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ARTIFICIAL INTELLIGENCE IN ENVIRONMENTAL SCIENCE AND ENGINEERING: A REVIEW OF APPLICATIONS, CHALLENGES, AND SUSTAINABLE FUTURES

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Abstract

In environmental engineering and science, artificial intelligence (AI) is becoming an essential tool which deals with serious global issues such as pollution, biodiversity loss, climate change and helping victims of disasters. The broad range of AI applications emphasized in this review article includes waste management, disaster anticipation, air and water quality assessment, climate modelling process and monitoring of the environment. AI technologies such as neural networks and deep learning have significantly improved the processing of data, real time forecasting and decision making process. These advancements promote resource efficiency, enable early warning systems to be accessible and increase the success rate of environmental solutions. Public health and the safeguarding of ecosystems that are natural both benefit from the massive, precise information gathering and analysis made available by the integration of the AI into environmental tracking mechanisms. For effective accountable AI execution, data restrictions, model transparency, excessive use of energy and ethical issues have to be overcome. The role of AI in achieving sustainable development goals (SDGs) and affecting future environmental laws are both addressed. This paper also highlights that AI has the potential to completely change environmental investigation and engineering through looking at current advances, limitations and potential future developments and it also promotes ethical development and multidisciplinary collaboration in order to achieve for a long time sustainable development.

Introduction

Artificial intelligence (AI) has recently captured significant public interest and is widely considered as a transformative technology set to shape the future (Cheng et al., 2024). Over the development of many a long time, AI has developed from a simple set of "if-then" principles to consist of complicated algorithms that stimulate how the human brain works (Kaul et al., 2020). AI has a mile longer records than most of the people realize, with philosophical and medical foundations that cross returned to historical Greece. But Alan Turing and the 1956 Dartmouth college meeting, when John McCarthy first used the word "Artifical

Intelligence," which he described as "the science and engineering of constructing functional machines," are largely accountable for its current shape (Collins et al., 2021). AI has attracted both public and scientific interest and is enlarged by the emergence and greater accessibility of chat-based applications such as ChatGPT (OpenAI, LLC) and Bard (Google, LLC). The goal of artificial intelligence, a hastily developing discipline of computer science, is to create robots or computational models which could perform a variety of intellectual activities at degrees which are on par with or even higher than human intellect (Lin & Chou, 2022). Medical discovery is regularly using AI to improve and accelerate studies methods. It allows researchers create hypotheses, plan experiments, examine big datasets, and find insights that might not had been viable with convenient conventional scientific techniques (Wang et al., 2023).

Due to their quick development and effective solutions, AI technologies have become more and more popular in a consequences of disciplines and look at regions. As the result of fields, along with environmental technological know-how and engineering, these technologies provide a wealth of blessings for each person and specialists. Recent studies display a growing hobby in the usage of AI technologies to decorate environmental research and engineering, no matter the truth that AI has been comparatively inactive in the environmental area for decades (Konya & Nematzadeh, 2024). Environmental pollutants and habitat destruction are troubles that civilization has been facing recently. The developing environmental problems, particularly in growing nations, have increased human subject for the environment (Ogiemwonyi et al., 2023). As to Acheampong and Opoku (2023), environmental dangers resulting from environmental degradation are taken into consideration to be one of the biggest obstacles to conducting the Sustainable development dreams (SDGS). Degradation of ecosystems, the loss of species, and the depletion of sources including soil, water, and air are all examples of environmental degradation. According to Choudhary et al. (2015), it's miles any alteration or disruption to the environment that is deemed adverse or undesired. The tremendous stresses that human activities are known to vicinity in the surroundings have led to their sizable reputation as a number one motive of environmental deterioration (Scrucca et al., 2018). The tremendous release of greenhouse gases into the environment is also an end result of human activity (Vale et al., 2020). At the worldwide stage, climate change is the serious environmental problem because of the increasing levels of greenhouse gases (Guo et al., 2021).

