphasis on monitoring and prediction, AI technologies have been used to address conservation-related challenges.

CONCLUSION:

In summary, the innovative use of artificial intelligence (AI) to environmental conservation marks a turning point in our collaborative efforts to address the grave issues facing our world. AI proves to be a powerful partner as we tackle the challenges of resource depletion, biodiversity loss, and climate change, offering innovative solutions and game-changing potential. In addition to enhancing our comprehension of environmental dynamics, artificial intelligence (AI) helps us implement targeted and effective conservation efforts by analyzing vast datasets, optimizing resource management, and supporting well-informed decision-making. AI technologies and environmental protection initiatives create new opportunities by enabling real-time ecosystem monitoring, environmental trend prediction, and proactive response to new threats.

Intelligent algorithms guide us toward solutions that strike a balance between ecological preservation and human development, fostering a more resilient and sustainable conservation strategy. Additionally, AI-driven innovations like eco-friendly urban planning, intelligent waste management, and precision agriculture show that technology and environment can coexist peacefully. It is evident that the adventure has only just begun as we commemorate the first anniversary of integrating AI into environmental protection initiatives. AI will continue to develop, adapt, and significantly improve the health of our world if scientists, legislators, and technologists continue to work together. In addition to being a paradigm shift, this meeting point of technology and environmental stewardship is a ray of hope that encourages us to keep moving forward in the direction of a prosperous and healthy coexistence with our cherished planet Earth.

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