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Review Article

Artificial Intelligence for Climate and Environmental Governance: A Review

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Abstract *- A sustainable, clean, and healthy environment is necessary for the basic human rights like health, water, housing, life, and food. Recognising it as a separate right would draw a significant step forward in international human rights law. Clean water, air, a healthy ecosystem, and fertile soil are essentials for health and life. Also, many countries have recognised the right to a healthy environment as a constitutional right in their constitution. The study aims to examine the right to a clean environment in India and the impact of climate change on it. It also analyses the applications, challenges, and opportunities of integrating Artificial Intelligence in climate action and environmental governance. Artificial Intelligence can transform environmental governance in India by enabling real-time monitoring, predictive analytics, and proactive interventions to combat pollution and climate risks. Despite challenges like data quality and inclusivity, AI-driven collaboration fosters stronger laws, equitable resources, and sustainable development, securing citizens' right to a healthy environment.*

Keywords *- Artificial Intelligence, Environmental Governance, Predictive Analytics, Climate Resilience, Pollution Monitoring.*

1. Introduction

SDG 13 closely aligns with the right to a healthy and clean environment, and climate action emphasizes combating climate change and its impacts. Protecting the right to a healthy and clean environment helps in reducing degradation of the environment, which also includes deforestation and pollution, by promoting climate resilience. It promotes healthier conditions for living and safeguards communities from the hazards related to climate. By combining the legal framework with the sustainable practices, it helps in achieving the climate action goals [1]. A sustainable, clean, and healthy environment is necessary for basic human rights like health, water, housing, life, and food. Yet, there exists no such global agreement that tells us that it is just a condition for existing rights or an independent human right. Recognising it as a separate right would draw a significant step forward in international human rights law [2]. Clean water, air, a healthy ecosystem, and fertile soil are essentials for health and life. Also, many countries have recognised the right to a healthy environment as a constitutional right in their constitution. While talking about India, although this right is not guaranteed directly, the Hon'ble Supreme Court has expanded Article 21, which is the right to life, to include the right to pollution-free water and air, addressing it as a fundamental right. Through precedents, the Indian courts have mandated protection of the environment by making it possible for NGOs and citizens to ask for remedies despite the procedural delays [3]. The Supreme Court played a vital role in evolving India's green jurisprudence and hence broadened the scope of the 'right to life' to include environmental protection. Public Interest Litigation (PIL) has empowered the groups and citizens to seek remedies, but there exist some limitations also. More recently, the National Green Tribunal (NGT) has been set up for strengthening environmental protection and providing dedicated judicial oversight [4]. Global climate change is mainly due to the rise of greenhouse gas emissions, which is disrupting the ecosystem, agriculture, and societies by affecting the water, soil, and food security. It results in rising sea levels, shifting the patterns of the weather, as well as the spread of diseases and pests, causing serious risks to both human beings and the environment. Hence, there are requirements of policies that promote clean technologies, support climate adaptation and mitigation, and reduce emissions [5]. The no-harm rule of international law says that countries must use their own resources, but there must not be any environmental damage to other nations by the use of those resources. This is recognised by the global agreements, such as the Rio and Kyoto treaties, and highlights the duty to prevent the harm that is foreseeable. If, after this, any environmental harm is caused to a nation by the resource usage of another country, then the country using the resources must compensate the

