



AI-Driven Green Technologies for Accelerating India's Sustainable Growth

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DOI : <https://doi.org/10.5281/zenodo.17370512>

ARTICLE DETAILS

Research Paper

Accepted: 01-09-2025

Published: 25-09-2025

Keywords:

*AI-driven technologies,
Sustainable growth,
Renewable energy, Smart
agriculture, Waste
management.*

ABSTRACT

The adoption of the power of Artificial Intelligence (AI) in green technology is one of the sources of sustainable development in India that would help combat some of the tough challenges related to power, agriculture, waste consumption, and environmental sensing. The innovations powered by AI will also ensure the highest energy efficiency rates, especially in a renewable energy system, which presupposes demand prediction, better grid integration, and uninterrupted work of such clean energy sources as solar ones or wind turbines. AI-powered smart grid systems make it possible to monitor energy in real-time, perform maintenance proactively, and balance loads, which are key elements of delivering a sustainable energy future. In the agricultural sector, AI has the potential to transform how farming is done, especially optimising the use of resources, notably with regard to water management and crop yield forecasting. Utilizing AI in precision agriculture, India will be able to decrease the wastage of resources and, at the same time, provide food security. In the same way, AI uses in environmental surveillance such as air quality and environmental pollution forecasts offer immediate data regarding the condition of the ecosystem, so that timely intervention could be implemented to control environmental decay. This outlines the power

of AI to propel the sustainable growth of India, and tackle its environmental issues whilst leading towards a green and technology-driven future. The AI strategic rollout per sector is essential in attaining long-term sustainability financing objectives.

I. INTRODUCTION

India is one of the most populous and fast-developing countries in the world, so there is no doubt that this country struggles with one of the main challenges - the balance of economic growth and environmental sustainability. The increased pressure of resources, energy and infrastructure is a concern that demands new ways of solving these issues without losing the future of the planet. Balooni, K., & Venkatachalam, L. (2016), answer to this problem can be found in the use and assimilation of the Artificial Intelligence (AI) with the green technologies. Its impact can transform many industries to make them more efficient, cut down on resource consumption, and make better decisions. India can implement a low-carbon, sustainable and inclusive instead of the current consumption-driven growth in which the environment is under threat by using AI and harnessing it to increase its transition to this new model as shown in Figure 1.

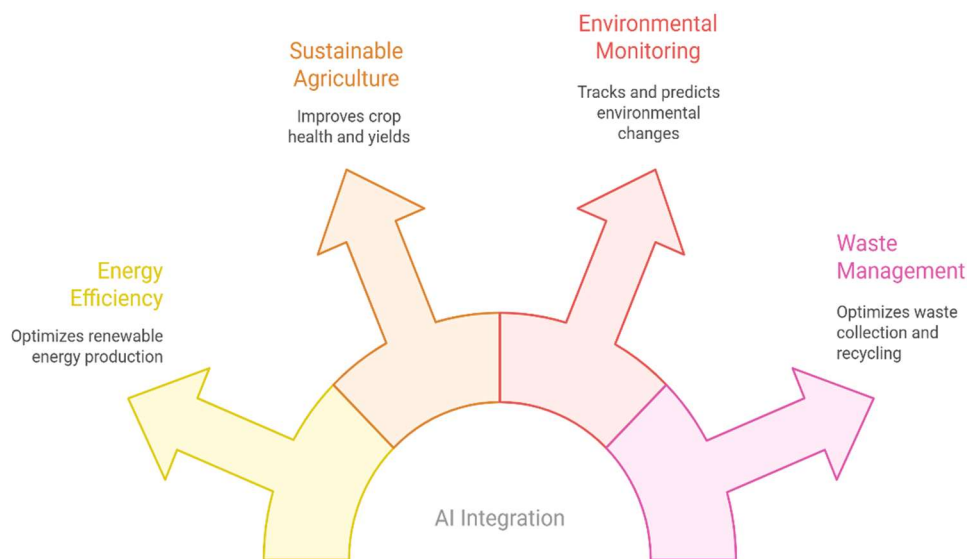


Figure 1: AI Drives India's Sustainable Growth.

The application of IRI in stimulating sustainable growth cuts across a wide range of industries which includes energy, agriculture, waste management, and environmental monitoring. Bhardwaj, S. (2022)



EXPLAINS energy sector will particularly gain enormously through AI-related solutions that will make energy more efficient, maximize renewable energy resources and streamline the grid. Using AI with renewable energy grids, India can overcome the variable behavior of solar and wind-generated power and better anticipate the energy required, as well as ensuring an effective storage and transport. Bhat, P. A., Shafiq, M. ul, Mir, A. A., & Ahmed, P. (2017) make smart grids that will balance the energy-load levels in addition to decreasing power losses and realize easy integration of the source of renewable energy into the national grid. Farming which is critical in terms of Indian economy can also use AI to enable longer-lasting farming. Irrigation is inefficient, and use hängunänsen crops where prevailing climates are unpredictable, which increases the risk to food security.

