



A STUDY ON ARTIFICIAL INTELLIGENCE FOR A SUSTAINABLE FUTURE IN INDIA: OPPORTUNITIES AND CHALLENGES

Swetha Golla¹, T Sanjay Kumar^{2*}

Original Article

¹Aristotle PG College, 501504 Telangana, India²TKR Institute of Management and Science, 500097 Hyderabad, India*Corresponding Author's Email: sanjay.taurani@gmail.com

Abstract

Artificial intelligence (AI) holds significant potential to promote sustainability in India and address key challenges in areas such as energy, agriculture, waste management, and climate change. However, its adoption presents unique opportunities and challenges within the Indian context. This article explores how AI can contribute to sustainable development by optimising renewable energy integration, enhancing precision agriculture, and enabling intelligent urban planning. At the same time, it examines barriers such as high computing costs, data shortages, ethical concerns, and inadequate digital infrastructure. The study highlights India's growing AI initiatives, including government policies, private-sector innovations, and state-level guidelines, while emphasizing that it requires energy-efficient AI models and better system integration. The paper concludes that coordinated efforts by policymakers, researchers, and industry leaders are crucial to harness the full potential of AI for a sustainable future in India.

Keywords: *Artificial Intelligence; Climate Resilience; Ethical AI; Renewable Energy; Sustainability; Smart Agriculture*

Introduction

Artificial Intelligence (AI) revolutionises industries around the world, providing transformative solutions to complex sustainability challenges. In India, where rapid urbanisation, climate change and resource reduction are significant threats, AI offers opportunities to promote sustainable development [1]. The integration of AI in sectors such as energy, agriculture, waste management and climate effectiveness can improve efficiency, reduce waste, and promote environmentally friendly practices. The country is the third largest emitter of greenhouse gases, and its agricultural sector is extremely vulnerable to climate change. Meanwhile, urban areas are fighting waste management and energy inefficiency. AI can play a central role in treating these issues by enabling data-controlled decisions, predictive analytics, and automation. The adoption of AI for sustainability in India is not without its challenges. High computing costs, lack of quality data, ethical concerns, and inadequate digital infrastructure have hindered widespread implementation. Furthermore, the energy consumption of the AI system itself raises questions about its environmental impact. This paper examines the opportunities and challenges of using AI for a sustainable future in India [2].

Literature Review

Studies highlight AI's role in optimising centres by giving them a sharper picture and helping them balance supplies and renewable energy systems. Machine learning algorithms improve solar and wind energy forecasting, enhancing grid stability [3]. In India, AI-driven smart grids can reduce transmission losses and integrate decentralised renewable sources effectively. Precision agriculture powered by AI helps farmers optimise water usage, predict crop yields, and detect pests early [4]. In India, AI-based solutions like IBM Watson Decision Platform for Agriculture assist smallholder farmers in making informed decisions [5]. AI-enabled waste sorting systems improve recycling efficiency [6]. Startups like Binish in India use AI-powered robots to segregate waste, reducing landfill dependency [7]. Despite its potential, AI adoption in India faces hurdles such as data scarcity, high costs, and ethical concerns [8]. Additionally, the carbon footprint of training large AI models raises sustainability concerns [9].

Key Applications of AI in Energy, Agriculture, and Waste Management. AI in Energy Artificial intelligence smooths the power grid by predicting demand, spotting faults, and blending solar and wind into the mix [3]. Machine-learning tools now warn operators before turbines or generators fail, trimming costly outages [10]. For tall buildings, LSTM networks learn daily rhythms and shave excess chill or heat from rooms [11]. Together, these systems give control centres a sharper picture and help them balance supply when the sun or wind dips [12]. AI in Agriculture Farmers fly drones and set out IoT probes to watch soil moisture and crop health from afar [4]. Cameras backed by computer-vision code spot wilting or blight early, so growers need far fewer sprays [13]. Other models merge forecasts and past readings to guess how many tonnes of corn or beans the field will yield [14]. When combined with smart drip rigs, that intel curbs wasteful irrigation and keeps roots fed even in dry spells [15]. AI in Waste Management Sorting robots equipped with cameras and AI hands deal with tangled plastics far faster than humans [6]. Route-planning software trims miles on collection runs, saving fuel and cutting street congestion [16]. Out at the dump, models can gauge cell temperature and gas flow, flagging spots that might leak methane [17]. Marine cameras powered by deep-learning nets even spot PET bottles in the water, helping crews pull targets instead of nets [18].