other country to whom the harm is caused [6]. In the last decades, India was often seen as resistant in the global climate talks, but recently India has taken a more constructive role in these talks, especially at the Paris agreement. India has supported the ambitious 1.5°C goal, quickly adopted the treaty, and launched an international alliance named the International Solar Alliance for supporting and leading the efforts of clean energy. As India is the world's third-largest carbon emitter, these actions by India are now central in achieving the global climate targets, but there is also a requirement for stronger commitments [7]. Artificial intelligence and machine learning are transforming the field of environmental monitoring by enabling real-time tracking, predictive modelling, and analysis of large-scale data. They support applications such as deforestation detection, climate modelling, biodiversity conservation, and pollution tracking [8]. Also, Artificial Intelligence is now a key tool for solving environmental changes by supporting sustainable farming, disaster resilience, climate action, water, and ocean management. It is also helping in improving the efficiency of energy in buildings, promoting low-carbon economies, and reducing construction waste. However, its high usage of energy raises concerns of raising carbon footprints, and hence, more efficient AI solutions are required for future environmental governance [9]. Environmental monitoring is now evolving from the labour-intensive and manual surveys to the smart and intelligent systems powered by Artificial Intelligence and Internet of Things (IoT). IoT sensors now track the water, soil, air, and climate conditions in real-time. While AI helps in analysing the huge data for detecting patterns, predicting risks, and guiding resource management. These technologies together help in smarter, faster, and more effective responses to challenges of the environment and strengthen the efforts of sustainability [10]. Objectives of the study are as follows:

- To examine the right to a clean environment in India and the impact of climate change on it.
- To analyse Artificial Intelligence applications in climate action and environmental governance.
- To identify the challenges and opportunities for integrating AI into sustainable environmental policy.

The organisation of the article is as follows section 2 contains overview of AI in environmental governance, section 3 describes about impact of climate change on environmental rights, section 4 talks about AI applications in environmental governance, section 5 describes Challenges and Limitations of AI in environmental governance, section 6 consists of recommendation and finally section 7 shows the conclusion as per shown in Figure 1.

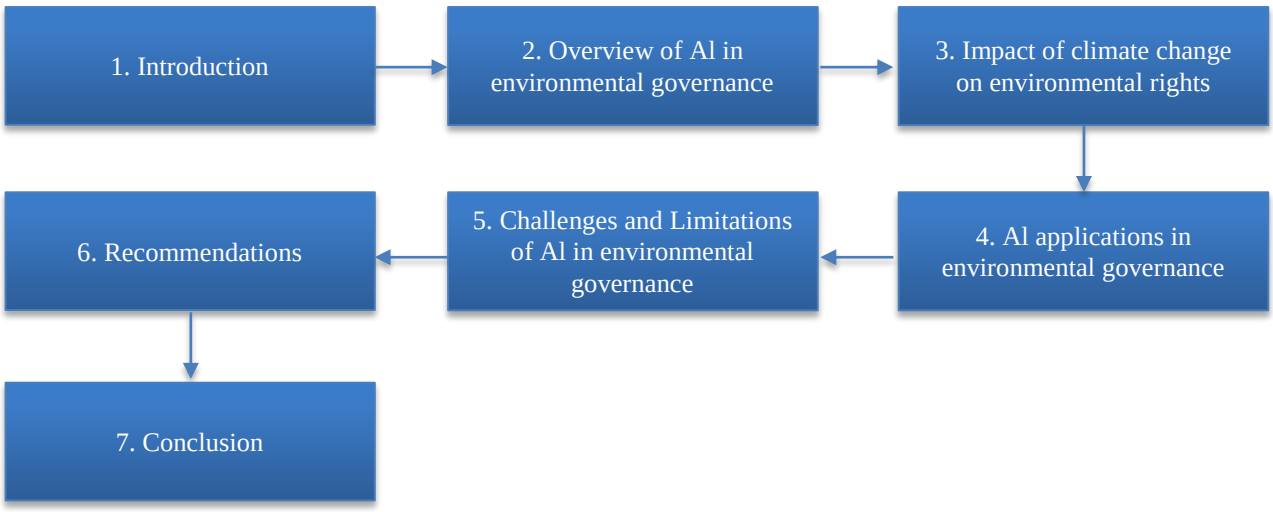

Fig. 1 Organisation of the article

2. Overview of AI in Environmental Governance

Powered by digitalization, IoT, AI, advanced robotics, cloud computing, and smart sensors, Industry 4.0 shows a profound change. Smart factories, also called Cyber Physical Systems (CPSs), connect humans with machines to produce intelligent output, make the procedures automatic and adaptive to shifting demands. Although they were invented in Germany, all regions of the world give similar ideas with various names like IoT, advanced manufacturing, and smart industry [11]. Artificial Intelligence is a discipline of science and engineering that explores and generates systems that have the power to act intelligently. Introduced by Alan Turing and inspired by Aristotle's early logic, modern AI helps machines to perform cognitive activities similar to humans, as assessed by the Turing Test. Technologies based on AI are introduced to replicate human intelligence, such as learning, problem-solving, and reasoning. [12]. Real-time monitoring, decision-making based on data, and sustainable urban management are all made easier by AI and IoT (AIoT), which is developing smarter eco-cities. Various innovative

