ISSN–2278-5655

AMIERJ Aarhat Multidisciplinary International Education Research Journal

Volume–XV, Special Issues– I(a) Jan – Feb, 2026

OPEN ACCESS

Original Research Article

ROLE OF AI IN E-WASTE MANAGEMENT AND RECYCLING

*** Ms. Amruta Mayuresh Joshi**

* *Assistant Professor, Department of Information Technology, Ramanad Arya D.A.V.College (Autonomous).*

Abstract:

The rapid growth of electronic waste (e-waste) has a significant impact on environmental, economic, and public health challenges worldwide. Traditional e-waste management and recycling methods are often inefficient, labor-intensive, and unable to cope with the increasing volume and complexity of discarded electronic products. This paper shows the study of the role of Artificial Intelligence (AI) in e-waste management and recycling processes. AI technologies such as machine learning, computer vision, and intelligent robotics enable automated identification, sorting, and disassembly of e-waste, leading to improved material recovery and reduced human exposure to hazardous substances.

Keywords: *Sustainability , E-waste , Artificial Intelligence, Recycling.*

Introduction:

Electronic waste (e-waste) is one of the fastest-growing waste streams due to rapid technological advancement and short product life cycles. Improper handling of e-waste leads to severe environmental pollution and health hazards. Considering the developing countries, e-waste is the major problem related to environmental sustainability. The role of Green Computing or green it is to effectively and efficiently manage the E waste. As computers and computer related resources contain many hazardous substances which are harmful to the ecological system.

Following are the different ways to improve the e-waste management using artificial intelligence techniques.

1. Artificial intelligence helps to sort the e-waste intelligently .
2. Computer vision helps to identify the different e-waste as circuit boards, breadboards, capacitors, register, plastic etc
3. Artificial intelligence also helps to disassemble the different electronic products such as laptops, TV, batteries etc.
4. AI also helps in extracting valuable metals such as copper Silver Gold etc
5. Artificial intelligence also helps in analysing the data related to the e-waste management so that better strategies can be prepared for a better ecological system.
6. AI also helps in consumer awareness and behaviour analysis

Review of Literature:

One of the most significant applications of AI in e-waste systems is automated classification. E-waste comprises heterogeneous materials—plastics, metals, glass, cables, circuit boards—requiring accurate separation for recycling.

Multiple studies demonstrate that convolutional neural networks (CNNs) significantly outperform manual sorting and basic image analysis. CNN architectures like ResNet and MobileNet extract visual features to accurately classify components from images captured on conveyor belts.

ISSN–2278-5655
AMIERJ Aarhat Multidisciplinary International Education Research Journal
Volume–XV, Special Issues– I(a) Jan – Feb, 2026
OPEN ACCESS
Original Research Article

Zhang and Wang (2022) showed CNN models achieving accuracy above 90% in distinguishing plastics, metals, and circuit boards with labeled e-waste image datasets.*Hassan et al. (2023)* integrated CNN classification with robotic sorting, reducing misclassification by over 35% compared to non-AI systems.

Combining visual data with hyperspectral imaging and near-infrared sensors further improves classification of materials with similar visual properties (e.g., different plastics). Manual disassembly of electronics is laborious, hazardous, and uneconomical. AI enhances robotic automation to efficiently disassemble complex devices.*Kim & Choi (2021)* demonstrated that AI-controlled robots can recognize screws, clips, and fasteners on circuit boards and perform disassembly with minimal human intervention. These systems reduce worker exposure to toxic substances and increase throughput. Machine learning models like Random Forest Regression and Long Short-Term Memory (LSTM) networks analyze trends in sales, consumer behavior, and demographic data to forecast future e-waste generation.*Singh et al. (2023)* used LSTM to forecast e-waste quantities in metropolitan cities, improving planning accuracy for recycling facilities.

A 2024 research article in the *Indian Journal of Forestry* investigates how AI can be applied to e-waste sorting, waste amount prediction, and recycling process optimization to reduce environmental damage. The paper emphasises sustainability outcomes alongside technological efficiency, connecting AI methods with ecological benefits.

Objectives of the Study:

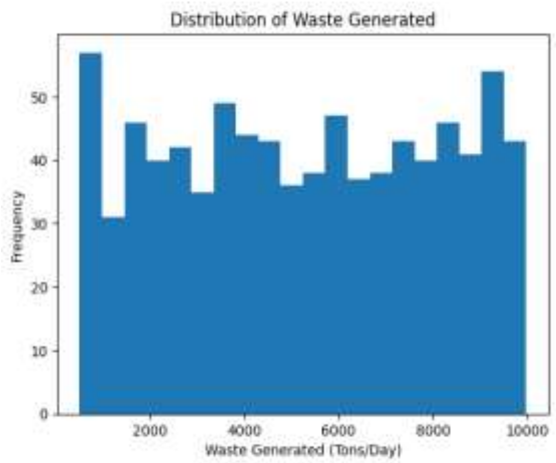
- To study the role of Artificial Intelligence in improving the efficiency, accuracy, and sustainability of e-waste management and recycling systems.
- Promote efficient waste management practices across Indian cities.
- Analyze trends in recycling and waste disposal methods.
- Support research and development in sustainability, environmental science, and urban planning.