Challenges Hindering AI Adoption for Sustainability Poor data availability and patchy sensors still hamstring many projects, leaving algorithms half-baked at launch.

Objective

1. To identify key applications of AI in energy, agriculture, and waste management.
2. Examine challenges hindering AI adoption for sustainability.
3. Propose policy and technological recommendations for responsible AI deployment.

Methodology

This research employs Secondary Data Analysis: Review of academic papers, government reports, and industry case studies.

Discussion

Artificial Intelligence (AI) presents transformative opportunities for advancing sustainability in India, but its implementation must be carefully managed to address existing challenges. Below, the author discusses key opportunities, barriers, and policy recommendations [19].

Opportunities for AI in Sustainability

- **Renewable Energy Optimisation**

AI can significantly enhance India's renewable energy sector by:

- **Improving Energy Forecasting:** Machine learning models predict solar and wind energy generation, reducing reliance on fossil fuels [20].
- **Smart Grid Management:** AI optimises electricity distribution, minimizing transmission losses.
- **Demand-Supply Balancing:** AI-driven demand response systems help stabilise grids with high

renewable penetration [21].

- **Precision Agriculture**

AI applications in agriculture include:

- **Crop Monitoring:** Drones and satellite imagery combined with AI analyse soil health and crop conditions [4].
- **Predictive Analytics:** AI models forecast pest attacks and droughts, enabling proactive measures [5].
- **Resource Efficiency:** AI-based irrigation systems reduce water wastage by up to 30% [22].

- **Waste Management & Circular Economy**

AI-driven waste management solutions:

- **Automated Waste Sorting:** AI-powered robots segregate recyclable and non-recyclable waste [6].
- **Smart Bin Systems:** IoT-enabled bins with AI optimize waste collection routes, reducing fuel consumption.
- **Plastic Waste Tracking:** AI identifies and tracks plastic waste in rivers, aiding cleanup efforts [23].

- **Climate Resilience & Disaster Management**

- **AI-Powered Early Warning Systems:** Predict floods, cyclones, and heatwaves with higher accuracy [24].
- **Carbon Footprint Tracking:** AI helps industries monitor and reduce emissions [25].

Key Challenges in AI Adoption

- **Data Limitations & Infrastructure Gaps**

- **Lack of High-Quality Data:** Many AI models require large, labelled datasets, which are scarce in India [8].
- **Digital Divide:** Rural areas lack high-speed internet and computing infrastructure.

- **High Costs & Energy Consumption**

- **Computational Expenses:** Training deep learning models requires expensive GPUs and cloud computing [9].
- **Carbon Footprint of AI:** Large AI models consume massive energy, contradicting sustainability goals [26].

- **Ethical & Regulatory Concerns**

- **Algorithmic Bias:** AI systems may reinforce existing social inequalities [27].
- **Job Displacement:** Automation in agriculture and waste management could affect low-skilled workers [28].

Policy & Strategic Recommendations

To maximise AI's potential for sustainability, India must:

1. **Enhance Data Accessibility:**

- Government-led open data initiatives for climate, agriculture, and energy sectors.
- Public-private partnerships to build AI-ready datasets [20].

2. **Invest in Green AI:**

- Promote energy-efficient AI algorithms (e.g., TinyML, federated learning).
- Use renewable energy to run AI data centres.

3. **Strengthen Regulatory Frameworks:**

- Ethical AI guidelines to prevent bias and ensure transparency [29].
- Incentives for startups developing sustainable AI solutions.

4. **Boost Digital Infrastructure:**

- Expand 5G and IoT networks in rural areas for AI-driven agriculture.
- Establish AI research hubs in universities.

