

**USING ARTIFICIAL INTELLIGENCE (AI) FOR ENVIRONMENTAL SUSTAINABILITY:  
CHALLENGES, STRATEGIES AND SOLUTIONS****Ms. Tanisha Sinha<sup>1</sup> and Yogita Sawant<sup>2</sup>**<sup>1</sup>Bachelor in Management Studies, JVM's Mehta Degree College<sup>2</sup>Assistant Professor, BMS Department, JVM's Mehta Degree College**ABSTRACT**

*This paper examines the dual role of Artificial Intelligence (AI) in environmental sustainability: As a tool for conservation and as a source of environmental burden. AI-driven systems are being applied to monitor ecosystems, optimize agriculture, and manage energy while contributing to advances like precision farming, smart grids and pollution forecasting. At the same time, training and running AI models leads to consumption of large amounts of energy, water and materials which is raising technical, ethical and social concerns. This paper is based on secondary data collection and hence, surveys recent research studies along with real-world cases to identify how AI supports sustainability; what are the challenges that arise, and what strategies can be used to address them, including policy guidance and best technological practices to harness AI's benefits while minimizing its negative footprints on the environmental. The goal here is to achieve a balanced understanding of AI and its utility for Environmental Sustainability.*

**Keywords:** Artificial Intelligence, Conservation, Environment, Sustainability, Technology, Strategies, Challenges

**INTRODUCTION**

AI systems rely on complex networks of algorithms and data to perform tasks like pattern recognition, prediction and optimization. These capabilities have been applied to sustainability domains – for example, to forecast climate patterns, optimize energy use, or monitor wildlife. Indeed, AI is increasingly viewed as a strategic tool for sustainable development: it can contribute to climate action, biodiversity conservation, and other Sustainable Development Goals. However, rapid AI growth also raises concerns. It can embed biases and consume massive power which heavily impact climate change, potentially harming vulnerable communities. AI's sustainability impact depends on how it is developed and deployed.

AI's prospects and pitfalls must be understood together. On one hand, AI can make society more efficient – for instance, optimizing irrigation and fertilizer use in farming to boost yields while reducing waste. On the other hand, AI systems themselves require significant resources to develop and train, to such an extent that even leading tech companies find that scaling AI often requires them to prioritize performance over energy efficiency. Hence, to ensure that AI truly supports a sustainable future requires giving attention to both, its applications and its own footprint.

**LITERATURE REVIEW**

Research on AI and sustainability spans many domains. Recent surveys and reports highlight numerous applications of AI for the environment. For example, IBM's Green Horizons initiative uses machine learning and IoT data to forecast urban air quality and renewable energy output. IBM's AI system produced fine-scale 1 km×1 km pollution forecasts 72 hours ahead, enabling officials to reduce particulate pollution (PM2.5) by about 20% in three quarters of 2015. This shows how AI and data can inform policy decisions and yield measurable improvements in air quality. Similarly, Microsoft's "AI for Earth" program has funded projects in precision agriculture and conservation. Its "FarmBeats" project collects soil, weather and satellite data to advise farmers on optimal planting and irrigation timing. Advanced AI models have also been deployed for large-scale land-cover mapping (e.g. classifying 200 million aerial images over the entire US in minutes) and for wildlife monitoring through camera traps and drones. These AI-driven tools can rapidly analyse complex environmental data, giving scientists and managers insights that were previously laborious or impossible. In short, the literature shows AI enabling efficiency and understanding in sustainability efforts – from smarter farming and energy grids to better disaster prediction and species tracking.

Quantitative studies reinforce this promise. For instance, a recent econometric analysis of 21 countries found that increases in AI-related patents and investment were statistically linked to lower CO2 emissions. It has been

reported that a 1% rise in AI innovation corresponded to a significant drop in emissions, especially in high-carbon economies. They further note that combining AI with clean energy and human capital investment amplifies its sustainability benefits. In line with this, AI is being used in climate action and biodiversity efforts, noting its role in climate-smart agriculture and emissions reduction strategies. Overall, the literature suggests that when guided by renewable energy and supportive policies, AI can help decouple growth from emissions (a “green tech” effect).