Current studies spotlight how AI is becoming increasingly important in earth system modeling and weather technology. AI methods particularly artificial neural networks have outperforming conventional strategies in temporary water demand predication (Jain & Ormsbee, 2002). AI applications play a greater role in comprehending, monitoring, and mitigating environmental problems (Gundeti et al., 2024). Through using statistics, sensing devices, and studying algorithms, AI is a relatively advanced gadget that holds splendid promise for evaluating, forecasting, and decreasing the dangers associated with climate trade. To lessen the effects of climate change, it generates projections and does calculations before acting as it should be. Additionally, AI improves knowledge of the way weather alternate affects exclusive parts of the area (Amiri et al., 2024).

The environmental monitoring is necessary to ensure that populations may additionally lead healthy lives. Environmental monitoring (EM) encompasses handling and preparing for catastrophes, stopping pollution, and correctly tackling the problems because of unhealthful environmental circumstances (Ullo & Sinha, 2020). We will reach a new step of comprehension and enhance prediction capacities by way of incorporating AI algorithms into environmental tracking structures (Pattyam, 2021). In the end, there is a remarkable danger to achieve greater resilient and sustainable environmental control techniques by way of incorporating AI into environmental monitoring and forecasting (Avaz, 2024).

AI is becoming a feasible alternative for treating water as a way to success over the drawbacks of traditional strategies. AI techniques are quite advantageous in water purification and wastewater treatment processes because the automation of such facilities resulted in easy and low cost operations; in addition to the significant reduction in the occurrence of human errors (Safeer et al., 2022). In line with market research, the water business is spending increasingly more in artificial intelligence these days, with projections showing that through 2030, this expenditure would overall $6.3 billion. Additionally, with the aid of slicing costs and optimizing the use of chemical compounds in water treatment, AI is expected to decrease operating expenses by 20 to 30% (Alam et al., 2022). AI structures can also compute water satisfactory traits which can be hard and time-consuming to evaluate the usage of conventional strategies like fuel chromatography-mass spectrometry (GC-MS). This makes it feasible to diagnose water great fast, thoroughly, and affordably. Moreover, AI has historically been visible as a "black container," concentrating best on input factors and output effects while providing little perception into the underlying mechanisms (Li et al., 2021).

In line with Amann et al. (2020), the biggest environmental risk issue for human health globally is modern-day exposure to ambient air pollution. As the deadliest kind of pollution (world bank, 2016) and one in all the biggest environmental risks to human fitness (UNECE, 2020), air pollutants has had a giant poor impact on human fitness and fine of lifestyles in latest decades. According to WHO (2016), it causes around 6.5 million deaths globally every year (Anjum et al., 2021). Artificial intelligence (AI)-based methods have become the most powerful and forward-looking approaches for air pollution forecasting because of their specific features such as organic learning, high precision, superior generalization, strong fault tolerance, and ease of working with high-dimensional data. The most widely used AI-based techniques for air pollution forecasting namely Artificial Neural Networks (ANN), Deep Neural Network (DNN), Support vector machine (SVM) and Fuzzy logic through a systematic literature review (SLR) (Masood et al., 2021).

AI has gained a lot of interest in the atmospheric and medical sciences in current years as one of the most drastically used technology strategies for controlling and mitigating the negative consequences of various air pollutants. To become aware of, cure, and manage illnesses related to air pollution, a few researchers have used AI strategies as medical choice support systems (Masood & Ahmad, 2021). AI has discovered huge use in environmental engineering to tackle issues of waterborne disease, air pollutants, water and wastewater treatment modeling, soil remediation simulation, and strong waste management (SWM) strategy planning (Abdallah et al., 2020). As a result, the concern of municipal solid waste management (MSWM) has a number of promises for the use of deep getting to know. However, students in this subject are no longer very well tested the thoughts and strategies of deep mastering (Lin et al., 2022). Those factors advise that AI might and should be a key thing in achieving the 17 Sustainable development strategies (SDGS) (Palomares et al., 2021).

1. AI Applications in Environmental Science and Engineering

The several uses of AI in environmental studies and engineering are discussed inside the sections that follow.