Conclusion

AI has enormous potential to promote sustainable development in India by optimising energy consumption, improving agricultural productivity, improving waste management, and strengthening climate resistance. However, we must address challenges like data shortages, high costs, ethical concerns, and energy-intensive AI models. Cooperative approaches that influence state guidelines, private sector innovation, and academic research are essential. India needs to prioritise green AI, ethical framework conditions, and integrated digital growth to ensure that AI provides a sensible contribution to sustainability. By using India responsibly, he is able to achieve its Sustainable Development Goals (SDGs) while simultaneously promoting economic growth and environmental protection.

Conflict of Interest

The authors declare that they have no conflict of interest.

Acknowledgement

The authors are thankful to the institutional authority for completion of the work.

References

1. Doran NM, Badareu G, Doran MD, Enescu M, Staicu AL, Niculescu M. Greening automation: Policy recommendations for sustainable development in AI-driven industries. *Sustainability*. 2024 Jun 8;16(12):4930. <https://doi.org/10.3390/su16124930>
2. Kanjilal P, Karmakar S, Ray N, Maity B, Basu S. Harnessing AI for Sustainable Future Tourism Industry. *International Journal of Advances in Business and Management Research (IJABMR)*. 2025 Sep 12;3(1):22-34. <https://doi.org/10.62674/ijabmr.2025.v3i01.003>
3. Omitaomu OA, Niu H. Artificial intelligence techniques in smart grid: A survey. *Smart Cities*. 2021 Apr 22;4(2):548-68. <https://doi.org/10.3390/smartcities4020029>
4. Kamilaris A, Kartakoullis A, Prenafeta-Boldú FX. A review on the practice of big data analysis in agriculture. *Computers and electronics in agriculture*. 2017 Dec 1; 143:23-37. <https://doi.org/10.1016/j.compag.2017.09.037>
5. Gemme G, Grossi M, Ferraro D, Vallecorsa S, Sassetti M. IBM quantum platforms: A quantum battery perspective. *Batteries*. 2022 May 14;8(5):43. <https://doi.org/10.3390/batteries8050043>
6. Kaza S, Yao L, Bhada-Tata P, Van Woerden F. What a waste 2.0: a global snapshot of solid waste management to 2050. World Bank Publications; 2018 Dec 12.
7. Raimi D, Zhu Y, Newell RG, Prest BC, Bergman A. Global energy outlook 2023: sowing the seeds of an energy transition. *Resour. Future*. 2023 Mar;1(1):1-44.
8. Brynjolfsson E, McAfee AN. Artificial intelligence, for real. *Harvard business review*. 2017 Jul;1(1):1-31.
9. Strubell E, Ganesh A, McCallum A. Energy and policy considerations for modern deep learning research. In *Proceedings of the AAAI conference on artificial intelligence 2020 Apr 3 (Vol. 34, No. 09, pp. 13693-13696)*. <https://doi.org/10.1609/aaai.v34i09.7123>
10. Ajao OR. Optimizing Energy Infrastructure with AI Technology: A Literature Review. *Open Journal of*

Applied Sciences. 2024 Dec 3;14(12):3516-44. <https://doi.org/10.4236/ojapps.2024.1412230>