systems like city brain, smart urban metabolism, and platform urbanism are contributing to better resource consumption, tackling pollution, and addressing climate issues. By connecting such technologies, urban planning could benefit as they improve environmental governance, resilience, and stakeholder engagement in it [13].

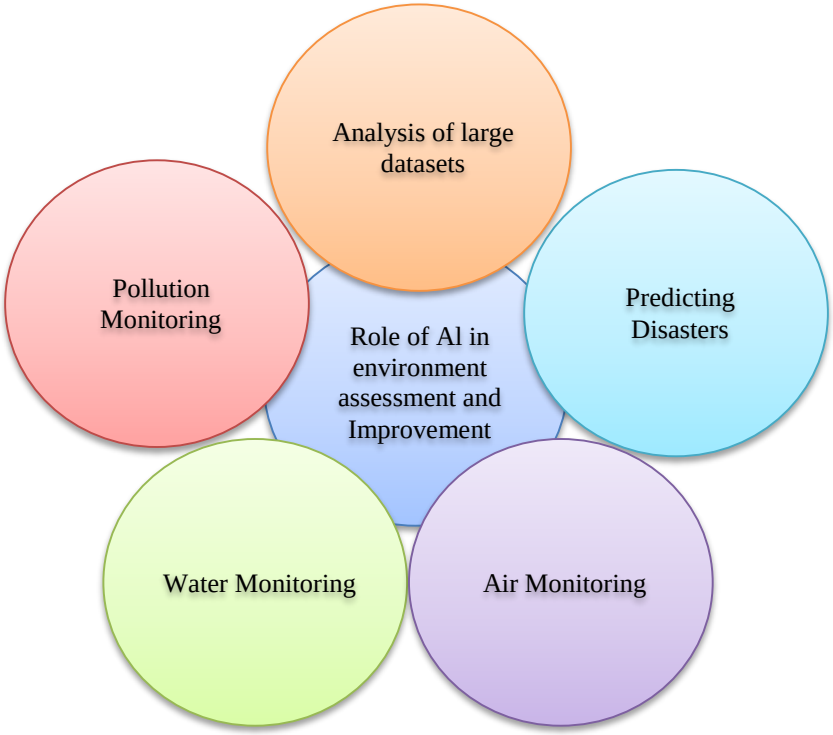

Fig. 2 Role of AI in environment assessment and improvement

Environmental Impact Assessment (EIA) integrates environmental, social, and economic factors into project design, thus playing a prominent role in sustainable development. It works on cost efficiency, legal compliance, and environmental issues, and encourages public involvement. Implementing AI and ML into EIA improves planning, resource management, and ecosystem restoration, also tools like text analytics and NLP expedite document analysis and administrative workflows, fostering efficiency and facilitating data-driven governance [14]. Variability in ecosystems and public health is measured by environmental monitoring; however, conventional setups are expensive, time-consuming, and inaccurate. AI works on these issues by evaluating complex datasets, forecasting calamities, and regulating air, water, and pollutant levels, thereby increasing the efficiency of environmental oversight, as shown in Figure 2 [15]. Though environmental monitoring assesses public safety and ecosystem soundness, it is constrained and expensive. Real-time data gathering, predictive analysis, and effective resource management are made possible by AI, machine learning, IoT, and sensor networks, which foster environmental preservation and regulatory monitoring [16]. The AirQo project monitors and controls urban air pollution in African cities, utilizing IoT and AI. It mixes community participation frameworks, AI-powered visualization tools, high-resolution citizen-driven data collecting, and inexpensive Internet of Things air quality sensors. Despite resource limitations, these methods increase awareness, policy action, and environmental management by giving individuals and decision-makers punctual information. [17]. Sustainable energy management is necessary as dependence on fossil fuels and energy demand are increasing. AI and machine learning can enhance the efficiency, estimate demand, and maximize the integration of renewables; however, clear and integrated solutions are required to attain sustainability and Net Zero goals [18]. AI and IoT use sensors and machine learning to analyse data to enhance better monitoring and prediction of pollution. With the help of these, managing urban air quality and resource organising is done effectively. Yet, issues related to a lack of data, higher expenses, and scattered sources of pollution remain. To improve decision-making and environmental governance, these issues must be addressed [19]. The objectives of smart cities are to establish an ecosystem based on sustainability and enhance every aspect of urban life. Smart cities are created and administered using several emerging technologies, especially AI, that support innovation and efficiency. Various industries, including healthcare, education, green technology, and finance, are broadly influenced by AI. The growing environmental consciousness has also led to the adoption of eco-friendly solutions [20].