1.1. Applications of AI in Weather Prediction and Modeling

In the twenty-first century, climate change has end up a worldwide trouble that affects every side of human existence in every country (Usman et al., 2024). Rising ocean temperatures, sea level rise, ocean acidification, and an increase in the frequency of extreme weather activities make it a serious global danger that is already affecting the planet. According to Ford et al. (2022), those changes are generating extensive ecological and socioeconomic impact that is simplest going to emerge as worse. Global suggest temperatures have reportedly risen by using 0.6 °C since 1950s.

Decreased agricultural productiveness, soil erosion, desertification, surroundings deterioration, ocean acidification, depletion of freshwater sources, biodiversity loss, and ozone layer depletion are only some of the results of this temperature increase (Cuschieri & Calleja Agius, 2021). Several multidisciplinary clinical studies have focused on climate exchange for the reason that it's far a very complicated trouble with many difficult ramifications. This has brought about the accumulation of a substantial quantity of facts on the weather device (Mesarović, 2019). The Paris Agreement is a legally binding (there is no legally binding target, but the obligation to regularly set improved national targets is binding) international treaty on climate change. Its goal is to limit global warming to well below 2, preferably to 1.5 ∘C, compared to pre-industrial levels (Dewitte et al., 2021). Countries throughout the world are recognize that it is necessary to mitigate climate change by resolving to decrease emissions and utilizing technology to reduce the generation of greenhouse gases emissions (Yang et al., 2023). In order to guide societal activities and inform coverage for climate change models and mitigation, climate modeling and climate services are critical (Hewitt et al., 2020). Understanding and forecasting the Earth's climate system requires weather modeling. It simulates interactions among several elements of the Earth system, including the environment, seas, land floor, and ice, and the use of mathematical models. In line with Bala and Pandey (2020), those models are vital for learning historic climate versions, forecasting future weather adjustments, and assessing the consequences of human activity on the weather. The broad field of Earth system science appears to be well suited for the application of (Deep Learning) DL technique. Ever-increasing amounts of Earth system data are available, from heterogeneous sources ranging from sophisticated Earth Observation (EO) satellites to massively deployed low-cost crowdsourcing sensors. Most of the algorithms and models used to exploit those data are still designed by hand and suffer from insufficient scalability when large amounts of data are considered (Dewitte et al., 2021). Those models are based on a wealth of climatic records gathered over many years and are based on the bodily and chemical characteristics of the climate system. They undergo validation to guarantee that the version faithfully depicts the actual weather system (Reichle, 2023). The mathematical formulas used to forecast atmospheric conditions, which include momentum, electricity, and water mass conservation, make up a weather model. It expresses unknown processes the use of known variables using schemes and parameterizations. Those nonlinear equations, along with turbulence, which have no analytical solutions, are resolved by the use of numerical methods (Liu et al., 2024). A general move version, or GCM, is a mathematical model that mimics ocean currents, planetary atmospheric movement, or their interactions. It examines essential hydro-climate interaction factors at diverse temporal and geographical resolutions (Thokchom, 2020). Usually 3-dimensional, regional climate models (rcms) are much like gcms but are made to represent a specific area of the world using global facts from reanalyzing gcms as boundary conditions. Rcms always have a finer resolution than the original global facts set because they dynamically downscale the global dataset to a better decision for the place of interest (Abiodun & Adedoyin, 2016). Comparing the output of sophisticated climate models with recent climatic observations allows for the evaluation in their performance (Navarro & Merino, 2022).

Artificial intelligence is becoming more and more important in weather forecasting due to the complexity of climate models and the enormous quantity of data from observation satellites. AI is widely utilized to enhance accuracy, decrease prediction bias, discover new climate models, and evaluate data (Chen et al., 2023).

