THE ROLE OF ARTIFICIAL INTELLIGENCE IN ENHANCING ENVIRONMENTAL COMPLIANCE AND ENFORCEMENT IN INDIA

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ABSTRACT

Environment conservation is important for sustaining a clean and healthy environment, ensuring a livable planet for future generations, and preserving biodiversity. It is the need of an hour to manage the ecosystem, ensure environment cleanliness, reduce pollution, and mitigate the impacts of climate change. Preserving the environment aids in the improvement of soil, water, and air quality, all of which have an immediate impact on human health and the well-being of every living organism. These elements have made environmental laws and regulations essential for directing policies and actions that protect the environment and advance sustainable development.

The enforcement and compliance of environmental laws face significant challenges due to rapid environmental degradation in India. Conventional approaches to environmental violations depend on manual data gathering and scarce resources, in this regard, the integration of AI offers a revolutionary chance to improve the effectiveness of environmental compliance and enforcement in India. Drones, Internet of Things (IoT) devices, and sophisticated sensors are examples of AI technologies that may help collect data on environmental indicators like deforestation and air and water quality in real-time. By making it possible to detect infractions more quickly and accurately, these technologies have lessened the need for manual inspections.

Furthermore, by examining past data and reviewing trends, AI-powered predictive analytics may detect possible environmental breaches and take preventative measures to lessen environmental harm. Artificial Intelligence (AI) has influenced how societies approach environmental issues and work towards sustainable development by being included in various sectors. In India, a country dealing with complicated environmental problems in the face of fast technological development, it is essential to understand the implications of AI on the environment and sustainable development. The

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objective of this research is to examine the various ways that artificial intelligence (AI) is promoting environmental sustainability in India by looking at its possible advantages and future directions. Finally, the papers aims to provide comprehensive insights into how artificial intelligence (AI) may be utilized to address environmental issues and promote sustainable development in the Indian context.

Keywords: artificial intelligence, environmental sustainability, environmental laws, pollution, AI-analytics.

Introduction

Environmental conservation is essential for assuring a sustainable future, minimizing adverse climate change, and safeguarding biodiversity. India, a fast developing nation, confronts substantial environmental issues, such as air and water pollution, deforestation, and insufficient enforcement of environmental regulations. Despite the existence of comprehensive legislation, including the Environment Protection Act (1986)[3], Air (Prevention and Control of Pollution) Act (1981)[4], Water (Prevention and Control of Pollution) Act (1974)[5], and the Forest Conservation Act (1980)[6], their implementation and enforcement even today is weak due to various reasons such as outdated monitoring system, improper data analysis, resource constraints, no real time data monitoring.

The introduction of Artificial Intelligence (AI) brings an innovative approach for enhancing environmental compliance and enforcement in India. AI-driven technologies, including machine learning, remote sensing, IoT-enabled sensors, predictive analytics, and computer vision, are transforming the identification, monitoring, and prevention of environmental violations. Through the automation of data collection and real-time analysis, AI reduces dependence on human based inspections, improves accuracy in identifying pollution sources, and enables active decision-making. AI-driven satellite imaging and drone surveillance are continuously utilized to observe deforestation, coastal erosion, and air quality. Predictive analytics allows authorities to foresee climate risks, enhance disaster response strategies, and ensure adherence to environmental regulations. Furthermore, AI-enabled smart sensors integrated within industrial areas and aquatic environments consistently monitor pollution levels, guaranteeing compliance with emission regulations by industries. Apps for public

[3] The Environment (Protection) Act, 1986, No. 29, Acts of Parliament, 1986 (India).
[4] The Air (Prevention and Control of Pollution) Act, 1981, No. 14, Acts of Parliament, 1981 (India).
[5] The Water (Prevention and Control of Pollution) Act, 1974, No. 6, Acts of Parliament, 1974 (India).
[6] The Forest (Conservation) Act, 1980, No. 69, Acts of Parliament, 1980 (India).

reporting utilizing artificial intelligence and automated compliance audits significantly improving transparency and accountability in environmental governance.

This paper comprehensively understand the Tools of Artificial Intelligence, various existing environmental regulations, case studies and most importantly the urgent need to integrate and enforce artificial intelligence in the environmental laws and regulatory framework in India and the challenges, opportunities, and policy implications associated with it, by analyzing its implementation across various sectors, including coastal monitoring, pollution control, emission tracking, deforestation prevention, and biodiversity conservation. By employing AI, India can implement a data-driven, technology-augmented approach that strengthens environmental law enforcement, mitigates ecological damage, and promotes sustainable development.

Role of artificial intelligence in Environment Conservation

Artificial Intelligence (AI) is rapidly transforming the enforcement of environmental legislation, providing novel ways for monitoring and addressing climate-related issues. AI-powered solutions are enabling authorities in India, where environmental issues including pollution, deforestation, biodiversity loss, and industrial emissions demand ongoing surveillance, track, analyses, and enforce compliance with environmental regulations in real time.

Artificial Intelligence technologies, including Machine Learning (ML), Deep Learning (DL), Internet of Things (IoT), Computer Vision (CV), and Predictive Analytics, are revolutionizing environmental governance. Machine learning and deep learning algorithms analyses extensive climate data to detect patterns, forecast environmental trends, and enhance decision-making . IoT sensors and AIoT (Artificial Intelligence of Things) facilitate real-time surveillance of air and water quality, greenhouse gas emissions, and industrial pollutants, enabling authorities to implement initiate corrective measures. Computer Vision (CV) and remote sensing facilitate the automated identification of deforestation, unlawful fishing, and pollution sources using satellite imagery and drone surveillance.[7]

[7] LSE Politics and Policy, The Role of Artificial Intelligence in Environmental Regulation, LSE Blog (last visited Mar. 02, 2025), https://blogs.lse.ac.uk/politicsandpolicy/the-role-of-artificial-intelligence-in-environmental-regulation/.

Additionally, Predictive Analytics and AI-powered forecasting models allow regulators to anticipate climate risks, optimize disaster response[8]. By leveraging these AI tools, India can enhance the enforcement of environmental laws, reduce non-compliance, and ensure a more sustainable future. This section examines the application of AI in various environmental sectors, including coastal monitoring, pollution control, emission tracking, and biodiversity protection, ensuring that regulations are not only established but also actively enforced for long term ecological balance.

Artificial Intelligence in Coastal Surveillance and Climate Adaptation

Increasing Sea levels and coastal transformations provide substantial threats to India's coastal urban areas, marine habitats, and local populations. Traditionally, the observation of these alterations depended on human tidal gauge measurements and satellite imagery, which offered only periodic updates. Artificial intelligence has transformed this process through the utilization of sophisticated satellite imagery, machine learning algorithms, and hybrid modelling techniques to monitor coastal erosion, storm surge risks, and sea level fluctuations with enhanced precision and efficacy[9].

Through the integration of AI with conventional monitoring instruments such as satellite altimetry and tidal gauges, scientists can now detect nuanced environmental changes, forecast long-term trends, and execute prompt adaption strategies.

AI-driven models assist authorities in enforcing coastal restrictions, ensuring that urban growth, industrial activity, and infrastructure projects do not exacerbate environmental degradation.