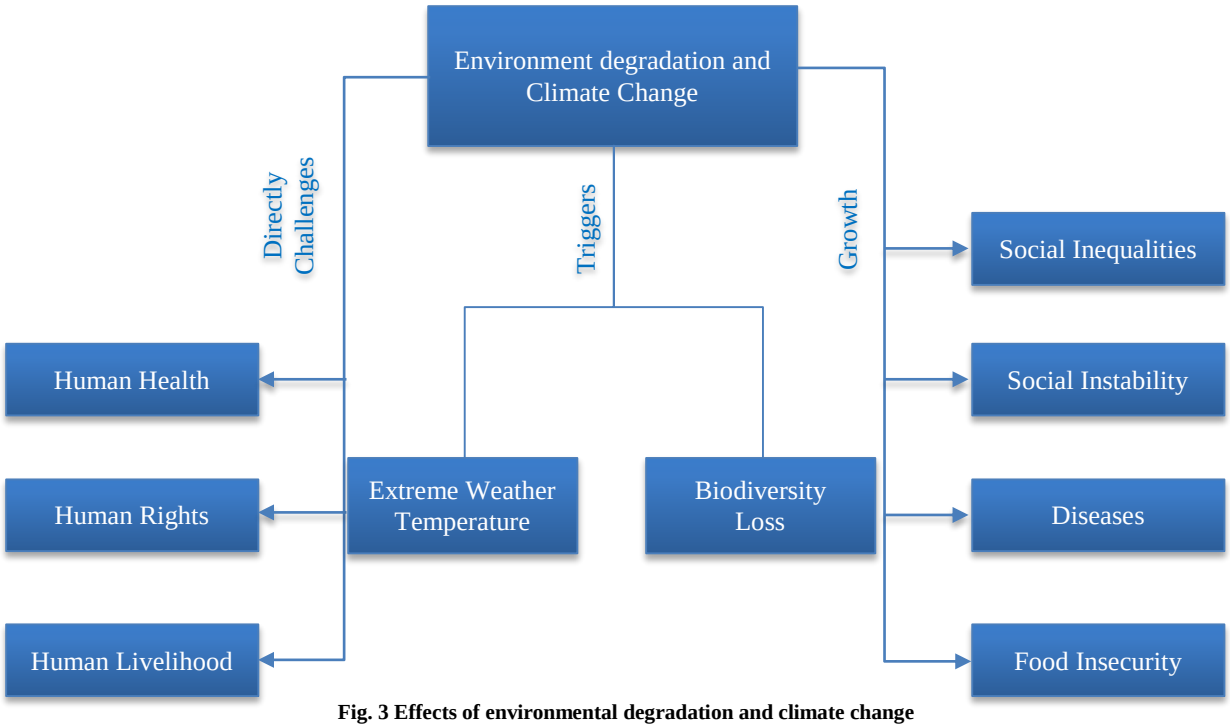

Fig. 3 Effects of environmental degradation and climate change

3. Impact of Climate Change on Environmental Rights

Protection of the environment is an issue of human rights because it directly affects health, life, and property, which holds the government responsible for pollution control and law enforcement. Greening human rights emphasizes procedural rights, access to justice, and public participation in environmental decision-making. When a healthy and safe environment is recognized, it can be linked to human rights and sustainable development, while balancing ecological and economic goals [21].