Research Methodology:

- **Research Design**: Descriptive and analytical.
- **Data Collection**: Secondary data of e-waste management and recycling across the different major Indian Cities.The dataset consists of 850 observations collected from various Indian cities and districts over the period 2019–2024. It includes variables related to waste generation, recycling performance, municipal efficiency, population characteristics, cost factors, awareness initiatives, and landfill capacity. The dataset provides a comprehensive basis for analyzing the effectiveness of existing waste management systems and identifying opportunities for AI-driven
- **Analysis Tools**: Statistical tools like Power BI, Python ,Excel for descriptive analytics

Data Analysis and Findings:

1) Variation in e- Waste Generated in Tons/Day



The analysis indicates considerable variation in waste generated across cities. Urban and semi-urban districts generate significantly higher waste volumes, reflecting population concentration and consumption patterns.

ISSN–2278-5655

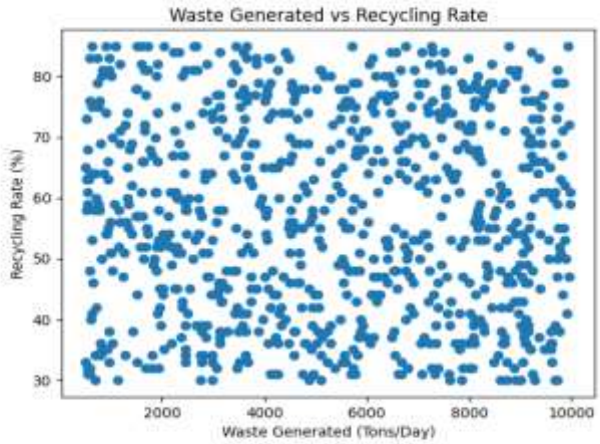
AMIERJ Aarhat Multidisciplinary International Education Research Journal

Volume–XV, Special Issues– I(a) Jan – Feb, 2026

OPEN ACCESS Original Research Article

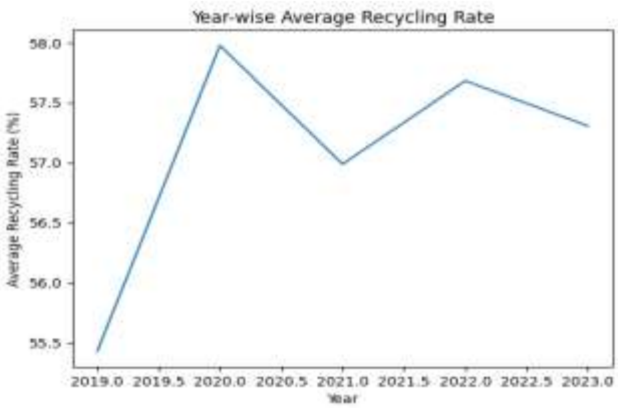
However, high waste generation does not consistently correspond to higher recycling rates.This mismatch highlights the limitation of traditional waste management approaches and underscores the need for AI-based sorting and optimization systems that can handle large and heterogeneous waste streams efficiently and effectively to attain sustainability goals.

2) Waste Generated vs Recycling Rate



Recycling efficiency depends more on process management, technology advancement, and governance quality than on waste quantity alone. AI-driven automation and predictive analytics can help standardize and improve recycling outcomes.Governance and awareness are important, their impact is limited without technological support. AI can enhance these efforts by enabling data-driven decision-making and targeted public engagement strategies.

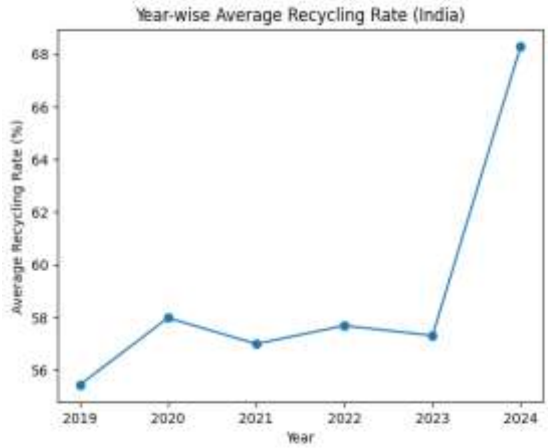
3) Year-wise analysis of Recycling rate



Year-wise analysis shows only gradual and inconsistent improvements in recycling rates over time. There is no evidence of rapid transformation in waste management efficiency during the study period. Incremental policy measures alone are insufficient. Adoption of AI technologies is necessary to achieve significant and sustained improvements.