11. Ahmad T, Zhang D, Huang C, Zhang H, Dai N, Song Y, Chen H. Artificial intelligence in sustainable energy industry: Status Quo, challenges and opportunities. *Journal of cleaner production*. 2021 Mar 20; 289:125834. <https://doi.org/10.1016/j.jclepro.2021.125834>
12. Smart EE, Olanrewaju LO, Usman J, Otaru K, Umar D. Artificial Intelligence (AI) in renewable energy forecasting and optimization. *renewable energy*. 2025; 10:11. <https://doi.org/10.30574/wjaets.2025.15.2.0300>
13. Mohanty SP, Hughes DP, Salathé M. Using deep learning for image-based plant disease detection. *Frontiers in plant science*. 2016 Sep 22; 7:215232. <https://doi.org/10.3389/fpls.2016.01419>
14. Van Klompenburg T, Kassahun A, Catal C. Crop yield prediction using machine learning: A systematic literature review. *Computers and electronics in agriculture*. 2020 Oct 1;177:105709. <https://doi.org/10.1016/j.compag.2020.105709>
15. Goap A, Sharma D, Shukla AK, Krishna CR. An IoT based smart irrigation management system using Machine learning and open source technologies. *Computers and electronics in agriculture*. 2018 Dec 1;155:41-9. <https://doi.org/10.1016/j.compag.2018.09.040>
16. Nuortio T, Kytöjoki J, Niska H, Bräysy O. Improved route planning and scheduling of waste collection and transport. *Expert systems with applications*. 2006 Feb 1;30(2):223-32. <https://doi.org/10.1016/j.eswa.2005.07.009>
17. Brunner PH, Rechberger H. Waste to energy–key element for sustainable waste management. *Waste management*. 2015 Mar 1;37:3-12. <https://doi.org/10.1016/j.wasman.2014.02.003>
18. Jia T, Kapelan Z, De Vries R, Vriend P, Peereboom EC, Okkerman I, Taormina R. Deep learning for detecting macroplastic litter in water bodies: A review. *Water Research*. 2023 Mar 1;231:119632. <https://doi.org/10.1016/j.watres.2023.119632>
19. Diyin Z, Bhaumik A. The Impact of Artificial Intelligence on Business Strategy: A Review of Theoretical and Empirical Studies in China. *International Journal of Advances in Business and Management Research (IJABMR)*. 2025 Mar 12;2(3):9-17. <https://doi.org/10.62674/ijabmr.2025.v2i03.002>
20. Parvathareddy S, Yahya A, Amuhaya L, Samikannu R, Suglo RS. A Hybrid Machine Learning and Optimization Framework for Energy Forecasting and Management. *Results in Engineering*. 2025 May 23:105425. <https://doi.org/10.1016/j.rineng.2025.105425>
21. Agarwal JD, Agarwal A. NITI Aayog's INDIA–Three year action agenda 2017-18 to 2019-20: Review and analysis. *Aestimatio: The IEB International Journal of Finance*. 2018(16):142-63.
22. TEKER D, ORMAN I. SUSTAINABILITY OF AGRICULTURE: AGRITECH PRACTICES. *Journal of Global Strategic Management*. 2023 Dec 1;17(2).
23. Tanis AH. The Ocean Cleanup Barrier. Retrieved from: <https://theoceancleanup.com/>
24. Desai BH. 14. United nations environment programme (UNEP). *Yearbook of International Environmental Law*. 2020 Dec 1;31(1):319-25. <https://doi.org/10.1093/yiel/yvab060>

25. Mehrabi N, Morstatter F, Saxena N, Lerman K, Galstyan A. A survey on bias and fairness in machine learning. ACM computing surveys (CSUR). 2021 Jul 13;54(6):1-35. <https://doi.org/10.1145/3457607>
26. Schwartz R, Dodge J, Smith NA, Etzioni O. Green ai. Communications of the ACM. 2020 Nov 17;63(12):54-63. <https://doi.org/10.1145/3381831>
27. Wang Z, Li Y, Wang K, Cain J, Salami M, Duffy DQ, Little MM, Yang C. Adopting GPU computing to support DL-based Earth science applications. International Journal of Digital Earth. 2023 Oct 2;16(1):2660-80. <https://doi.org/10.1080/17538947.2023.2233488>
28. Schwab K. The Global Competitiveness Report 2014–2015. Geneva: World Economic Forum; 2015. Retrieved from: https://www3.weforum.org/docs/WEF_GlobalCompetitivenessReport_2014-15.pdf
29. Hutapea RT, Ramadhan RP, Meity AT, Ngongo Y. Competitiveness of Indonesian Rice prices in the international market. InE3S Web of Conferences 2022 (Vol. 361, p. 01016). EDP Sciences. <https://doi.org/10.1051/e3sconf/202236101016>