However, concerns about AI’s own negative footprints also appear widely here. Multiple studies and experts warn that modern AI models, especially deep learning and generative AI are extremely resource-intensive. Training a single large model can require hundreds of megawatt-hours of electricity, leading to substantial greenhouse-gas emissions unless the power is fully renewable. This is pushing the grid demand and CO<sub>2</sub> output upward leading to speculations that global AI data centre electricity use could triple by the year 2030. Such growth would result in prolong fossil fuel reliance, since overall demand soars. Water use is also a critical issue: AI data centres already consumed an estimated 175 billion litres of water in 2023, and this could quadruple by 2030, straining scarce resources. In short, AI is a key driver of energy demand in the entire data infrastructure sector and its rapid expansion poses significant risks to climate goals.

These technical challenges are further compounded by potential ethical and social risks. AI systems are often trained on historical data reflecting linear economies, which can bias them against circular or sustainable practices. AI-based optimizations such as in, supply chains or advertising industries may inadvertently prioritize cost and consumption, and even enable green-washing through misleading reports. Unequal access to AI technologies could widen the gap between wealthy and under-resourced communities, creating an “AI divide” in sustainability gains. Therefore AI needs to be assessed for its impacts on sustainability, fairness and accountability to ensure that its benefits reach all and the systems are transparent.

### **Objectives**

The study has four main objectives:

- Assess AI’s contributions to environmental sustainability by reviewing its applications (e.g. in energy, agriculture, conservation).
- Identify key challenges in using AI sustainably, spanning technical (energy use, data limitations), ethical (bias, privacy), and social (equity, governance) dimensions.
- Review strategies and solutions (technological improvements, policies, ethical guidelines) that have been proposed or implemented to address these challenges.
- Present real-world case studies (e.g. data centre optimization, pollution forecasting) to illustrate both successes and lessons learned.

By meeting these objectives, the paper aims to provide an integrated understanding of how AI can be aligned with sustainability goals.

### **RESEARCH METHODOLOGY**

This study uses a descriptive research methodology, based on systematic literature review and case synthesis using secondary data. We surveyed recent journal articles, industry reports, and reputable news sources on AI and sustainability on both positive uses and critical analyses. The approach is qualitative where we interpret and organize existing knowledge to reveal patterns, insights and themes. Key case studies (e.g. Google’s AI data centres, IBM’s air-quality project) were identified from the literature to ground the discussion in real examples. The narrative is structured to cover theory and practice, and to remain accessible: technical details are explained in plain language, and findings are linked to concrete references.

### **AI in Practice: Case Studies**

**Data centre efficiency:** Google’s DeepMind demonstrated that AI can significantly reduce energy waste. By training neural networks on thousands of sensors in its data centres, DeepMind cut the energy required for cooling by **up to 40%**. This is a clear win: even at Google’s already-efficient facilities, machine learning algorithms found operating adjustments that human engineers had missed. The implication is that if AI is used

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to manage its own infrastructure, total energy use can drop. However, this also highlights a paradox that: as AI models become bigger and more ubiquitous, the demand for data centre resources can still grow faster than gains in efficiency.

**Air quality and energy forecasting:** IBM's *Green Horizons* program exemplifies AI for environmental management. In China, IBM Research built an AI-powered forecasting system for urban air pollution. The system ingests data on emissions, weather, traffic and topography, using machine learning to predict pollutant dispersal hours and days ahead. In Beijing, this allowed officials to take pre-emptive actions; reportedly, their city saw a 20% reduction in ultra-fine particulates (PM2.5) over one year. Beyond Beijing, Green Horizons was deployed in cities like Delhi and Johannesburg to model pollution trends and test intervention strategies. IBM also applied AI to renewable energy: for example, helping forecast wind farm output with high accuracy. Governments and utilities use the predictions to balance the grid or restrict emissions, leading to tangible environmental gains.

