



**International Journal of Research and Technology (IJRT)**

**International Open-Access, Peer-Reviewed, Refereed, Online Journal**

**ISSN (Print): 2321-7510 | ISSN (Online): 2321-7529**

**Conference “Innovation and Intelligence: A Multidisciplinary Research on Artificial Intelligence and its Contribution to Commerce and Beyond”**

**Held at IQAC – KHMW College of Commerce-December 2025**

**Harnessing Artificial Intelligence (AI) to Combat Plastic Pollution: A Case Study of India**

Submitted To

K.H.M.W COLLEGE OF COMMERCE

Research Paper

Submitted By

Shaikh Hamida Anwar

Course: Mcom(Advance accountancy)

K.H.M.W College of commerce

Supervisor: Dr.Sabina Ashfaque Shaikh

IQAC Coordinator

K.H.M.W.Degree college of commerce

### **Abstract**

Plastic pollution has emerged as a significant global issue. Each year, over 350 million tons of plastic are generated, and existing recycling systems are unable to cope with the entirety of this waste. Artificial Intelligence (AI) has surfaced as a revolutionary instrument that can improve detection, monitoring, waste segregation, recycling efficiency, consumer awareness, and policy enforcement (United Nations Environment Programme [UNEP], 2021). This research paper explores how AI-driven technologies can bolster international initiatives aimed at addressing plastic pollution, featuring a comprehensive case study of India—one of the largest producers of plastic waste worldwide. Utilizing secondary literature, satellite analytics, case studies, and governmental reports, the paper posits that AI provides a scalable, cost-effective, and innovative approach to developing sustainable waste management systems. It concludes that although AI cannot supplant traditional waste management frameworks, it significantly enhances the global effort to tackle plastic pollution when applied ethically and inclusively.

**Keywords:** Plastic Pollution, Artificial Intelligence, Waste Management, Recycling Systems, Sustainability, Environmental Policy

### **Introduction**

Plastic pollution has become widespread in both terrestrial and aquatic ecosystems, presenting serious threats to biodiversity, environmental health, and human well-being. Microplastics infiltrate air, food, and soil, jeopardizing ecological stability and global health systems. Conventional waste management methods—including manual sorting, community-driven clean-up efforts, and mechanical recycling—are struggling to keep up with increasing consumption. Consequently, countries are progressively investigating technological solutions to tackle the magnitude, velocity, and intricacy of plastic pollution. Artificial Intelligence offers tools for swift data analysis, automated decision-making, and scalable environmental interventions. AI systems



**Conference “Innovation and Intelligence: A Multidisciplinary Research on Artificial Intelligence and its Contribution to Commerce and Beyond”**

**Held at IQAC – KHMW College of Commerce-December 2025**

are capable of identifying plastic waste through satellite imagery, categorizing materials in recycling facilities using computer vision, predicting waste generation trends, and improving policy enforcement via digital tracking (European Space Agency [ESA], 2021). This paper examines these technological innovations and assesses India’s implementation of AI in its waste management and river-cleaning initiatives

### **Understanding Plastic Pollution**

#### **Global Scale of the Crisis**

The production of plastic has surged dramatically since the 1950s, with over 350 million tons being produced each year (UNEP, 2021). A mere 9–10% of the global plastic waste is recycled, while the remainder accumulates in landfills, aquatic environments, and soil. Each year, more than 8 million tons of plastic enter the oceans, creating vast debris patches that are visible from space (NASA, 2020). Microplastics—particles that are less than 5 mm in size—have been found in marine organisms, agricultural fields, drinking water, and even in human blood, which raises significant concerns regarding potential long-term health effects.