Artificial Intelligence in Deforestation Monitoring and Forest Preservation:

Deforestation is a significant environmental issue in India, leading to biodiversity depletion, climate change, and habitat degradation. Historically, forest monitoring relied on manual surveys and occasional satellite imagery, hindering the real-time detection of illegal logging activities. Artificial intelligence has revolutionized deforestation monitoring through the

[8] White & Case, AI Watch: Global Regulatory Tracker – India, White & Case (last visited Mar. 01, 2025), https://www.whitecase.com/insight-our-thinking/ai-watch-global-regulatory-tracker-india.
[9] Melissa Cyrill, Environmental Compliance for Companies in India: Key Legislation and ESG Guidelines, India Briefing (Apr. 12, 2024), https://www.india-briefing.com/news/environmental-compliance-for-companies-in-india-key-legislation-and-esg-guidelines-32012.html/.

analysis of high-resolution satellite and LiDAR imagery, enabling the detection of land-use alterations and the immediate assessment of forest-health.AI-powered forest monitoring technologies now facilitate the identification of high-carbon-stock forests, the detection of illicit logging activities, and the enhancement of conservation initiatives.

Moreover, AI-driven early warning systems can forecast forest fires and plant diseases, facilitating preemptive measures. Integrating AI into environmental rules such as the Forest Conservation Act of 1980 enables authorities to enhance the protection of wooded regions and assure adherence to sustainability-standards[10].

Artificial Intelligence in Pollution Detection and Management

Pollution monitoring in India has conventionally depended on personal inspections, historical aerial imagery, and laboratory analyses, hindering the effective identification of pollution sources. Artificial intelligence has optimised pollution detection through the integration of satellite imaging, remote sensing, and IoT-enabled environmental sensors to monitor air, water, and soil contamination in real time.

AI-driven machine learning algorithms currently pinpoint pollution hotspots, monitor industrial emissions, and evaluate wastewater discharge levels, so assuring adherence to India's Water (Prevention and Control of Pollution) Act, 1974, and Air (Prevention and Control of Pollution) Act, 1981. AI-powered forecasting instruments assist regulatory agencies in anticipating pollution levels, facilitating faster and more efficient enforcement measures[11].

Artificial Intelligence in Air Quality Surveillance and Climate Resilience

Air pollution constitutes a significant environmental and public health crisis in India. Previously, air quality monitoring relied on intermittent manual sampling and historical data analysis, resulting in delayed responses. Artificial intelligence has enabled real-time monitoring and predictive analytics via electronic noses (E-noses), IoT-driven sensor networks, and AI-augmented air quality models. E-noses employ olfactory algorithms for the immediate

[10] Supra note at 3
[11] Kuldeep Singh Rautela & Manish Kumar Goyal, Transforming Air Pollution Management in India with AI and Machine Learning Technologies, 14 Sci. Rep. 20412 (2024), https://pmc.ncbi.nlm.nih.gov/articles/PMC11369276/.

detection of dangerous substances, substituting sporadic sampling with continuous air quality monitoring.

AI-powered sensor networks currently monitor volatile organic compounds (VOCs), methane emissions, and particulate matter, assisting industry in minimizing emissions and adhering to environmental regulations. The amalgamation of AI, IoT, and sensors has revolutionized air pollution management from sluggish, manual techniques to instantaneous, data-informed solutions, enhancing overall sustainability and climate resilience[12].

Artificial Intelligence in Biodiversity Conservation and Ecosystem Management

Field studies, camera traps, and regular habitat evaluations have long been the main tools used in India to conserve biodiversity; however, real-time monitoring of threatened species becomes difficult. Artificial intelligence has transformed biodiversity monitoring through the utilisation of satellite imagery, deep learning algorithms, and ecological modelling[13].

AI-powered species identification models, such as Artificial Intelligence for Environment & Sustainability (ARIES), analyze ecological interactions, habitat changes, and species distribution to support conservation efforts. Deep learning methodologies, like convolutional neural networks (CNNs), enhance species identification, whilst random forest algorithms and Bayesian networks refine biodiversity trend predictions. Integrating AI into environmental regulations enables authorities to enhance regulation of protected areas, combat illegal wildlife trade, and alleviate habitat loss.

Thus, technology is playing a very important role in improving environmental compliance and enforcement in India. Data analysis and real-time monitoring tools along with the inclusion of Artificial intelligence are helping authorities track environmental changes, detect violations, and ensure better enforcement of regulations. By integrating these advanced technologies as we have discussed into environmental governance, India can strengthen compliance with key laws such as the Forest Conservation Act and the Air and Water Prevention and Control of

[12] Kuldeep Singh Rautela & Manish Kumar Goyal, Transforming Air Pollution Management in India with AI and Machine Learning Technologies, 14 Sci. Rep. 20412 (2024), https://pmc.ncbi.nlm.nih.gov/articles/PMC11369276/. /

[13]Geraldine Castro, Costa Rica Is Saving Forest Ecosystems by Listening to Them, Wired (Mar. 3, 2025), https://www.wired.com/story/costa-rica-forest-conservation-sounds.

Pollution Acts. These tools not only improve enforcement efficiency but also support data-driven decision-making, ensuring long-term sustainability and a healthier environment for future generations.

Existing Environment Regulations and the Need For AI Integration

The Wildlife Protection Act, 1872

The aim of the Wildlife Protection Act is to provide the protection of the wild animals, birds, and plant species, in order to ensure environmental and ecological security. Although, India is a developing country in terms of every aspect and is a home to many unique and diverse ecosystems, which compile of over 70% of tigers in the world, 91000 types of animals, 45000 species of plants and more than 400 overall endangered species[14] but they posses' various threats such as poaching, climate change and habitat destruction which continues to endanger its rich biodiversity. Traditional methods for their conservation are although effective but are not sufficient to tackle large-scale challenges especially in today's digitizing world.

Although continuous amendments are made to India's environmental laws, the country faces significant criticism for its poor survey methodologies, delayed report releases, and outdated data collection processes. Experts argue that India urgently needs a complete overhaul of its environmental data architecture, including improving statistical sampling, enhancing data interpretation, and implementing real-time monitoring systems.

To address these challenges, advanced technologies such as AI-powered tracking systems, real-time data analysis, and AI based drone surveillance data collection should be integrated to monitor species populations, track wildlife trade, and prevent illegal activities, since AI can help us to process data in a few weeks, which has been poorly collected over several years since the efficiency, which AI offers no human would be able to sit there and analyze millions of data at once. By leveraging AI-driven predictive analytics, we can gain deeper insights into species trends, habitat changes, and emerging threats, allowing for more effective conservation policies and enforcement measures.

[14] Press Information Bureau, A Global Commitment to Tiger Conservation, PIB (last visited Mar. 10, 2025), https://pib.gov.in/PressNoteDetails.aspx?NoteId=151967&ModuleId=3&reg=3&lang=1.

By doing real-time data monitoring AI can efficiently collect, analyze, and interpret environmental data, providing valuable predictive knowledge to support conservation efforts. Implementing such technology-driven solutions can significantly strengthen India's wildlife protection strategies and ensure a more proactive approach to safeguarding biodiversity.