The analysis of waste management data across Indian cities shows significant inefficiencies and weak linear relationships among key variables such as recycling rates, production of e-waste and population density. These limitations are due to conventional waste management systems. These findings strongly support the adoption of AI-based solutions to enhance recycling efficiency, optimize operations, and promote sustainable e-waste management. Green computing and adoption of green IT pathways with the advancement of technology like AI , Machine Learning and Deep learning definitely provide the resolutions to above limitations.

4) Rapid Transformation in Recycling rate



In 2024–25, India has seen a rapid transformation in waste management, with the overall waste processing capacity in urban areas significantly rising from 52% in 2019 to 68% by 2024, and continuing to improve under the Swachh Bharat Mission 2.0. While specifically targeted recycling rates for all municipal waste in 2024-25 are often integrated into overall "processing" metrics, specific sectors and cities show varying,, accelerating progress, While some older estimates suggested a 20-30% recycling rate in major cities, recent reports indicate that Indian cities are transitioning rapidly, with processing (including composting and recycling) reaching 70% in many urban areas, with a goal of 100% processing.

Conclusion:

The growing volume and complexity of electronic waste present significant challenges to environmental sustainability, public health, and resource conservation. Traditional e-waste management and recycling methods are increasingly inadequate due to their dependence on manual processes, limited efficiency, and inability to handle heterogeneous waste streams. This study concludes that Artificial Intelligence plays a transformative role in addressing these challenges by introducing automation, accuracy, and data-driven decision-making into e-waste management systems.

AI technologies such as machine learning, computer vision, and intelligent robotics significantly improve the identification, sorting, and disassembly of e-waste, leading to higher material recovery rates and reduced human exposure to hazardous substances. Predictive analytics enable accurate forecasting of e-waste generation, optimized collection logistics, and efficient resource allocation. Furthermore, AI supports circular economy principles by extending product life cycles and minimizing landfill dependency.

References:

1. *Baldé, C. P., Forti, V., Gray, V., Kuehr, R., & Stegmann, P. (2017). The global e-waste monitor 2017: Quantities, flows and resources. United Nations University, International Telecommunication Union, and International Solid Waste Association.*
2. *Forti, V., Baldé, C. P., Kuehr, R., & Bel, G. (2020). The global e-waste monitor 2020: Quantities, flows and the circular economy. United Nations University (UNU), International Telecommunication Union (ITU), and International Solid Waste Association (ISWA).*
3. *Zhang, L., & Wang, J. (2022). Application of deep learning techniques for automated e-waste classification and recycling. Journal of Cleaner Production, 335, 130–145. https://doi.org/10.1016/j.jclepro.2021.130145*
4. *Hassan, R., Khan, S., & Ahmad, M. (2023). Artificial intelligence and robotics for sustainable e-waste management. Waste Management, 156, 45–56. https://doi.org/10.1016/j.wasman.2022.10.018*
5. *Singh, P., Sharma, R., & Verma, A. (2023). Predictive analytics for electronic waste generation using machine learning techniques. Environmental Science and Pollution Research, 30(5), 11245–11258. https://doi.org/10.1007/s11356-022-23145-6*
6. *Luo, Y., Li, X., & Chen, Z. (2022). Optimization of waste collection and recycling logistics using artificial intelligence approaches. Sustainable Cities and Society, 76, 103–118. https://doi.org/10.1016/j.scs.2021.103118*
7. *Kim, H., & Choi, S. (2021). Intelligent robotic disassembly for electronic waste recycling. IEEE Access, 9, 89450–89462. https://doi.org/10.1109/ACCESS.2021.3089142*
8. *Allen, T., Brown, P., & Smith, J. (2024). Artificial intelligence applications for circular economy–based waste management systems. Environmental Science & Technology, 58(2), 780–789. https://doi.org/10.1021/acs.est.3c04567*
9. *Organisation for Economic Co-operation and Development. (2022). Extended producer responsibility and electronic waste management. OECD Publishing.*
10. *European Commission. (2021). Artificial intelligence for the circular economy. Publications Office of the European Union.*

11. *Patkar, A. A., & Dwivedi, A. K. (2024). Leveraging policy synergy for sustainable e-waste management in India: A comparative policy–technology analysis (2011–2025). Journal of Informatics Education and Research, 4(2).*

12. *Singh, D. S. (2024). Study of e-waste management and Indian scenario. International Journal of Scientific Research in Science and Technology.*

Cite This Article:

Ms. Joshi A. M. (2026). *Role of AI in E-Waste Management and Recycling.* **In Aarhat Multidisciplinary International Education Research Journal**: Vol. XV (Number I, pp. 92–96).

Doi: https://doi.org/10.5281/zenodo.18608803