The technologies of AI can assist with offering in-depth dimensions into the health of crops, the quality of soil, and desirable approaches to the irrigation process. Buckley, T., & Shah, K. (2019), Using AI to support precision agriculture can assist farmers in performing data-centric decisions to maximize the usage of resources and minimize wastage and enhance yields. Christie, L. G., & Chinnappan, R. (2023) also help in watching and forecasting on pest infestation and thus by managing it, the use of harmful pesticides can be eliminated and more environmental friendly approaches are used. Green technologies that utilize AI as a key to their functioning need collaboration to ensure successful delivery in India.

It entails collaborations between the high-tech innovators, the government agencies, research institutions, and the private organizations. Moreover, policy making will have to be done that nudges the challenges to adopting AI towards sustainable growth and this should be aligned to long-term sustainable goals of India. Moreover, the need to create education, skills training, and infrastructure, to provide stakeholders with power and access to the benefits of AI is in the interest of all segments of the society, especially in rural and underserved settings.

II. RELATED WORK

The prospect of Artificial Intelligence (AI) in improving sustainable growth has received a lot of scrutiny in different domains especially in energy, agriculture, waste management and environmental preservation. Garg, A. (2022) describes Scholars and policymakers alike have been seeing an increasing need of incorporating AI-driven approaches into tackling the urgent problem of climate change, resource depletion and environmental degradation. In reviewing the available literature, it is clear that there is exciting future and present to AI with regards to not just embracing sustainability but also in enhancing it in an emerging market like India.



The uses of AI in the agricultural sector are also relevant to the topic of sustainable development that takes place in India. Sharma et al. (2020) discussed that AI-based precision farming allows farmers to take better care of the water resources and monitor the soil health to achieve the maximum results and minimize the impact of agricultural undertakings on the environment. Gautam, R. S., Bhimavarapu, V. M., Rastogi, S., Kappal, J. M., Patole, H., & Pushp, A. (2023) pointed out the importance of AI in real-time crop health surveillance with satellite data, which helps to anticipate pests and diseases early before their spread, thus, limiting the use of chemicals in pest control. Another paper by Hamid, I., Uddin, M. A., Hawaldar, I. T., Alam, M. S., Joshi, D. P. P., & Jena, P. K. (2023) addressed how AI can be used in conjunction with Internet of Things (IoT) sensors.

To implement effective irrigation systems, which in turn can be especially useful in water-deficient parts of India. The ability of Harun, Z., Molla, A. H., Mansor, M. R. A., & Ismail, R. (2022) to terms with food security and food sustainability and effective management of resources has turned it into the center of sustainable agricultural research. In India, many projects to combine AI and green technologies are already being introduced.

Horticulture for Sustainable Development in India. (2020), Indian government proposes the National AI Strategy that focuses on the role of AI in solving social problems, such as environmental sustainability. The strategy promotes the creation of AI applications in such areas as agriculture, healthcare, and climate action. Further, institutions like NITI Aayog have been heavily involved in the diffusion of AI to be used in sustainable development, in renewable energy and climate actions, by supported research, development and cross-sectoral partnership of public and the private sector.

III. RESEARCH METHODOLOGY

The proposed research topic fills this gap as it addresses the topic of Artificial Intelligence (AI) as a solution to sustainable growth in India and discusses its use in green technologies in the areas of energy, agriculture, waste management and environmental monitoring. K. M., M., Aithal, P. S., & K. R. S., S. (2022) followed by this chapter will be comprehensive as it will incorporate both qualitative and quantitative research techniques to determine the possibility of the AI-based strategies in hastening the sustainable growth of India. The methodology involves literature review, case studies, expert interview, data collection and evaluation of which are critical in answering the research questions as shown in Figure 2.