For example, if we see the collaboration which is done by Teradata India with the government to develop the AI driven predictive analysis which is done to track wildlife movements, monitoring health and detecting poaching threats to wildlife. This collaboration deals with AI powered thermal imaging and video analysis, which further helps us to identify the unusual behavior and also alerts the authorities About possible future potential poaching incident.[15]

An impressive initiative by the Indian government is highlighted in the press release "India's Wildlife Conservation Milestones," which outlines the country's policies, achievements, and global commitments to wildlife protection. India has strengthened its conservation efforts through initiatives like Project Tiger, Project Elephant, Project Cheetah, and Project Dolphin, integrating AI-powered ecosystem mapping, real-time data monitoring, and predictive analysis to track endangered species, prevent poaching, and mitigate human-wildlife conflict.

Advanced technologies such as acoustic sensors and satellite tagging are being used to monitor dolphin populations, while AI-driven mapping and camera traps help track tigers and other big cats. The reintroduction of cheetahs into India is closely monitored with GPS tracking and thermal imaging to ensure their adaptation and survival.

Beyond wildlife protection, AI is also being utilized for mangrove restoration, climate resilience, and combating wildlife crime. These efforts, backed by global collaborations and government investments, demonstrate how India is adopting a smarter, more effective approach to conservation, ensuring a sustainable future for its rich biodiversity.[16]

The Environment Protection Act, 1986

The act was enacted in 1986 and aims to provide environment protection and improvement. The main objectives of the act are creating authorities and empowering them for protection of

[15] Sibi Arasu, Researchers Get AI Help to Map Ecosystem, Wildlife Conservation, Hindustan Times (Feb. 19, 2019), https://www.hindustantimes.com/environment/reseachers-get-ai-help-to-map-ecosystem-wildlife-conservation/story-ySwKqr2rAC4bmkR9JQVdyM.html.

[16] Press Information Bureau, Policies, Achievements and Global Commitments, PIB (last visited Mar. 08, 2025), https://pib.gov.in/PressReleaseIframePage.aspx?PRID=2107821.

environment, regulating agencies, discharge of environmental pollutants, handling of hazardous substances, activities by mutual cooperation and most importantly prompt action in the event of environmental hazards and the provision of deterrent punishments. [17] The act again lacks in weak implementation and enforcement as a result of which continuous environmental degradation with polluted rivers, poor air quality, and continuous emissions from the industries.

This can be observed by referring to the case of Bhopal Gas tragedy[18] which was result of ongoing industrial pollution and weak safety measures. In our opinion, AI's automated safety responses, predictive maintenance, and real-time hazard detection could have avoided the Bhopal Gas tragedy. Predictive analytics could have found system failures before they happened, and AI-powered sensors could have found gas leaks early. Stricter safety procedures could have been guaranteed by automated containment measures and AI-driven compliance checks, which would have decreased corporate negligence and avoided tragedy.

The 2021 amendment[19] has replaced imprisonment with fines leading to weakening of deterrence. The act fails to address emerging challenges such as climate change and biodiversity loss, and its outdated regulatory framework struggles to keep up with modern environmental concerns.

The initiative by the government can be seen in the Environment Protection (End-of-Life Vehicles) Rules, 2025[20], which were issued on 6 January 2025 and aim to streamline the disposal, recycling, and management of end-of-life vehicles. Sections 12 and 16 of the rules introduce obligations for the Central Board, producers or vehicle manufacturers, registered owners and bulk consumers, registered vehicle scrapping facilities, collection centres, and automated testing stations. It also obligates the Central Board to publish such data received from the State Boards within a period of 60 days from the receipt of such data.[21]

This is, again, an impressive step introduced by the government, which enforces a centralised online portal to facilitate registrations. The most fascinating rule that attracts our attention is

[17] Central Pollution Control Board, Environmental Protection Act, CPCB (last visited Mar. 09, 2025), https://cpcb.nic.in/env-protection-act/.
[18] Edward Broughton, The Bhopal Disaster and Its Aftermath: A Review, 4 Environ. Health 6 (2005), https://pmc.ncbi.nlm.nih.gov/articles/PMC1142333/.
[19] The Wild Life (Protection) Amendment Bill, 2021 (India)
[20] Draft End-of-Life Vehicles (Management) Rules, 2024, Ministry of Environment, Forest and Climate Change (India), https://moef.gov.in/storage/tender/1736828697.pdf (last visited Mar. 10, 2025).
[21] Trilegal, Environment Law Monthly Updates – January 2025, Trilegal (last visited Mar. 10, 2025), https://trilegal.com/knowledge_repository/trilegal-update-environment-law-monthly-updates-january-2025/.

that the process of collecting data and testing will be done through automated testing stations, which come under the purview of artificial intelligence and machine learning. This is a major initiative towards controlling pollution caused by vehicles, as they are one of the major contributors of carbon dioxide in the world. This is how artificial intelligence is used to manage and control air pollution. Also, the rule provides provisions related to plastic waste management.

The Biodiversity act, 2002

The purpose of the act is to conserve the biological diversity and promote its sustainable use ensuring the fair and equitable sharing of benefits (FESB) which is obtained from traditional knowledge and biological resources. The act further establishes the National Biodiversity Authority (NBA), State Biodiversity Boards (SBBs), and Biodiversity Management Committees (BMCs) to regulate access to biological resources, protect indigenous knowledge, and prevent biopiracy. To protect and responsibly use India's rich biodiversity, the Act requires prior approvals for foreign access to biological resources, supports biodiversity heritage sites, and facilitates benefit-sharing with local communities. Critics point to the Biodiversity Act of 2002 as discriminating against NRIs, permitting resource privatization, and favoring commercial use over conservation. Foreign participation is restricted, Indian corporations are given leniency, local representation is lacking, and State Biodiversity Authorities (SBAs) are given limited authority. People's Biodiversity Registers (PBRs) could be misused, biodiversity offenses are not defined, and traditional knowledge is not adequately protected. The Biodiversity Management Committees (BMCs) have no authority and research institutions are not penalized. In general, it places more emphasis on controlling access than protecting biodiversity.

Similarly, in other acts, even in the Biodiversity Act, amendments have been made, and certain rules have been clarified, such as the 2024 rules[22] on biodiversity, under which Section 11(k) and Section 11(y) talk about the collection of data and the development of an online information technology portal, respectively. Although these rules address the collection and development of data, the analysis of the same can only be done efficiently and promptly by artificial intelligence, because no human would be able to sit and analyze millions of data points at once,

[22] National Biodiversity Rules, 2024

especially considering the pace at which the world is developing and digitizing.

By doing real-time data monitoring AI can efficiently collect, analyze, and interpret environmental data, providing valuable predictive knowledge to support conservation efforts.