The climate is primarily changing due to the accumulated anthropogenic emission of carbon dioxide, with an expected atmospheric lifetime extending from centuries to millennia. (Dewitte et al., 2021). Many countries have these days embraced AI-based methods which include Adaptive Neuro-Fuzzy Inference systems (ANFIS) and artificial Neural Networks (ANN) to forecast rainfall depth while accounting for weather and weather (Pham et al., 2020). In step with latest research by using Unal et al. (2023), the AI version predicts summer months more accurately than winter months, which is comparable to the imply CMIP6 performance. Heatwaves may be accurately and reliably predicted through device studying algorithms. Device studying for heatwave prediction is a more powerful and reliable technique than traditional strategies, with major advantages for communities and selection-makers (Mane et al., 2023). Furthermore, AI has shown itself to be a powerful tool for evaluating and growing carbon markets, producing extra precise models of carbon charges, including dynamic carbon pricing mechanisms, and constructing more potent evaluation fashions for projecting carbon fees. Studies of carbon trading programs, including the ones in China and the UK, have used those techniques (Lewis et al., 2024).

1.2. Applications of AI in Disaster Management and Prediction

Natural and man-made disasters both have a massive impact on how the surroundings features on earth. Natural catastrophes happened long earlier than humans, and they may probably remain for as long as the earth exists (Lee, 2018). Natural failures have ended up becoming increasingly more common within the remaining several decades. Floods, droughts, heavy rains, wildfires, excessive temperatures, volcanic eruptions, earthquakes, landslides, tsunamis, and avalanches are the various most common natural calamities (Kourkouli, 2023). Adverse natural fasten ups have been occurring more regularly for the duration of the globe in latest years, which has severely harmed economic increase and social infrastructure (Zhou et al., 2018). Statistics for 2017 indicate economic losses from natural hazards in the USA exceed $300 billion; Hurricane Harvey alone has caused $125 billion in socioeconomic losses (Sun et al., 2020). One of the most crucial troubles facing the arena now could be effective catastrophe management (Rajan et al., 2021). With the main goal of allowing emergency managers to successfully react to vital events and plan for catastrophes, the development of speedy and efficient emergency control (EM) systems has grown to be more vital (Huang et al., 2021). Using AI to analyze the voluminous data to rapidly extract useful and reliable information becomes increasingly popular for supporting effective decision-making in disaster management (Sun et al., 2020). AI applications in various areas of disaster management such as hazard risk assessment, vulnerability assessment, early warning systems, disaster detection, event mapping, damage assessment, disaster rescue and relief and resource allocation (Linardos et al., 2022). With applications which include prediction, alternate detection, early warning structures (EWSS), vulnerability and risk management, spatial modeling, and mitigation techniques, AI has sizable promise within the geohazard quarter. Get right of entry to widespread amounts of atmospheric, climatic, and faraway sensing facts encourages researchers to create novel approaches that facilitate straightforward choice-making for upcoming geohazards (Albahri et al., 2024). Furthermore, AI may additionally improve decision-making with the aid of imparting accurate, actual-time statistics that facilitate catastrophe response teams prioritize obligations and allocate assets effectively (Ghaffarian et al., 2023).

ML and DL enable the utilization of big and complex datasets in order to develop systems that can predict disasters as well as assist during the response and recovery after such events and practical decision-support tools have been developed (Linardos et al., 2022).