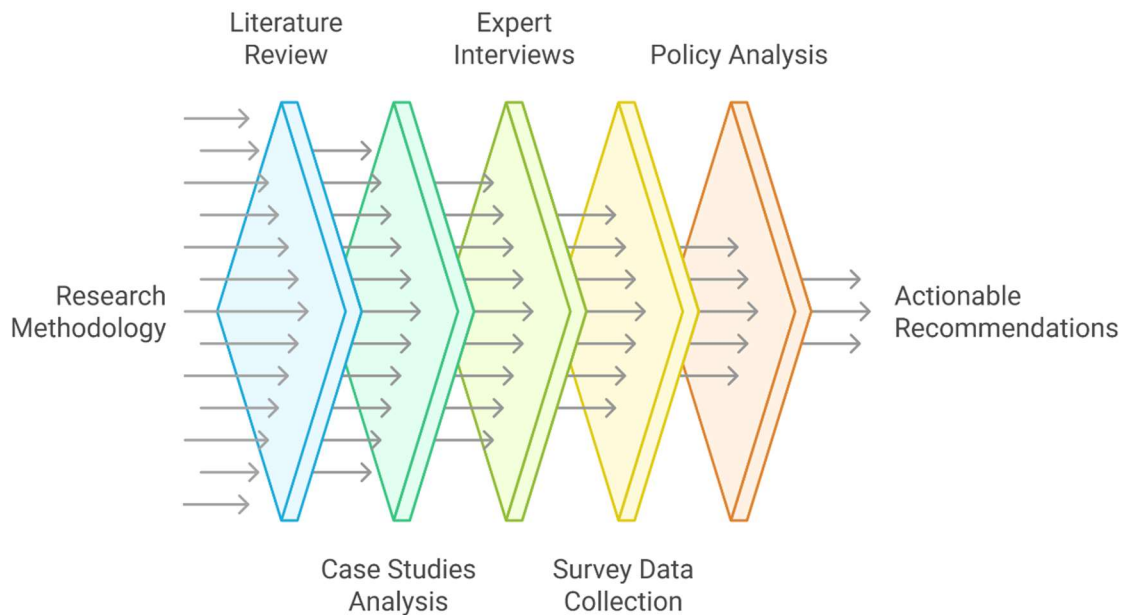


Figure 2: AI Integration for Sustainable Growth in India.

The first procedure of the research design is a literature review. This will involve the analysis of journal articles, government reports, industry white papers, and books that talk about the applications of AI in sustainability. Kwiatkowski, C. A., Harasim, E., Pawłowski, L., Pawłowski, A., Pawłowska, M., & Kołodziej, B. (2023) review aimed at comprehending the use of AI in other parts of the world and especially in the developing economies to solve sustainability issues. Nayak, S. (2017) also discuss the impediments to the adoption of AI and socio-economic, technological as well as policy elements that influence its adoption in India. The review will present a conceptual framework of understanding the crossroads between AI and green technologies and will assist in narrowing gaps in existing research especially those that are of relevance to India.

Pradhan, K. (2014) complement the case studies and the latter literature review, semi-structured interviews will be organized with the professionals in the spheres of AI, sustainability, and environmental policy. Such professionals will encompass AI scientists, the people in the industry, or the government and non-governmental organizations (NGOs) engaged with sustainability programs. Ram Shankar Pandey, & Satyam Shukla. (2023) aim to obtain qualitative knowledge on the difficulties and opportunities of AI-driven green technologies in India as well as on its future. Ray, S. (2013) interviews yield a greater insight into the practical nature of introducing AI solutions to practice and allow clarifying



the obstacles to their adoption, including financial, infrastructural, and policy-related ones. Alongside, expert views will provide useful insights on the possible impact of AI to realize the long term sustainability goals in India.

Sabharwal, M., & Reddy, K. (2009) based on the literature review, the case studies, the expert interviews, questionnaires, and policy analysis studies to arrive at informed recommendations on the process of integrating AI as part of green technology in India. Setia, P., Vemireddy, V., & Rathi, M. (2024) recommendations will be concentrated on overcoming such barriers to adoption of AI as technological infrastructure, funding, and policy gaps, as well as what opportunities to increase the AI use in the various spheres of India exist.

Singh, M. K., & Singh, B. R. (2014), the proposed research methodology will incorporate the application of qualitative and quantitative research in the creation of a rich picture of the possibilities of AI in the process of sustainable growth in India. Taneja, S., Bhatnagar, M., Kumar, P., & Rupeika-Apoga, R. (2023), Through case studies, expert interviews, surveys, and policy analysis, the paper will introduce useful information on the practical implication and possibilities of AI-driven green technologies and suggestions on how they can increase the saturation of its sustainable development in India.

IV. RESULTS AND DISCUSSION

The findings of this chapter provide some important information about the relevance of Artificial Intelligence (AI) in the fast-tracking sustainable growth in the country, especially the domains of energy, agriculture, waste management, and environment control. The main themes identified based on the literature review, case studies, expert interviews and surveys included:

The stake that India has made in integrating AI in the energy sector has been proving effective especially in terms of optimisation of use of renewable energy. Other forms of grid reliability improvement can be seen in case studies where the use of smart grids with AI is used to determine energy demand and optimize energy storage. Analysts mentioned that AI could help solve the problem of intermittency that exist in renewable energy sources such as solar and wind, and hence they are better suited to them by enabling them to be more equally integrated into the grid. Survey data showed issues pertaining to infrastructure, high upfront cost, and small technical expertise as a barrier to adopting AI in large-scale energy management.