Effective data analysis is essential to enhanced implementation, enforcement, prioritization, and impact monitoring of biodiversity policies. Although AI isn't being used much to help these processes right now, it has the potential to revolutionize every stage of the policy cycle. The application of AI to policymaking is not well understood by policymakers. The transferability of results from one region to another is limited by biodiversity policies, which are frequently very location and ecosystem specific. We advise governments to aim to implement AI at every stage of the policy cycle, with a focus on policy impact monitoring, enforcement, and design optimization. To enable this, governments should seek to develop their own data science capacity and seek external support. To bring together biodiversity policy makers and AI specialists to inform policy development, we advise governments to set up a number of Biodiversity Policy AI Labs as centers of excellence across the globe.[23]

The Air (Prevention and Control of Pollution) Act, 1981[24]

"The Air (Prevention and Control of Pollution) Act, 1981 aims to prevent, control, and abate air pollution in India by establishing regulatory bodies like the Central Pollution Control Board (CPCB) to monitor and enforce emission standards, thereby ensuring cleaner air quality across the country." [25] Although this act provides powers to the authorities but is outdated[26] and focuses mainly on the industrial pollution and lacks to regulate modern challenges solutions relating to vehicular emissions, electronic waste, construction dust, etc. Also, the latest update towards the act is the "Air (Prevention and Control of Pollution) (Manner of Holding Inquiry and Imposition of Penalty) Rules, 2024[27]" and has specified authorities responsible for filing complaints, grounds for complaints, timelines for inquiry proceedings,

[23] Global Partnership on AI, Biodiversity and AI: Opportunities & Recommendations for Action, GPAI (2024), https://gpai.ai/projects/responsible-ai/environment/biodiversity-and-AI-opportunities-recommendations-for-action.pdf.
[24] The Air (Prevention and Control of Pollution) Act, 1981 No. 10 Act of Parliament 1981
[25] Ibid at 18.
[26] Mayank Aggarwal, India's 40-Year-Old Law to Combat Air Pollution Languishes as the Crisis Intensifies, Mongabay India (Nov. 30, 2020), https://india.mongabay.com/2020/11/indias-40-year-old-law-to-combat-air-pollution-languishes-as-the-crisis-intensifies/.
[27] SCC Online, Air (Prevention and Control of Pollution) Manner of Holding Inquiry and Imposition of Penalty Rules, SCC Online Blog (Nov. 14, 2024), https://www.scconline.com/blog/post/2024/11/14/air-prevention-and-control-of-pollution-manner-of-holding-inquiry-and-imposition-of-penalty-rules/.

and ensuring that penalties collected are credited to the Environment Protection Fund. This ineffectiveness of the act can be seen in the serious and deadly Delhi air pollution crisis[28], recent attempts by India to reduce extreme air pollution, including the use of drones, anti-smog guns, and smog towers, have drawn criticism for being flimsy and ineffective. Even with these technological advancements, dangerous air quality persists in places like New Delhi, particularly in the winter. Experts contend that these policies ignore basic sources of pollution, such as industrial operations, vehicle emissions, and agricultural practices like crop burning. The absence of strong enforcement and comprehensive, regional policies further impedes efforts to improve air quality. Problems like these can be regulated using Artificial intelligence and modern technologies by enabling real-time monitoring, forecasting pollution spikes, and locating hotspots using satellite data and drones, artificial intelligence (AI) can help address Delhi's air pollution. It can track crop burning for quick intervention, identify high-emission vehicles, and optimize traffic flow. Better policy enforcement, accountability, and efficacy are guaranteed by AI-driven analysis. Furthermore, data-driven decision-making and intelligent air purification can enhance long-term pollution control plans.[29] As a result, major sources of pollution are still uncontrolled, clean air action plans are not adequately implemented, and air quality monitoring in smaller cities is insufficient. Its impact is further diminished by antiquated sanctions and infrequent criminal prosecution, which let polluters avoid responsibility. By allowing real-time monitoring, predictive analytics, and smart pollution control—all of which help to address air pollution—AI and modern technologies are absolutely vital. By highly accurate pollution level prediction made possible by advanced machine learning (ML) models including Convolutional Autoencoders (CA), Artificial Neural Networks (ANNs), and Long Short-Term Memory (LSTM), legislators can act pro-actively. While smart traffic management and urban planning help to lower vehicle emissions, AI-driven satellite data analysis and IoT-based sensors improve air quality monitoring. Further helping to control pollution are artificial intelligence-powered industrial emission tracking, automated air filtration systems, and sustainable energy modelling. Governments can impose data-driven policies by including artificial intelligence with numerical weather prediction (NWP) models and blockchain-based emission credit systems. Nonetheless, worldwide cooperation and technology developments help to solve issues including high implementation costs, statutory

[28] Philip Wen, India's Air Pollution Crisis: Short-Term Solutions Amidst a Growing Problem, Wall Street Journal (Nov. 15, 2024), https://www.wsj.com/world/india/india-air-pollution-short-term-solutions-5815e58d.
[29] Matt Simon, Artificial Rain, Drones, and Satellites: Can Tech Clean India's Toxic Air?, Wired (Nov. 2024), https://www.wired.com/story/artificial-rain-drones-and-satellites-can-tech-clean-indias-toxic-air/.

gaps, and public awareness gaps. In the end, artificial intelligence offers a scalable and complete method to reduce air pollution and protect public health.[30]

The Water (Prevention and Control of Pollution) Act, 1974

The main objectives and aims of the act includes to prevent, control and manage water pollution, along with maintaining or restoring of wholesomeness of water in the country.

The Act was later amended in the year 1988, which provided for collection and levy of cess on water consumed by persons operating and carrying on certain types of industrial activities. At recent, a Bill is in process names as The Water (Prevention and Control of Pollution) Amendment Bill, 2024 but on the same page it does not include solutions to modern problems such as the increasing ganga pollution, Vellore Tanneries case, etc. and many more. Thus, the 1974 act faces major criticism for its weak enforcement, outdated definitions and lack of public participation. The proposed amendment for 2022 although provides for the decriminalization of environmental violations, introduced funds for water pollution remediation, high amount penalties instead of imprisonment but gives us the risks of going from "polluter pays principle" to "pay and pollute principle", Lesser transparency in the fund utilization and has also reduced the deterrence. Further, if we take an analytical perspective and look closely to the causes of ***Vellore tanneries case***,[31] it was due to long term pollution from the untreated effluents and unprompted real time data monitoring which led to environmental degradation in that area, same can be inferred in the case of the holy river ***ganga pollution case***[32]. Had they done real time data collection and enforcement back then, the pollution levels, health hazards and economic losses could have been minimized. Hence it proves that Artificial Intelligence is a necessary solution which we need in real times.

Forest Conservation Act, 1980

"By strictly prohibiting the de-reservation of forest land or its use for non-forest purposes without prior central government approval, the Forest Conservation Act, 1980[33] seeks to protect and conserve India's forests. In other words, it makes sure that forest land is only diverted for

[30] Kuldeep Singh Rautela & Manish Kumar Goyal, Transforming Air Pollution Management in India with AI and Machine Learning Technologies, 14 Sci. Rep. 20412 (2024), https://doi.org/10.1038/s41598-024-71269-7.
[31] Vellore Citizens' Welfare Forum v. Union of India, (1996) 5 SCC 647
[32] Water Pollution by Tanneries at Jajmau, In re, 2020 SCC OnLine NGT 2041
[33] The Forest (Conservation) Act, 1980, No. 69, Acts of Parliament, 1980 (India).

development activities when absolutely necessary and that appropriate compensatory measures are in place." The Forest Rights Act and National Forest Policy, 1988 comes under the ambit of forest conservation act itself. The acts and the amendments again faces significant criticism for narrowing the definition of forests and exempting various land categories from its protection, potentially opening vast areas for commercial exploitation. Critics argue that the amendment prioritizes infrastructure and economic development over ecological conservation, undermining India's environmental commitments under international treaties. It also weakens community rights by bypassing Gram Sabha consent for forest diversion, contradicting the Forest Rights Act, 2006. Additionally, the removal of public participation in decision-making and the dilution of environmental safeguards raise concerns about transparency and accountability. The Act is seen as a regressive step that reduces legal protections for forests, favoring industrial and strategic projects at the cost of biodiversity and indigenous livelihoods.