**Agriculture and conservation:** AI is widely used to make farming more sustainable and to protect biodiversity. Microsoft's AI for Earth funds many such initiatives. For instance, the FarmBeats project combines machine learning with sensors and drones so that farmers know exactly when and where to irrigate or apply fertilizers for optimal yield with minimal waste. AI-driven land cover mapping can process satellite images in bulk, rapidly identifying deforestation or changes in land use, which is invaluable for conservation planning. In wildlife research, deep learning algorithms can scan thousands of camera-trap images to count animals or detect poaching, and perform tasks that used to take human analysts months. In these cases, AI enhances data-driven environmental management and conservation by turning raw data into actionable information.

**Quantitative findings:** Beyond individual projects, analytic studies offer insight into AI's overall impact. AI innovation can correlate with emissions. Panel data was used to find that AI adoption (measured by patents) has a statistically significant negative effect on CO<sub>2</sub> emissions in most models. For example, their results suggest that a 1% increase in AI technology leads to roughly a 0.047% drop in CO<sub>2</sub>. The effect was especially strong in the most carbon-intensive economies. Coupling AI with higher shares of renewable energy yields even better outcomes. These analyses support the idea that AI can help reduce emissions when used in the rightly in conjunction with clean energy and skilled workforce investments.

### **Challenges and Limitations**

While AI offers these benefits, the data also reveal significant challenges.

**Energy and resource use:** As noted, training and running AI models demands electricity and cooling. Simple deployment of models for millions of users (as in chatbots) continually draws large amount of power. The Greenpeace report warns that by 2030 the power needed for AI data centres could become comparable or at par with the amount of power being used by all data centres today, putting climate targets at risk. Each data centre also uses water for cooling which is a concern in arid regions. For example, it has been projected that AI infrastructure in US could consume up to 1.1 billion cubic litres of water per year by 2030 given a high-growth scenario. These figures show that even if individual data centres become more efficient, the aggregate effect of rapid AI expansion could still raise total emissions and resource use.

**Technical limitations:** AI's effectiveness for sustainability depends on data quality and context. Models often rely on historical data, which may not capture novel environmental changes. If AI is trained on linear-economy datasets, it may fail to recognize circular (recyclable) or sustainable alternatives. In practice, many AI tools (like optimization for logistics or manufacturing) are designed for cost minimization and profit, potentially neglecting long-term resource reuse or waste reduction. This means that without deliberate design, AI could inadvertently reinforce the status quo rather than drive green innovations.

**Ethical and social concerns:** The literature emphasizes that technology does not exist in a vacuum. AI should respect human rights, transparency, and environmental wellbeing. It warns that AI biases and lack of oversight can compound social inequalities. For instance, an AI system allocating land or resources without accounting for indigenous rights could harm marginalized communities. Socially, access to AI tools is uneven: rural farmers or developing countries may lack the data and infrastructure to benefit from AI advancements, leading

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to an "AI divide." These social dimensions highlight that sustainability encompasses not just ecology but also equity and participation.

### KEY FINDINGS

From the above analysis we derive several key findings:

- **AI's dual impact:** AI can both advance and hinder sustainability. Empirical cases (e.g. Google's data centres, IBM's forecasts) show AI improving efficiency and environmental management. At the same time, macro-scale analyses and reports warn that unchecked AI growth will raise energy use and emissions. Thus, whether AI is "good" or "bad" for the environment depends on how it is deployed.
- **Context matters:** The net effect of AI hinges on context. Studies suggest that AI-driven emission reductions are strongest when matched with renewable energy and human capital investment. Conversely, if AI computation is powered by coal-heavy grids, total emissions can increase even as efficiency per model improves. Spatial factors matter too: placing data centres in water-stressed regions exacerbates water scarcity, whereas placing them in low-carbon areas can mitigate the impact.
- **Integrated strategy needed:** No single fix exists. Studies show that combining siting, grid decarbonisation and operational efficiency could cut AI-related carbon by 73% and water use by 86%. This implies that both technological solutions (better cooling, efficient algorithms) and policy measures (clean energy infrastructure, regulations) must work together.
- **Ethics and governance are crucial:** Experts concur that ethical guidelines and multi-stakeholder governance are key. UNESCO's recommendation places sustainability and human rights at AI's core. This means projects must be evaluated for social and environmental impact. Without transparency and accountability, AI systems risk entrenching inequality or enabling green-washing. Therefore, trust and inclusion are just as important as technical performance.