Environmental degradation and climate change directly challenge human health, rights, and livelihoods while triggering extreme weather events and biodiversity loss. Excessive use of resources and rising pollution have led to an increase in social inequities and environmental harm, resulting in social instability, disease, and food insecurity, as illustrated in Figure 3 [22].

Due to historic emissions, climate change has become inevitable, emphasizing the need for adaptation. However, its scope and effectiveness vary as per the regions, sectors, and income levels. Territories with high income are capable of adaptation, while vulnerable populations are least able to adjust. Measures are often reactive rather than proactive, which leads to a lack of measurable indicators, limited understanding, and fragmented implementation, restricting effective adaptation planning and investment [23]. The MENA region is highly vulnerable to climate change, facing extreme droughts, heatwaves, and aridity, which threaten water resources, agriculture, and livelihoods. Since 70% of agriculture is rain-fed, this indicates a decline in productivity, which leads to migration, increased import dependency, and exacerbates social unrest. The growing population and increasing resource pressures intensify vulnerabilities, creating unprecedented challenges for the region's social and economic systems, as illustrated in Figure 4 [24].

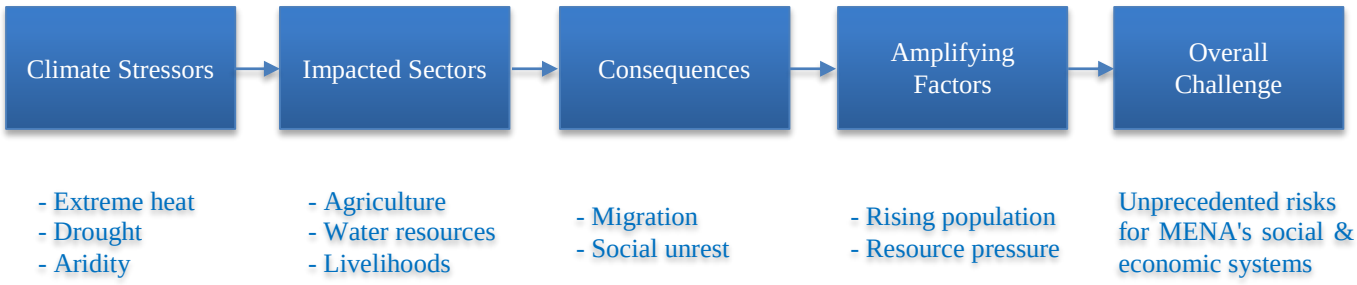

Fig. 4 Pathways of climate vulnerability in the MENA region

Unprotected groups such as children, elders, women, and people with disabilities face most of the risks from climate disasters due to inequality, poor governance, and limited adaptation, which makes them weaker. They do not have access to resources or warning systems that would make them suffer violence and trauma. Therefore, coordinated support and gender-sensitive policies are crucial for enhancing resilience and reducing vulnerability [25]. Health is directly affected by climate change, causing disease, illness, injury, and indirectly by food insecurity, displacement, impacting vulnerable groups like women, children, the elderly, and disadvantaged groups. The public outlook emphasizes the need for targeted climate-health awareness and adaptation strategies, but underestimates personal risk [26]. Communities like those with indigenous and minority populations living in vulnerable regions need locally tailored adaptation due to disproportionate climate impacts. Their traditional knowledge and cultural identity stand out, making them more resilient; yet, multi-level support is equally important. Case studies from Canada, Laos, Nepal, and Vietnam illustrate effective community-based adaptation strategies [27]. Multiple fields have undergone significant transformations since the rise of AI, including environmental management. This paper illustrates the monitoring and mitigation of environmental issues through remote sensing analysis, as well as wastewater and solid waste management. Proactive responses are developed from AI-driven early-warning systems. Overall, AI enables high accuracy, adaptability, and real-time decision-making for a sustainable and resilient future support [28].