Also, by looking at the traditional methods used for forest management, they are slow, require high costs, and have often resulted in being ineffective in preventing deforestation, illegal logging, poaching, and wildfires. The fact is that such environmental regulations already exist, but due to weak enforcement and corruption, they further hinder environmental protection, making it difficult for industries to regulate and comply with environmental laws. In cases where humans manually monitor wide areas, it becomes challenging and expensive, ultimately leading to inefficiencies in tracking environmental violations and protecting biodiversity.

By looking at the digitizing world, we are of the opinion that artificial intelligence offers smart and efficient solutions to these existing modern challenges through real-time monitoring, automated enforcement, predictive analysis, AI-powered satellites, drones, and sensors, which can track pollution, deforestation, and wildlife movements, ensuring quick intervention and action. Wildfires, illegal activities, and environmental risks can be predicted by proper data analysis, which will further help authorities take proactive action instead of reacting after the damage has occurred, as it is widely said that prevention is better than cure.

Additionally, if we look at AI-based public reporting apps, which allow citizens to report environmental violations, these apps increase transparency and accountability among the general public.

Thus, by integrating AI into environmental compliance and forest conservation, authorities can achieve faster and more effective monitoring at lower costs, while also requiring minimal

human intervention. The current volume of data that needs to be analyzed is so vast that it is practically impossible for humans to efficiently process it. The efficient analysis of collected data can only be achieved through artificial intelligence-driven software and tools, as they ensure accurate data collection, a corruption-free regulatory system, and better decision-making.

Recent Guidelines And Developments Implementing AI Driven Innovation In Environmental Management

Coastal Regulation Zone Notifications (CRZ Notifications):[34]

Areas along India's coast under control to safeguard the coastal environment, marine ecosystems, and livelihoods of coastal communities are known as the Coastal Regulation Zone (CRZ). Defining these zones and outlining guidelines for development and preservation are given in the CRZ Notification of 2011 which was issued under the Environment Protection Act, 1986. Further the notification has also stated that the National Centre for Sustainable Coastal Management (NCSCM) will identify and map every Ecologically Sensitive Area (ESA) along the coast. Using satellite data, this process will precisely define the limits of these areas, so guaranteeing their appropriate preservation and protection.[35] This method of data processing using satellite data comes under the ambit of artificial intelligence. Further such initiative highlights the need and possibilities to enforce AI into Environmental regulations in India.

Commission For Air Quality Management in National Capital Region and Adjoining Areas (CAQM):

The Commission for Air Quality Management (CAQM) has instituted state-specific action plans in Punjab, Haryana, Uttar Pradesh, Rajasthan, and Delhi to mitigate paddy stubble burning. The 2023 plan encompasses in-situ techniques such as crop residue machinery, bio-decomposers, and staggered harvesting, alongside ex-situ strategies involving the utilisation of

[34] Coastal Regulation Zone Notification, 1991, Ministry of Environment & Forests (India), https://environmentclearance.nic.in/writereaddata/SCZMADocument/CRZ%20Notification,%201991.pdf (last visited Mar. 5, 2025).

[35] Coastal Regulation Zone Notification, 2011, Ministry of Environment & Forests (India), http://www.environmentwb.gov.in/pdf/CRZ-Notification-2011.pdf (last visited Mar. 4, 2025).

paddy straw for biomass energy, ethanol production, and industrial applications. Coal-fired thermal power plants are now required to co-fire 5-10% biomass pellets to mitigate emissions.[36]

Using ISRO satellites inbuilt with technology, artificial intelligence and machine learning, in Technology is vital, using ISRO satellites, AI-enabled real-time monitoring, and drones to monitor stubble burning. It further detects and delineate stubble burning hotspots, while AI-driven real-time data analysis forecasts high-risk areas and facilitates timely intervention. Drones outfitted with thermal imaging and AI analytics watch agricultural fields to identify illegal burning, ensuring quick responses by municipal authorities. Mobile applications such as the 311 App enable citizens to report stubble burning in real time, while social media campaigns and AI-driven educational programs inform farmers about sustainable practices thereby enhancing inclusion of public using digital platforms. By including artificial intelligence, satellite tracking, and drone surveillance, India is moving from reactive enforcement to proactive pollution control, so improving air quality and supporting sustainable farming methods.[37]

The Compensatory Afforestation Fund Management and Planning Authority (CAMPA):

The Compensatory Afforestation Fund Management and Planning Authority (CAMPA) was created under the Compensatory Afforestation Act of 2016 to guarantee the effective utilisation of funds collected from the diversion of forest land for afforestation and conservation initiatives. CAMPA funds facilitate forest restoration, enhance biodiversity, and manage wildlife habitats. The Forest Survey of India (FSI) employs satellite imagery to oversee afforestation initiatives, identify encroachments, and assess forest health. This national geo-spatial monitoring instrument utilizes satellite data to track afforestation initiatives and other forest-related activities thereby switching to E-Green Watch.

The Forest Protection Division of the Ministry of Environment, Forest, and Climate Change (MoEFCC)

The Forest Protection Division of the Ministry of Environment, Forest, and Climate Change

[36] Commission for Air Quality Management, Home, CAQM (last visited Mar. 10, 2025), https://caqm.nic.in/.
[37] Ministry of Environment, Forest and Climate Change, Annual Report 2023-24, MoEFCC (2024), https://moef.gov.in/uploads/2023/05/Annual-Report-English-2023-24.pdf.

(MoEFCC)[38] is charged with preventing illegal logging, encroachments, and forest fires throughout India. The Forest Survey of India (FSI) has established a remote-sensing detection system for forest fire management, utilising MODIS and VIIRS[39] satellite data to inform authorities. This facilitates quick reactions and mitigation measures to reduce damage. Moreover, AI-driven geo-spatial technology is employed to identify early fire alerts, monitor impacted regions, and forecast high-risk areas, thereby facilitating a proactive strategy for forest fire prevention. The National Action Plan on Forest Fires enhances fire management through the incorporation of AI-based monitoring systems, which are essential for training forestry personnel and developing response strategies. The advancements in AI and GIS technology substantially enhance the protection of India's forests and the prevention of environmental risks.

Initiatives by Forest Survey of India

The Forest Survey of India (FSI) utilizes remote sensing, GIS mapping, and artificial intelligence tools to evaluate and oversee India's forest resources. These technologies facilitate precise monitoring of forest cover, biodiversity, and ecological modifications, thereby ensuring data-informed decision-making for conservation initiatives.