#### **Environmental and Economic Impact**

Plastic waste significantly disrupts marine ecosystems by ensnaring marine creatures, harming coral reefs, and introducing harmful microplastics into food chains (Zambrano-Monserrate et al., 2020). On land, blocked drainage systems lead to urban flooding, while deteriorated soil quality diminishes agricultural productivity. Economies reliant on tourism experience considerable losses due to contaminated coastlines. UNEP (2021) estimates that marine plastic pollution incurs USD 13 billion in yearly economic losses, which include clean-up expenses, damage to fisheries, and a decline in tourism.

### **Role of Artificial Intelligence in Combating Plastic Pollution**

#### **AI for Monitoring and Detecting Pollution**

##### **Satellite and Aerial Surveillance**

Artificial Intelligence systems facilitate the accurate identification of plastic waste by analyzing satellite imagery provided by organizations like ESA and NASA. Machine learning algorithms detect plastic debris by interpreting spectral signatures that distinguish plastics from marine vegetation and water surfaces (ESA, 2021). These extensive monitoring systems enable environmental agencies to monitor pollution hotspots, illegal dumping areas, and seasonal waste trends.

##### **AI-Based Drones for Local Detection**

Drones fitted with AI-powered object detection scanners monitor rivers, beaches, landfills, and urban drainage systems. AI algorithms evaluate the real-time footage to pinpoint locations of



**Conference “Innovation and Intelligence: A Multidisciplinary Research on Artificial Intelligence and its Contribution to Commerce and Beyond”**

**Held at IQAC – KHMW College of Commerce-December 2025**

plastic accumulation, allowing authorities to initiate swift clean-up efforts (NASA, 2020). Additionally, drones grant access to dangerous or hard-to-reach areas, enhancing safety and surveillance capabilities.

### **AI for Waste Management and Sorting**

#### **Smart Sorting Systems**

Conventional waste sorting predominantly depends on manual labor and frequently leads to subpar recycling because of contamination. AI-driven sorting technologies employ computer vision, infrared sensors, and robotic arms to categorize plastics including PET, HDPE, LDPE, and multilayered packaging. These systems minimize human error, enhance precision, and boost the overall efficiency of material recovery facilities.

#### **Predictive Waste Collection**

AI forecasting tools examine past waste trends, population density, climate information, and socio-economic factors to enhance municipal waste collection routes. Intelligent waste bins fitted with sensors notify authorities when they are approaching full capacity. Cities like Singapore and Dubai have demonstrated significant cost reductions through AI-driven waste management logistics (World Economic Forum [WEF], 2020).

### **AI in Recycling Technology**

#### **Improving Mechanical Recycling**

Artificial Intelligence improves mechanical recycling by assessing contamination levels and refining material processing, which leads to superior quality recyclate (Banyan Nation, 2022). Clean and properly sorted plastics command higher market prices and motivate industries to transition to recycled materials.

#### **Optimizing Chemical Recycling**

Machine learning enhances the optimization of pyrolysis and depolymerization processes by identifying the optimal temperature, pressure, and catalysts necessary for converting plastics into fuel or raw chemical components. This advancement contributes to the effectiveness of circular production models.

#### **Enhancing Plastic-to-Fuel Systems**

AI-guided plastic-to-fuel technologies maximize energy output while reducing emissions and residue, creating cleaner alternatives to landfill disposal.

### **AI for Ocean and River Clean-Up Operations**

#### **Autonomous Clean-Up Robots**

Autonomous robots designed for river cleaning, like The Ocean Cleanup's Interceptor, utilize AI-driven navigation to gather floating plastic while ensuring that marine ecosystems remain



**Conference “Innovation and Intelligence: A Multidisciplinary Research on Artificial Intelligence and its Contribution to Commerce and Beyond”**

**Held at IQAC – KHMW College of Commerce-December 2025**

undisturbed (The Ocean Cleanup, 2022). These technologies have been implemented in several of the most polluted rivers globally, successfully stopping tons of plastic from entering the oceans.

**Predictive Pollution Modeling**

Artificial intelligence models replicate the movement of plastic in rivers and oceans by analyzing currents, wind patterns, rainfall trends, and human activities. These forecasts inform focused clean-up operations and the distribution of resources.