Decreasing flood damage is mostly depending on flood prediction modeling and tracking. The improvement of machine learning (ML) strategies and the provision of huge amounts of hydrological information, together with streamflow and precipitation, have significantly progressed flood prediction competencies. Research comparing ML-based totally fashions with bodily and conventional statistical models suggests that ML fashions offer higher flood predicting accuracy (Mosaffa et al., 2022). Deep learning models have proven encouraging capability to improve accuracy and provide a higher expertise of typhoon dynamics in tropical cyclone prediction. These methods offer crucial insights for catastrophe making plans and response through enhancing forecasting and higher predicting cyclone behavior (Hao et al., 2024). Interpretation beyond occasion styles recorded by way of measuring devices and the usage of these insights to predict destiny seismic activity is one of the possible benefits of the use of AI for earthquake prediction. This method could contribute to higher early caution structures and multiplied earthquake readiness (Pwavodi et al., 2024). The use of deep getting to know models, particularly convolutional neural networks (CNNS), to perceive low-magnitude tremors—which is probably symptoms of extra effective, catastrophic earthquakes is growing. Those approaches can interpret seismic spectrum information from unmarried-station seismograms by means of taking gain of the common individual of tremors, which permits for the early identity of viable seismic risks. We will lessen the catastrophic outcomes of those life-threatening occurrences by way of growing readiness and prompt reaction by using developing gadget mastering packages in earthquake prediction (Dey et al., 2022). Certainly, the future of disaster management, AI is an effective force multiplier that substantially improves our capability to protect populations throughout emergencies. Governmental businesses, however, want a fundamental development approach that ensures AI deployment is both powerful and available on the way to successfully include AI into catastrophe response. To enable a clean and extensive integration of AI into emergency management processes, this strategy should include essential infrastructure, facts accessibility and regulatory frameworks (Abid et al., 2021).

1.3. Applications of AI in Environmental Monitoring

To protect the environment and human health, environmental tracking is critical. Regardless of upgrades on top of mechanisms, pollutants maintain growth due to population increase, commercial improvement, and increased energy use. In order to properly manage and reduce environmental dangers, this reality emphasizes the non-stop and essential necessity thorough environmental monitoring (Artiola & Brusseau, 2019). Weather exchange, pollutants, deforestation, and the loss of natural sources are a number of the issues which have brought about a major boom within the need for widespread environmental tracking in current years. To fully discover and mitigate environmental consequences, these problems want great information (Shalu & Singh, 2023). By permitting thorough evaluation of geographic information the use of techniques like information fusion and far-flung sensing, AI revolutionizes environmental monitoring and conservation. Those strategies enhance our potential to sing and effectively address ecological outcomes by permitting the large-scale identity of environmental modifications, which include adjustments in land use and erosion (Himeur et al., 2022). Using wireless sensor networks, AI-assisted semantic net of things (AI-SIOT) gadgets analyze environmental data with first rate precision and performance. These technologies provide context-conscious, real-time environmental monitoring, which improves statistics-driven decision-making for conservation and sustainable management initiatives (Zhang et al., 2021). Drones the usage of AI and Convolutional Neural Networks (cnns) are great at detecting and classifying forest fires. They can quickly identify hearth hotspots and differentiate among distinctive forms of fires. By assisting early warning structures, this sophisticated potential permits faster reaction instances to prevent the unfolding of fires and lessen environmental harm (Anitha et al., 2024). Various artificial neural networks employed in wastewater degradation process for the prediction of removal efficiency of pollutants and the search of optimizing experimental conditions; ii) Evaluation of fuzzy logic used for intelligent control of aerobic stage of wastewater treatment process; iii) AI-aided soft-sensors for precisely on-line/off-line estimation of hard-to-measure parameters in wastewater treatment plants; iv) Single and hybrid AI methods applied to estimate pollutants concentrations and design monitoring and early-warning systems for both aquatic and atmospheric environments; v) AI modelings of short-term, mid-term and long-term solid waste generations, and various ANNs for solid waste recycling and reduction (Ye et al., 2020). Programs of AI are critical for tracking animals, comparing habitat, studying biodiversity, and forecasting natural failures. AI improves conservation efforts and catastrophe practice with the aid of evaluating a selection of records assets, such as digital camera lure video, drone photographs, and acoustic recordings. It also displays units surrounding fitness, identifies species, and affords early warnings for calamities like floods (Chisom et al., 2024).