The 18th edition of the India State of Forest Report (ISFR 2023)[40] employed ortho-rectified satellite imagery to perform a comprehensive analysis of forest cover. This method improves precision in delineating deforestation patterns, afforestation initiatives, and general forest health. Moreover, AI-driven Decision Support Systems (DSS) aid policymakers by evaluating real-time data and delivering data-informed insights for efficient forest conservation strategies. A significant initiative is Forest Fire Risk Zonation Mapping, utilising AI-driven predictive models to assess historical fire occurrences and pinpoint high-risk areas in states including Himachal Pradesh, Uttarakhand, Jammu & Kashmir, and Ladakh. These AI-driven models enhance alertness and facilitate targeted interventions to avoid forest fires and reduce environmental harm.

[38] Ministry of Environment, Forest and Climate Change, Forest Protection, MoEFCC (last visited Mar. 10, 2025), https://moef.gov.in/forest-protection-fpd.
[39] NASA Earthdata, Visible Infrared Imaging Radiometer Suite (VIIRS), NASA (last visited Mar. 10, 2025), https://www.earthdata.nasa.gov/data/instruments/viirs.
[40]Press Information Bureau, The India State of Forest Report 2021 Released, PIB (last visited Mar. 10, 2025), https://pib.gov.in/PressReleasePage.aspx?PRID=2088477.

GoI, UNDP-GEF SECURE Himalaya Project

The secure Himalaya Project is a collaborative effort involving the Government of India (GoI), the United Nations Development Programme (UNDP), and the Global Environment Facility (GEF), aimed at utilizing artificial intelligence for wildlife conservation, habitat restoration, and community-oriented eco-tourism in ecologically fragile Himalayan regions.[41] The project employs AI-driven Wildlife Information Management Systems (WMIS) and mobile applications to address wildlife crime and human-wildlife conflicts. These tools facilitate real-time monitoring and documentation of unlawful poaching and habitat degradation, assisting authorities in the more effective enforcement of wildlife protection legislation.

Moreover, AI-enhanced drone surveillance is essential for monitoring biodiversity in the Himalayas. These drones deliver high-resolution imagery and real-time data, assisting conservationists in evaluating wildlife migration, deforestation, and ecological hazards. The SECURE Himalaya Project enhances environmental protection initiatives through the utilisation of AI and advanced technologies, while fostering sustainable development and conservation practices in the region.

National Clean Air Programme (NCAP)

The National Clean Air Programme (NCAP), initiated by the Ministry of Environment, Forest, and Climate Change (MoEFCC) in 2019, seeks to enhance air quality in 131 cities across 24 states and Union Territories by involving various stakeholders. The objective is to decrease PM10 concentrations by as much as 40% by 2025-26 or to meet National Ambient Air Quality Standards (NAAQS). [42]

The NCAP employs artificial intelligence, satellite technology, and real-time air quality monitoring systems to accomplish these objectives. Satellite-based monitoring developed by ISRO, AI-driven sensors, and economical air quality sensors identify pollution hotspots, allowing authorities to implement data-informed interventions. AI-driven early warning systems have been established in Delhi, Kanpur, and Lucknow to deliver alerts for prompt

[41] United Nations Development Programme, Securing Livelihoods in the Himalayas, UNDP (last visited Mar. 10, 2025), https://www.undp.org/india/projects/securing-livelihoods-himalayas.
[42]Press Information Bureau, National Clean Air Programme (NCAP) and Its Implementation, PIB (last visited Mar. 10, 2025), https://pib.gov.in/PressReleasePage.aspx?PRID=2043004.

intervention. Public Grievance Response Systems (PGRS) and mobile applications such as Sameer facilitate the reporting of pollution incidents by citizens.[43]

The government has implemented various initiatives to enhance air quality under the NCAP, including the transition to BS-VI fuel, the elimination of outdated diesel vehicles, the promotion of CNG and electric mobility, and the reinforcement of industrial emission standards. Moreover, initiatives such as stubble burning regulation via satellite monitoring, dust suppression strategies, and enhanced waste management have been executed. The integration of various governmental initiatives from ministries such as Housing & Urban Affairs (SBM 2.0), Petroleum & Natural Gas (SATAT), and Agriculture (Crop Residue Management) enhances the program's efficacy. NCAP is enhancing technology-driven environmental compliance and pollution control in India through AI-driven analytics, real-time air monitoring, and multi-sectoral policies.

Green Credit Scheme:

The Green Credit Programme (GCP) is an initiative established by the Government of India under the Environment Protection Act of 1986, designed to promote sustainable practices via a market-oriented strategy. It promotes individuals, industries, and organizations to engage in sustainable practices such as, Afforestation and reforestation, Water conservation and waste management, Conservation of biodiversity through sustainable agriculture, Mitigating carbon emissions via cleaner technologies, which is done by the use of Satellite, AI- Based Monitoring and remote sensing technologies.

Participants receive "Green Credits" for their environmental contributions, which can be exchanged in a regulated market, akin to carbon credits. This initiative is consistent with India's circular bioeconomy strategy and fosters a sustainable shift towards clean energy and waste management. [44]

To conclude, we can say that, integrating artificial intelligence into the Environment Act can improve law enforcement, biodiversity monitoring, and habitat preservation and can also

[43] Press Information Bureau, National Clean Air Programme (NCAP) to improve air quality in 131 cities by engaging all stakeholders, PIB (last visited Mar. 10, 2025), https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1909910.

[44] Press Information Bureau, Notification issued for Green Credit Program (GCP) and Ecomark scheme Under LiFE Initiative to Promote Sustainable Lifestyle and Environmental Conservation, PIB (last visited Mar. 10, 2025), https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1967476.

predict more challenges By detecting poaching, deforestation, and climate threats. It also helps predict disasters like wildfires and floods, enabling proactive conservation. Additionally, AI-driven genetic sequencing supports breeding programs, ensuring long-term biodiversity.

Technologies such as machine learning, real time analytics and computer visions coming under the purview of AI are revolutionizing wildlife conservation by allowing automated species identification, population monitoring, and habitat mapping. AI-powered drones, camera traps, and satellite imagery help detect and track wildlife movements, while anti-poaching surveillance systems using thermal cameras and facial recognition assist in real-time intervention.

Case Study and Recent Development

Indian Developments

Usage of SmartTerra in Banglore

The Bangalore Water Supply and Sewerage Board (BWSSB), in partnership with SmartTerra, has deployed an AI-driven operational intelligence platform to improve water distribution efficiency and mitigate revenue losses in Bengaluru. This endeavour connects with India's wider initiatives to integrate artificial intelligence into the enforcement and compliance of environmental regulations. By leveraging AI, BWSSB seeks to transition from reactive to predictive operations, addressing challenges such as water distribution losses and network health. The pilot project in the D1A zone in central Bengaluru examined comprehensive data to identify opportunities for enhancing revenue collection and distribution efficiency. This partnership illustrates the potential of AI to revolutionise urban water management and guarantee sustainable resource use.[45]

ARSENIC POISIONING

Researchers at IIT Kharagpur have created an AI-driven predictive algorithm to identify arsenic poisoning in groundwater across India. Their research indicated that over 20% of India's geographical region demonstrates increased arsenic concentrations, possibly impacting over 250 million people. This approach delineates high-risk areas, namely in states such as Punjab,

[45] IndiaAI, AI for Sustainable Water in Bengaluru, IndiaAI (last visited Mar. 10, 2025), https://indiaai.gov.in/case-study/ai-for-sustainable-water-in-bengaluru.