Health and the environment are both threatened by air pollution, and AI-based models show better performance than traditional physical and statistical methods. Complex and nonlinear data is handled using Neural Networks, LSTM, GRU, and SVM, which provide high accuracy. AI provides superior prediction and resilience even though a model does not fit every case [29]. AI enhances environmental monitoring by real-time data analysis, species tracking, and habitat assessment using advanced technology like ML, DL, drones, and IoT. Hybrid and Explainable AI (XAI) are advanced for improving accuracy and transparency. However, Data quality and computational challenges exist. For sustainable ecosystem management, ethical frameworks, policies, and collaboration are vital [30].

Table 1. Climate change, human rights, and AI in environmental protection

Research Focus	Scientific Contribution / Findings
Environmental protection & human rights [21]	Establishes legal and ethical frameworks linking environmental sustainability with fundamental human rights obligations.
Climate change & justice [22]	Identifies climate-induced risks (biodiversity loss, extreme weather, food insecurity) and frames them within climate justice discourse.
Adaptation challenges [23]	Evaluates limitations of current adaptation strategies; highlights the lack of standardized indicators and fragmented policy integration.
MENA region vulnerability [24]	Documents regional climate risks (heatwaves, drought, agricultural decline) with implications for migration and political instability.
Inequality & vulnerable groups [25]	Analyzes disproportionate exposure of women, children, the elderly, and disabled populations; calls for inclusive adaptation strategies.
Climate–health nexus [26]	Characterizes direct and indirect health consequences of climate change, emphasizing systemic underestimation of health risks.
Indigenous & minority populations [27]	Demonstrates how indigenous knowledge systems and community-based adaptation enhance resilience to climate change.
AI in environmental management [28]	Highlights AI applications in climate monitoring, early warning systems, waste management, and mitigation strategies.
AI for air pollution [29]	Compares machine learning models (NN, LSTM, GRU, SVM) with conventional methods; shows superior predictive accuracy in non-linear contexts.
AI for ecosystem monitoring [30]	Explores AI-driven biodiversity assessment, habitat monitoring, and integration of explainable AI for transparent decision-making.

4. AI Applications in Environmental Governance

Conservation of biodiversity is facilitated through the use of AI, which aids in the protection of wildlife, dynamic monitoring, and the detection of illegal activities. Precision forestry and sustainability are primarily driven by non-profit organizations and startups in industrialized countries, while many tropical countries are still lagging in the adoption of such methods [31]. Rising temperatures and harsh weather are two ways in which climate change is endangering urban areas. Data-driven and real-time tools for urban climate adaptation are enabled by technologies that leverage artificial intelligence and machine learning. Although mitigating

efforts have been successful, little is known about its capacity for adaptation [32]. Shukla, P. K., et al. employed IoT and AI in their study to detect and forecast air pollution. The system enhances real-time air quality management by forecasting pollution levels and alerting users to dangerous thresholds.

In contrast to conventional monitoring techniques, it seeks to improve sustainability, public health, and cost effectiveness as shown in Figure 5 [33]. Ullo, S. L., & Sinha, G. R. In their study, they employed a Smart Environment Monitoring (SEM) system, which utilizes IoT, wireless sensor networks, and artificial intelligence for real-time monitoring of water, air, soil, and weather. With the use of these smart technologies, smart city management and sustainable agriculture become possible. These systems not only improved resource productivity and overall public health but also provided environmental protection by offering precise data and control [34]. Biermann, F., in his study, used international environmental assessments for reference, but their influence is restricted because of bureaucratic barriers, northern dominance, and a lack of resources. Participation in these evaluations is often symbolic, with developed nations largely dictating the actual agenda. Even though these studies offer scientific guidance, many experts prioritize local research and publication because they are cautious of any Northern bias [35]. Significant environmental factors influencing a naturally occurring slate mine in Quiroga, Spain, are identified using a Bayesian network, which produced an impact index of medium-low with large uncertainty. The impact of Basin Contribution changes on flood zones and flow variations was demonstrated through scenario analysis. The findings demonstrate how AutoML and Bayesian networks can facilitate decision-making and enhance environmentally friendly mining methods [36]. Natural disasters such as floods, droughts, and other such calamities lead to forced migration and endanger human rights in severe Climate-induced Displacement (CiDD) in India. Artificial intelligence can improve early warning systems, weather forecasting, and disaster planning, but ethical application and high-quality local data are crucial. Supporting climate migrants, enhancing humanitarian responses, and building resilience against future climate catastrophes are all possible with the effective integration of AI [37]. By utilizing information collected from sensors, satellites, and climate models, environmental data science and AI collaborate to evaluate and model complex environmental events. Meanwhile, deep learning and machine learning work together to inform policymaking, assess environmental impacts, and predict changes. This integration promotes long-term fixes for problems, including resource management, biodiversity loss, and climate change [38].