1.4. Applications of AI in Solid Waste Management

As most waste management problems are inherently complex and ill-defined, it is evident that traditional methods based on mechanistic models and strict algorithms do not look like to provide an adequate solution in many cases, particularly those suffering from lack of data. AI models offer an alternative effective approach which has gained significant attention in the scientific community. Artificial intelligence (AI) techniques have gained momentum in offering alternative computational approaches to solve solid waste management (SWM) problems (Abdallah et al., 2020). With its capability to resolve issues including trash manufacturing forecasting, bin level detection, method parameter prediction, truck routing, and strategic making plans, AI has emerged as a sport-converting era in solid waste control (SWM). In keeping with Abdullah et al. (2020), these programs maximize sustainability and performance in SWM operations. Those uses demonstrate AI's potential to handle uncertainty, modify via training, and address complicated, unclear issues in solid waste management (SWM) (Ihsanullah et al., 2022). AI-primarily based models outperform conventional approaches in predicting garbage production and recycling fees, presenting incredibly higher prediction accuracy (Andeobu et al., 2022). Despite the fact that, obstacles which includes restrained actual-global applicability, poor repeatability, and restricted statistics availability stay foremost obstacles (Ihsanullah et al., 2022). Although research in this field is rapidly advancing, AI-based SWM systems are still mostly in the research and development (R&D) phase. Identifying the limitations of these techniques is crucial for future planning of robust AI-based SWM applications (Abdallah et al., 2020). Notwithstanding these obstacles, AI has great promise for reworking SWM methods and selling advancements in social welfare, environmental sustainability, and financial performance (Andeobu et al., 2022). AI technology integration into SWM is increasingly more crucial for achieving sustainable waste management practices because of the growth in trash creation (Kumari et al., 2023).

2. AI Strategies in Environmental Research

For the reason that in the 1980s, AI has been greater time-honored in environmental research, with programs spreading to fields which include pollution prevention, weather modeling, and natural aid control (Haupt et al., 2022). Applications of AI procedures have stepped forward image processing for environmental monitoring and conservation, stepped forward climate estimate models, and improved the accuracy of climate forecasting (Haupt et al., 2022). Over 65 % of environmental tasks that demonstrate interest in using AI tools initially relied on conventional statistical and mathematical models. Using AI tools can greatly benefit the areas of environmental science and engineering. One of the main advantages of utilizing AI tools is their ability to analyze and process large amounts of data efficiently (Konya et al., 2024). Latest advances in deep mastering have considerably improved the use of AI in environmental responsibilities through allowing more correct forecasts, intricate pattern recognition, and faster records processing in fields inclusive of pollution detection, weather modeling, and ecosystem tracking (Konya &

Nematzadeh, 2024). With predictive abilities that manual remediation operations and maximize resource allocation for environmental cleaning, AI has proven promise in detecting and controlling heavy metallic infection (Miller et al., 2023). AI and system studying are supporting environmental health researchers higher recognize the origins of pollutants, forecast chemical toxicity, and estimate human exposure to toxins. This enables threat assessment and the creation of focused public fitness interventions (Earth, 2019). However, AI's promise in environmental fitness studies, troubles such as bias, information fine, and AI systems' interpretability still exist. Reliable, honest, and obvious results in AI-driven environmental fitness programs rely on addressing those issues (Earth, 2019). Certainly, AI is still a beneficial tool for addressing pressing environmental issues, even within the face of limitations like interpretability and facts excellent. Its ability to assess sizable datasets, forecast styles, and improve solutions keeps pushing sustainable practices in a variety of industries, including resource control, pollution prevention, and weather adaptation (Konya & Nematzadeh, 2024; Miller et al., 2023). The amount of power consumed and the time required to train an AI model can greatly affect the carbon emissions it produces, exacerbating the challenges posed by climate change. Efforts are currently underway to develop AI technology that is environmentally sustainable, minimizes energy consumption, and has a low carbon footprint (Konya et al., 2024).