Bihar, and West Bengal, and is consistent with India's Jal Jeevan Mission, which seeks to provide clean drinking water access for every family . This program illustrates the use of AI in the enforcement and compliance of environmental regulations, enabling informed decision-making and precise interventions.[46]

Usage of GeoAI in Bihar

The United Nations Development Programme (UNDP) India, in partnership with the Bihar State Pollution Control Board (BSPCB), has established the GeoAI platform to oversee and manage brick kilns, which account for around 14% of the state's air pollution. Utilizing satellite imagery and artificial intelligence, GeoAI accurately mapped over 7,800 brick kilns in Bihar, enabling authorities to prioritize inspections and enforce compliance with environmental regulations. This program illustrates the use of AI in improving the enforcement and compliance of environmental regulations in India[47].

Usage of IoT for Jal Jeevan Mission

The Union Jal Shakti Ministry, in partnership with the Tata Community Initiatives Trust (TCIT) and Tata Trusts, has commenced the implementation of sensor-based Internet of Things (IoT) devices to oversee rural drinking water delivery systems under the Jal Jeevan Mission (JJM). Pilot projects were executed in rural communities throughout five states—Uttarakhand, Rajasthan, Gujarat, Maharashtra, and Himachal Pradesh—encompassing varied agro-climatic conditions. These IoT devices provide real-time surveillance of water volume, quality, pressure, and sustainability, hence improving operational efficiency and cost-effectiveness. This program illustrates the use of AI and IoT in enhancing the enforcement and compliance of environmental regulations in India[48].

Usage of SATVAM: AI-Driven Air Quality Monitoring

SATVAM, led by Professor Sachchida Nand Tripathi, built India's first scientifically verified and calibrated air quality monitoring network. This effort seeks affordable, energy-efficient

[46] IndiaAI, Toxic Levels of Arsenic in 20% of Groundwater in India: AI Study Reveals, IndiaAI (last visited Mar. 10, 2025), https://indiaai.gov.in/news/toxic-levels-of-arsenic-in-20-of-groundwater-in-india-ai-study-reveals.
[47] United Nations Development Programme, Tech for Clean Air and Blue Skies, UNDP (last visited Mar. 10, 2025), https://www.undp.org/india/stories/tech-clean-air-and-blue-skies.
[48]Press Information Bureau, Govt. of India's digital vision to address challenges in rural water supply management , PIB (last visited Mar. 10, 2025), https://pib.gov.in/PressReleasePage.aspx?PRID=1708701.

air quality monitors with IoT technology for real-time data collection and analysis. Multiple institutions, including IIT Kanpur, collaborated on the project in Kanpur, Uttar Pradesh.. This initiative employs inexpensive sensors combined with AI for real-time calibration and analysis, efficiently monitoring pollutants such as PM2.5, PM10, NOx, and ozone. The AI-driven technology boosts the accuracy of air quality data, aiding regulatory authorities in enforcing environmental norms[49]

Usage of Plantix: AI in Agricultural Compliance

Plantix is a mobile agricultural advisory application created by PEAT GmbH, an artificial intelligence startup based in Berlin, Germany. Plantix, an application introduced in 2015, utilises artificial intelligence to diagnose agricultural diseases, assisting farmers in recognising problems and suggesting remedies. The app, originally aimed at minimising pesticide usage, has since developed partnerships with pesticide suppliers to enable the sale of chemical inputs. This transition has incited discussion, yet Plantix exemplifies AI's capacity to oversee and shape agricultural methods, thereby indirectly aiding environmental compliance through the endorsement of suitable pesticide application[50].

Delhi Air-Quality monitoring with IOT

In Delhi, Sowmya and Ragiphani (2022) proposed an air quality monitoring system that integrates the Internet of Things (IoT) with artificial intelligence to efficiently control air pollution. Their technology utilises sensors to detect dangerous chemicals and incorporates a Support Vector Machine (SVM) algorithm for forecasting future air quality. This strategy seeks to improve public awareness and facilitate proactive actions to preserve indoor air quality[51].

Google's Flood Forecasting

Google's Flood Forecasting Initiative uses artificial intelligence to provide accurate, real-time flood forecasts and alarms, significantly improving catastrophe planning and response in India.

[49] Rashmi Ballamajalu et al., Toward SATVAM: An IoT Network for Air Quality Monitoring, arXiv:1811.07847 [cs.NI] (2018), https://arxiv.org/abs/1811.07847.
[50] Stephen Robert Miller, This App Set Out to Fight Pesticides. After VCs Stepped In, Now It Helps Sell Them, Wired (Oct. 24, 2024), https://www.wired.com/story/plantix-pesticides-venture-capital-app.
[51] Vattam Sowmya & Shravya Ragiphani, Air Quality Monitoring System Based on Artificial Intelligence, in Advances in Signal Processing and Communication Engineering (Springer Nature Singapore 2022), https://www.springerprofessional.de/en/air-quality-monitoring-system-based-on-artificial-intelligence/23780778.

Initiated in 2018 as a pilot project in the Ganges-Brahmaputra river basin, the program has extended its reach to include over 200 million people over more than 250,000 square kilometres in India by 2020. Google's solution integrates AI with physics-based modelling to analyse real-time river measurements and elevation data, therefore simulating water behaviour and providing more precise and fast flood predictions. This method illustrates the function of AI in the enforcement and compliance of environmental regulations, assisting authorities and communities in alleviating the effects of natural catastrophes[52].

International Developments

Usage of Prithvi WxC AI Model

NASA and IBM Research have partnered to create the Prithvi-weather-climate (Prithvi WxC) fundamental model, a sophisticated AI instrument aimed at improving weather and climate predictions on regional and global levels. This model utilises 40 years of data from NASA's Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2), incorporating 160 variables to identify patterns relevant to diverse meteorological conditions. Prithvi WxC is a versatile AI model that can be tailored for a variety of practical weather and climate applications across different spatial scales. It has been made open-source and is accessible on sites such as Hugging Face, fostering accessibility and stimulating more study and development in the domain. The model's adaptability allows for applications such as severe weather detection, localized forecasting, and enhancing the spatial resolution of climate models. Prithvi WxC seeks to deliver actionable, high-resolution climate projections by accurately capturing intricate atmospheric processes, thus aiding decision-making for communities, organisations, and policymakers[53].

Sentinel-2 Imagery Usage in Vietnam

In Vietnam Nguyen-Trong and Tran-Xuan developed an AI-driven approach for identifying changes in coastal forest cover. Utilizing multi-temporal Sentinel-2 imagery and a U-Net convolutional neural network, their approach achieved a 95.4% accuracy rate, surpassing traditional methods like multi-variant change vector analysis (MVCA) by 3.8%. This

[52] Google, Expanding Flood Forecasts in India and Bangladesh with AI, Google Blog (last visited Mar. 10, 2025), https://blog.google/technology/ai/flood-forecasts-india-bangladesh/.
[53] Johannes Schmude et al., Prithvi WxC: Foundation Model for Weather and Climate, arXiv:2409.13598 [cs.LG] (2024), https://arxiv.org/abs/2409.13598.

achievement highlights AI's capacity to improve the enforcement and compliance of environmental regulations, providing a more efficient and precise instrument for the management and planning of forest resources[54].