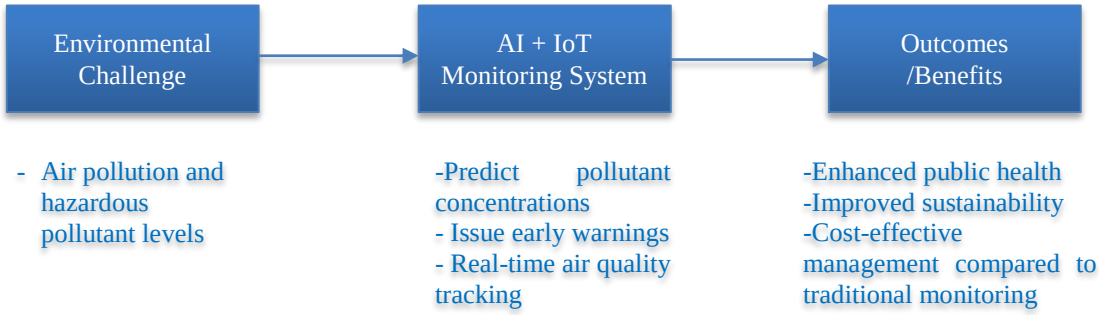

Fig. 5 AI–IoT framework used for predictive air quality management

Evaluating complex environmental data, improving forecasts, and assisting mitigation plans, artificial intelligence is being used more and more to fight climate change. It informs policy decisions and helps forecast weather, extreme events, emissions, and energy efficiency. However, to ensure that AI makes a meaningful and equitable contribution to climate solutions, ethical risks such as biases, privacy concerns, and impacts on human autonomy must be properly addressed [39]. Natural resource conservation is more important now that environmental problems are worsening day by day. We can better monitor, manage, and safeguard natural habitats by combining artificial intelligence with wireless connections. According to studies, ecological protection systems driven by AI are useful, effective, and able to function in real time. They tackle urgent environmental issues while encouraging more informed decision-making to protect ecosystems [40].

Table 2. Applications of AI in environmental monitoring and climate adaptation

Research Focus	Key Contribution
Forest & biodiversity [31]	Real-time monitoring and wildlife protection; adoption lags in the tropics.
Urban climate adaptation [32]	AI–ML supports city resilience; the use of adaptation is underexplored.
Air pollution monitoring [33]	AI+IoT predicts pollutants, issues warnings, and improves health.

Smart environment monitoring [34]	IoT+AI tracks air, water, soil, weather; aids smart cities/agriculture.
Global assessments & India [35]	Limited Southern influence; Northern dominance, local research prioritized.
Sustainable mining [36]	Bayesian networks + AutoML guide decisions, reduce uncertainty.
Climate displacement [37]	AI enhances forecasts and disaster preparation; ethics & local data are crucial.
Env. data science integration [38]	ML/DL with satellite & sensor data predicts change, guides policy.
Climate change mitigation [39]	AI improves forecasts & efficiency.
Ecological protection [40]	AI + wireless systems enable real-time ecosystem monitoring.