3. Obstacles and Restrictions

AI is important to environmental science and engineering as it gives strong devices to address tough troubles. It is able to deal with huge datasets quickly, boost the precision of predictions about pollutant removal, and optimize experimental settings for a diffusion of environmental sports, consisting of waste control, air best manipulate, and water treatment. These capacities offer advanced aid control, accelerated environmental sustainability, and greater informed choice-making (Konya & Nematzadeh, 2024; Ye et al., 2020). Particularly beneficial packages of system studying procedures encompass result prediction, vital function identification, anomaly detection, and the invention of novel substances (Zhong et al., 2021). But, a number of boundaries face AI applications on this domain, such as reliance on ancient information, human conduct this is unpredictable, cybersecurity threats, and difficulties comparing the outcomes of interventions (Nishant et al., 2020). Due to the fact teaching methods may additionally use a variety of energy and boom carbon emissions, the environmental results of AI are also a worry (Konya & Nematzadeh, 2024). Specialists in AI and the environment have to work together to fully realize AI's promise in addressing environmental troubles. Research needs to include systems dynamics methodologies, multilevel viewpoints, and mental, social, and financial aspects (Konya & Nematzadeh, 2024; Nishant et al., 2020).

4. AI's function within the d estiny of Sustainability

Through sophisticated analytics and predictive modeling, AI has proven to be a game-changing tool for addressing environmental sustainability troubles, assisting conservation, resource control, and climate exchange mitigation (Lohani, 2024). Applications of AI have the potential to revolutionize a number of critical fields, consisting of pollution control, agriculture, ocean health, catastrophe resilience, and renewable energy optimization (Yadav & Singh, 2023). Implementing AI for sustainability has demanding situations in spite of its ability, which include reliance on historical records, unpredictable human reactions to AI interventions, and cybersecurity flaws (Nishant et al., 2020). It is vital for the development of responsible AI in businesses that are dedicated to sustainability to integrate ethical AI with the IoT and business processes (Hosen et al., 2024). Researchers suggest a comprehensive approach that carries environmental, social, and monetary factors so that you can absolutely understand AI's promise in sustainability (Naeeni, 2023). To increase powerful AI-driven sustainability answers, destiny research ought to encompass psychological insights, systems dynamics, and multidimensional perspectives (Nishant et al., 2020). In the long run, constructing public consider and inspiring sustainable environmental stewardship relies upon enforcing moral and open AI practices (Naeeni, 2023).

5. AI and Environmental Policy

The use of AI to conservation and environmental policy is turning into greater widely typical. By improving selection techniques and optimizing effects in the social, economic, and environmental spheres, it helps sustainable policymaking (Milano et al., 2014). AI technologies can improve environmental data processing, assessment, and decision-making by enhancing precision, efficacy, and efficiency (Konya et al., 2024). AI enhances conservation efforts and ecosystem control through assisting with biodiversity evaluation, habitat appraisal, animal tracking, and natural catastrophe prediction (Chisom et al., 2024). AI-primarily based environmental control structures have the capability to growth strength efficiency and foster sustainable economic increase in areas with appropriate regulations and effective market legislation (Ansari et al., 2022). Efforts are currently underway to regulate AI and establish the first comprehensive AI law. In 2023, both the European Union (EU; European Parliament, 2023) and the United States of America (National Conference of State Legislatures, 2023) are working to legislate AI systems that are safe, transparent, traceable, non-discriminatory, and environmentally friendly to prevent harmful outcomes (Konya et al., 2024).

Conclusion

In order to address the pressing environmental problems brought on by human activity, including pollution, climate change, and biodiversity loss, has proven to be a critical device. AI has the potential to make a sizeable contribution to the sustainability of our planet by using enhancing the accuracy of weather models, facilitating real-time environmental tracking, streamlining waste control, and forecasting calamities. Even though AI technologies have many blessings, problems with records great, version accuracy, and ethical troubles continue to be major barriers to their vast use. AI's contribution to environmental research and engineering is growing, establishing the door to greater powerful, data-driven solutions for environmental problems at some point of the world.

Highlights

- Through the use of deep learning and machine learning methods, AI enhances environmental monitoring and modelling processes enabling accurate climate predictions, pollutant recording and prediction of hazards.
- AI transforms solid waste management by predicting the waste production, accelerating recycling and increasing gathering procedures for more sustainable methods.

By combining with a network of sensors, drones, satellite imagery to measure water, air and landscape ecological systems, AI allows immediate decision making

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