### SUGGESTIONS

Based on the above, the following strategies are recommended to align AI with sustainability goals:

- **Power AI with renewables:** Transition AI data centres to 100% clean energy sources (wind, solar, hydro) because, when AI growth is paired with decarbonisation, emissions can be cut dramatically. Tech firms and governments should incentivize placing AI workloads in regions with abundant green power.
- **Optimize AI resource use:** Encourage development of more efficient algorithms and hardware. For example, Google's practice of co-developing custom servers and cooling systems demonstrates how design choices reduce consumption. AI research should prioritize computational efficiency alongside accuracy.
- **Implement ethical frameworks:** Adopt and enforce guidelines like UNESCO's Recommendation on AI Ethics, which explicitly includes environmental sustainability as a criterion. This means AI projects should be evaluated with respect to their ecological impact and must require transparency. For instance, companies could be mandated to report their AI-related energy and water use, similar to carbon reporting.
- **Promote circular economy principles:** Integrate circularity into AI design. AI developers should incorporate circular-economy metrics in training data and optimization goals. For example, supply-chain AI tools could be programmed to value recycled materials. This helps to prevent AI from becoming subject to "linear" efficiency at the expense of reuse.
- **Foster multi-stakeholder collaboration:** Encourage joint planning among industry, regulators, and communities. AI infrastructure should be coordinated with local environmental conditions and needs. Establishing forums for industry and civic groups to co-design AI policy can ensure diverse perspectives including those from developing regions are heard.
- **Invest in human capital and data infrastructure:** Fund education in AI and data literacy for engineers and policymakers, so that AI is applied wisely. Robust environmental datasets should be made open and of high-quality so that AI models can learn effectively about ecological systems.

- **Leverage AI for sustainability monitoring:** Use AI to continuously monitor the outcomes of sustainability initiatives. AI tools can help track progress on goals (e.g. deforestation rates, pollution levels) and flag unintended consequences. By closing the loop between AI decision-making and real-world feedback, we can adapt strategies in real time.

## CONCLUSION

Artificial intelligence stands at a crossroads with respect to sustainability. It is both, an enabler and a challenge. On the enabling side, AI-driven tools are already helping to conserve resources, optimize energy, and protect ecosystems (as seen in data centre management, pollution forecasting, smart agriculture and biodiversity monitoring). These successes illustrate AI's potential to advance environmental goals. On the challenge side, the very computing power that AI demands can have a large ecological footprint. Recent analyses show that without careful planning, AI's growth could significantly increase electricity and water use.

The literature emphasizes that outcomes are not pre-determined. To steer towards a sustainable environment, stakeholders must take concrete actions: Power AI with clean energy, applying efficiency best practices (as in Google's example), and embedding sustainability into AI ethics and policy. UNESCO's global AI ethics framework underlines this by making environmental sustainability a core value.

In conclusion, AI for sustainability is not a silver bullet, but it can be a *powerful accelerator* if guided wisely. Our review finds that combined technical and governance strategies such as green computing infrastructure and inclusive AI guidelines are needed to maximize benefits and mitigate risks. Ultimately, integrating AI into environmental efforts must be done with transparency, accountability and collaboration. By doing so, the world can harness AI's ingenuity in service of a greener future, while avoiding new pitfalls.

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