5. Challenges and Limitations of AI in Environmental Governance

Strategies for effective environmental governance are needed that address specific challenges, such as balancing local initiatives with global coordination. To enhance adoption and political support, there is a need to frame policies. Long-term systems are required to combine adaptive learning with collective actions. To ensure resilience and sustain commitment, the hybrid governance should involve multiple actors [41]. Communities and civil societies are allowed by social license to operate and to influence organisations beyond legal rules, unlike CSR, which is controlled by businesses. Public engagement, which enables rapid scrutiny and pressure, especially on environmental practices, needs to be expanded through technological advancements, such as ICT and media technologies. This resulted in a shift of authority from the Corporation and government to society, promoting adaptive and network governance [42]. Human impacts in the Anthropocene have led to tech-driven environmental governance. Artificial intelligence and IoT are used as predictive systems to monitor and manage industrial impacts, turning environmental data into measurable information in Chile. This approach is commonly referred to as "echo-algorithmic governmentality," which treats nature as a resource to be controlled through digital oversight [43].

With the help of artificial intelligence, climate decisions can be sped up, but this may result in limiting policy options, reducing public and expert participation, and making accountability harder. Biases in data and models can save some groups over others. To ignore these problems, artificial intelligence should be used as a tool among many that are linked to open decisions and include diverse perspectives and knowledge. Artificial intelligence should be used responsibly, which can help us achieve climate governance that is faster, fairer, and more democratic [44].

The limits for a safe human impact on Earth are set by planetary boundaries, but it can be seen that the current institutions are struggling to manage them. To address these complex social and environmental challenges, there is a need for the implementation of a proper coordinated global governance, which includes decision-making and support for innovations [45]. Artificial Intelligence, research, and ecosystem services contribute to improving and transforming decision support, ecological monitoring, and data integration. This enables real-time tracking of environmental challenges by enhancing ecosystem models and providing the best support for conservation and management. The futuristic efforts must focus on integrating Artificial Intelligence with fostering interdisciplinary collaboration and ecological management. However, some challenges remain, including quality adaptability, data, models, and the ability to interpret them for sustainable ecosystem governance [46]. By enhancing resources, decision-making, and environmental monitoring, Artificial Intelligence facilitates the effective and efficient achievement of the SDGs. However, there remains a need for further research in the specific domain of environmental governance using Artificial Intelligence [47].

6. Recommendations

Artificial Intelligence demonstrates a significant ability to strengthen environmental governance in India by enabling real-time monitoring, predictive analysis, and informed policymaking. By applying AI in conjunction with climate action strategies, society can help protect and address the challenges posed by climate change, while also safeguarding the right to a clean environment. Recommendations for the same are as follows:

- Develop AI-powered systems for continuous air, water, and soil quality monitoring.
- Integrate IoT sensors with AI models for real-time environmental risk prediction.
- Promote open-access environmental data platforms to improve AI model accuracy and transparency.
- Align AI-driven governance tools with India's INDC and global climate commitments.
- Foster multi-stakeholder collaboration between government, industry, and civil society for AI-based environmental decision-making.

7. Conclusion

A transformative approach is presented by the Artificial Intelligence for environmental governance in India by empowering the right to a healthy and clean environment. By leveraging machine learning, remote sensing, and predictive analytics, artificial intelligence enables policy evaluation, risk prediction, and real-time monitoring, providing accurate insights into climate-related threats, pollution, and degradation. Hence, due to these capabilities, it supports

proactive interventions that align with the commitments of India towards the national and global environment, which also includes the INDCs and SDGs. However, some challenges remain, such as accessibility, limited data quality, algorithmic bias, privacy concerns, and inclusivity, which must be addressed. There is a need for collaboration among the research institutions, governments, civil societies, and the private sector for an effective deployment. Looking forward, the AI-integrated governance, like IoT, deploying climate models and multi-modal analysis can ensure equal access to the resources, promote law enforcement, and advance environmental justice, hence promoting sustainable development and resilience in the face of climate change.

Author Contributions Statement

Conceptualization: A.B.; Methodology: A.B. and C.D.E.; Data Collection: A.B.C.D.F.; Formal Analysis: A.B. and C.D.E.; Writing-Original Draft: A.B.C.F.; Writing-Review & Editing: A.B.C.E. and C.D. All authors have read and approved the final manuscript.

Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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