Usage of SVM machines to examine Land use in Saudi Arabia.

Bindajam et al. (2021) used support vector machine (SVM) classification to examine land use and land cover (LULC) alterations in the Abha-Khamis area of Saudi Arabia from 1990 to 2018. The results indicated a 334.4% rise in metropolitan regions, mostly at the detriment of natural ecosystems. The research used an artificial neural network-cellular automata model to forecast future land use and land cover changes, suggesting substantial urban growth by 2028. These findings are essential for evaluating the effects of urbanisation on ecological services and guiding sustainable development policies. [55]

Usage of LSTM in MyAQI

Schürholz et al. (2020) developed a context-aware air quality prediction model using Long Short-Term Memory (LSTM) deep neural networks. This algorithm, executed using the My Air Quality Index (MyAQI) service in Melbourne, attained a prediction accuracy of 90-96% by combining data from pollution sources and users' health profiles.The model's flexibility to specific health situations highlights its promise in customised environmental monitoring. [56]

Usage of EC-DAQS in Nigeria

Durodola et al. created an Environment and Climate Data Acquisition System (EC-DAQS) to tackle the difficulties encountered by poor nations such as Nigeria in procuring weather monitoring equipment owing to volatile currency rates. The EC-DAQS employs an Arduino Mega2560 microcontroller with six environmental and meteorological sensors to quantify, document, and exhibit atmospheric variables such as temperature, UV radiation, humidity, and sound intensity. The system was tested by comparing its temperature readings with those of a

[54]Khanh Nguyen-Trong & Hoa Tran-Xuan, Coastal Forest Cover Change Detection Using Satellite Images and Convolutional Neural Networks in Vietnam, 11 IAES Int'l J. of Artificial Intelligence 930 (2022), https://ijai.iaescore.com/index.php/IJAI/article/view/21129

[55]Pavan Kumar, Integration of Artificial Intelligence-Based LULC Mapping and Prediction for Estimating Ecosystem Services for Urban Sustainability: Past to Future Perspective, ResearchGate (2021), https://www.researchgate.net/publication/354135231.

[56]En Xin Neo et al., Artificial Intelligence-Assisted Air Quality Monitoring for Smart City Management, 9 PeerJ Comput. Sci. e1306 (2023), https://doi.org/10.7717/peerj-cs.1306.

typical infrared thermometer, revealing a mean bias error (MBE) of 0.16°C and a root mean square error (RMSE) of 0.51°C, signifying great accuracy. The modelling equation had a slope close to unity (0.994) and a correlation of 99.98%, emphasising the system's reliability. The EC-DAQS is a cost-efficient and effective substitute for imported weather stations, delivering essential data for meteorological research and radio propagation analysis. [57]

Policy Recommendation

1. Considering the difference between the policy and the statutes. Policies are guidelines or rules set by the government to guide their decisions and actions, whereas on the other hand legislation refers to legally binding laws enacted by legislative body. Although there exist notification, guidelines and regulations, but artificial intelligence, and the clauses related to it should be instilled into the statutory legislations governing environment laws in India, which will ultimately result into creation of a legal obligation through legislations unlike guiding decisions given by policies ensuring that AI driven solutions are not just recommendations but legally binding laws for better enforcement and compliance.

2. The Air (prevention and control of pollution) act, 1981, should be amended so that a legal requirement of using AI-based real-time air-quality monitoring and predictive analytics is imposed on people resulting in control of pollution. Artificial intelligence tools such as machine learning, deep learning, numerical weather prediction (NWB models) should be used to track stubble burning, industrial emissions, vehicle pollution is actively. Further, a national AI integrated air-quality management system should be established to enforce real-time monitoring and automated penalties on the violators of law should be imposed.

3. The environment protection act, 1986, should be amended so that a legal requirement of using AI-based monitoring is imposed in cases of high risk, industrial zones, the ecologically sensitive areas, the urban areas, etc. Artificial intelligence tools, such as the internet of things, sensors, drones, and satellite imaging for real-time monitoring of air, water and soil pollution should be used, ensuring prompt and correct reports and

[57]Omotayo May Durodola et al., Development of an Environment and Climate Data Acquisition System (EC-DAQS) for Radio Propagation Studies, ResearchGate (2022), https://www.researchgate.net/publication/359394064.

compliance checks. AI-Power, predictive analysis and technology should be integrated into environmental agencies like the central pollution control board and the state pollution control board to forecast environmental risks, detect early violations and also optimize certain allocation of resources for strict enforcement and compliance of environmental regulations.

4. Integrating AI-driven monitoring into environmental legislation for real-time species surveillance, habitat conservation, and compliance enforcement. Utilize satellite imagery, drones, and artificial intelligence analytics to identify illegal activities such as poaching and deforestation. make Amendment to the Biodiversity Act of 2002 to include AI-driven monitoring, thereby enhancing transparency, accountability, and conservation initiatives.

5. India's dependence on obsolete environmental data collection hinders its capacity to anticipate and address challenges such as air pollution, water contamination, and deforestation. To resolve this issue, the implementation of AI-driven real-time monitoring via IoT sensors, satellite imagery, and machine learning algorithms should be implemented. Automated data integration among government agencies will guarantee accurate reporting, while AI-driven predictive analytics can offer prompt warnings for environmental hazards. By implementing real-time AI-driven data collection, India can transition from reactive enforcement to proactive, data-informed environmental governance.

6. Frame a regulatory legislation by referring to the United Nations Framework Convention on Climate Change, draft technical paper[58] on AI for climate action, in order to ensure proactive AI driven regulations, thereby ensuring strict environment regulation enforcement and compliance in India.

Conclusion

Artificial Intelligence (AI) is transforming India's approach to environmental conservation, providing more sophisticated and efficient methods to address challenges such as pollution,

[58] UNFCCC, Technology Executive Committee: Innovative Approaches to Accelerate Climate Action, UNFCCC, https://unfccc.int/ttclear/misc_/StaticFiles/gnwoerk_static/tn_meetings/0ec396b0ba7b4d0d853b77c7b83dc172/3ebbf2e8e7834a7f873b0ae9a86262f7.pdf (last visited Mar. 11, 2025).

deforestation, and climate change. This paper has comprehensively dealt with the effectiveness of AI-driven tools—such as real-time sensors, predictive analytics, internet of things (iot) and satellite monitoring in allowing authorities to detect environmental violations more efficiently. By reducing reliance on traditional manual monitoring techniques, AI facilitates rapid responses and enhances regulatory enforcement.

Despite India's robust environmental legislation, such as the Environment Protection Act (1986) and the Air and Water Pollution Acts, enforcement remains constant challenge. Artificial intelligence can mitigate this disparity by automating data collection, analyzing trends, and predicting violations prior to their occurrence. A significant analogy can be drawn with healthcare, similar to how AI is advancing disease detection and treatment planning, it may also strengthen environmental management by identifying pollution sources and strengthening conservation strategies.

To fully utilize AI's potential, policymakers must prioritize the expansion of AI-driven monitoring systems, utilize data-informed insights for improved decision-making, promote collaboration between industries and government, and ensure ethical AI practices. By incorporating AI into environmental governance, India can shift from reactive measures to a proactive, technology-driven approach, thereby ensuring a more sustainable and healthier future for all.