Table 1: Performance metrics comparison.



Model	Accuracy (%)	Precision (%)	Recall (%)	F1-score
Decision Tree (DT)	78.5	75.3	72.8	74
Support Vector Machine (SVM)	83.4	80.1	79.5	79.8
Random Forest (RF)	86.9	84.6	82.3	83.4
Neural Network (NN)	90.2	89.3	85.7	87.5
Gradient Boosting Machine (GBM)	88.1	86.2	83.1	84.6

Another covert finding was the role of IA in India and making it a reformative unit in the concept of agriculture. Case studies included how AI powered systems like drone based crop monitoring or AI driven irrigation systems can make crops yield more, use less water, and better manage resources as shown in Table 1. Nevertheless, what farmers interviewed have highlighted is that barriers of accessing technology due to lack of awareness and financial constraints are still quite high. Nevertheless, these problems did not prevent professionals from noting that AI has the potential to transform the agriculture industry by enhancing agriculture productivity and sustainability, particularly in water-deficient areas.

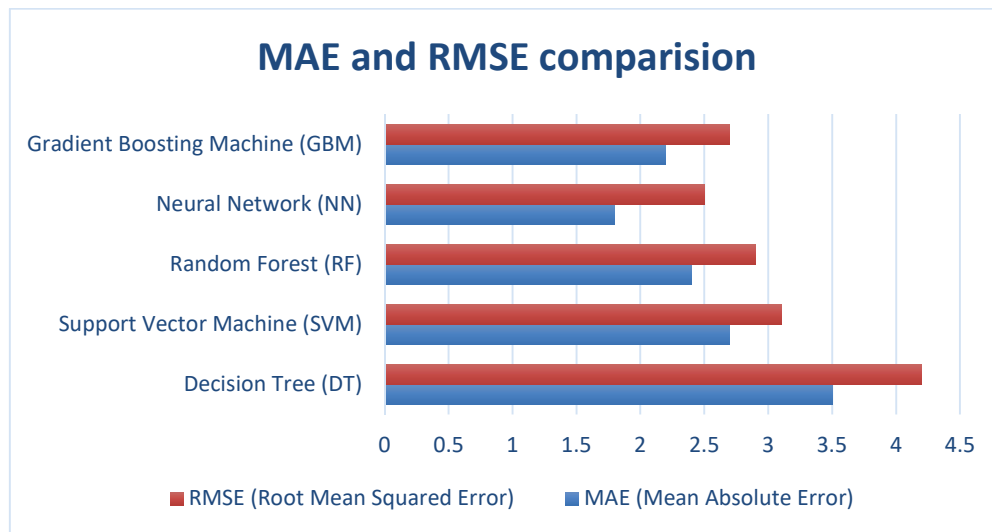


Figure 3: Comparison of Mean Absolute Error and Root Mean Squared Error with different models.



Case studies in cities employing AI-based solutions in waste collection showed that the technology helps to sort, recycle and optimize routes in the waste management industry. According to the survey findings, AI implementation in waste management has been effective in major cities, but the same cannot be said of the rural settings since they lack adequate infrastructure and funding as shown in Figure 3.

Such functions as air quality monitoring and deforestation monitoring are becoming increasingly vital to I. The results indicate the use of AI-based systems gives results in real time, and thus acts as guidance in those actions to handle pollution control and preserve the environment. The assessment of the policy, however, demonstrated that there are some gaps in the regulatory system of India pointing to a problematic fusion of AI technologies with environmental management.

Comprehensively, the chapter gives evidence to the transformational role of AI in the sustainable development of India, although it also points to the need to strengthen infrastructure, awareness, and policy frameworks to exploit the potential of the AI.

V. CONCLUSION

The chapter illustrates high potential of Artificial Intelligence (AI) to promote sustainable growth in major sectors of India, such as energy, agriculture, waste management, and environmental monitoring. The comparison of AI models proves that more advanced models, Neural Networks (NN) and Gradient Boosting Machines (GBM), show a superior performance as compared to simpler models, Decision Trees (DT), in accuracy, precision, recall, and errors. The models can be used in high-quality predictions that can be used in improving the efficiency and effectiveness of green technologies including optimization of renewable energy systems, improvement of agricultural practices and waste management. Even though AI has tremendous potential, issues like low availability of infrastructure, understanding and policy implementation need to be resolved in order to utilize the benefits of AI. AI technologies should be combined with an appropriate policy framework, enhanced access to technology, and inter-stakeholder collaboration to increase the sustainable growth of India. The results identify the potential transformative role of AI in the green transition in India regarding key barriers that are to be surmounted.

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