**AI for Policy and Regulation Support**

**Data-Driven Environmental Policy**

Governments rely on precise waste data to formulate and assess policies. AI analytics assist regulators in evaluating waste volumes, recycling rates, and sources of pollution, thereby facilitating evidence-based policymaking (Ministry of Environment, Forest and Climate Change .

**Detecting Illegal Dumping**

AI-enabled CCTV and drone footage analyzed with computer vision can detect unauthorized disposal activities, enabling swift enforcement actions

**Supporting Extended Producer Responsibility (EPR)**

AI systems track plastic packaging across its lifecycle, allowing governments to monitor manufacturer compliance with EPR guidelines.

**AI for Consumer Awareness and Behaviour Change**

**Mobile Apps Encouraging Low-Plastic Lifestyles**

AI-based mobile platforms analyze consumer habits, offer personalized plastic reduction tips, and reward sustainable choices.

**Product Footprint Scanning**

AI apps allow consumers to scan products and view their environmental impact, promoting conscious purchasing behaviour (Ellen MacArthur Foundation, 2019).

**AI-Driven Education Tools**

Chatbots and virtual assistants provide information about recycling rules, segregation practices, and the environmental consequences of plastic waste.

**Global Benefits of AI in Plastic Reduction**

Artificial Intelligence offers scalable, cost-effective, and data-informed solutions that improve detection, prevention, and recycling efficiency. Automated systems lessen reliance on labor, satellite monitoring facilitates extensive environmental mapping, and predictive analytics optimize waste logistics. Furthermore, AI mitigates long-term economic challenges linked to ecosystem degradation, declines in tourism, and ineffective waste management systems.

**Case Study: India’s Use of AI to Combat Plastic Pollution**



**Conference “Innovation and Intelligence: A Multidisciplinary Research on Artificial Intelligence and its Contribution to Commerce and Beyond”**

**Held at IQAC – KHMW College of Commerce-December 2025**

India produces more than 3.4 million tons of plastic waste annually, a significant portion of which finds its way into rivers, drainage systems, and open landfills (Central Pollution Control Board [CPCB], 2021). In response to this issue, the nation has started to incorporate AI technologies into its waste management framework.

**AI for Waste Management in Indian Cities**

**Hyderabad’s Smart Waste Monitoring**

Hyderabad has deployed AI-enabled smart bins that monitor waste levels, identify materials, and guide waste fleets in real time. These systems reduce overflow and prevent plastics from entering open environments.

**AI in Indian Recycling Facilities**

**Bangalore’s AI-Driven Sorting Plants**

Bangalore's material recovery facilities employ AI-powered conveyor systems that automate the identification of plastics with remarkable precision. These systems safeguard waste workers from hazardous exposure and enhance recycling efficiency.

**River Clean-Up with AI: Ganga and Yamuna**

**The Ganga River Project**

Artificial Intelligence cameras positioned along the Ganga oversee unlawful waste disposal and offer immediate notifications to regulatory bodies. Machine learning algorithms evaluate behavioral trends to avert repeated infractions.

**Yamuna Drone Surveillance**

Drones equipped with AI technology conduct surveys of contaminated areas along the Yamuna River, detecting floating debris, blocked drainage systems, and hazardous dumping sites. This facilitates quicker and more precise cleanup efforts.

**Start-Ups and Innovations in India**

India is home to numerous AI-driven environmental start-ups. Ishitva Robotics Systems has developed "Netra," a robotic waste sorter powered by AI. Banyan Nation employs AI to improve the purity of recycled plastics. The Ocean Cleanup works in partnership with Indian authorities to implement AI-equipped Interceptors in significant rivers.

**AI Supporting India’s Plastic Waste Policies**

In the wake of India's 2022 prohibition on certain single-use plastics, artificial intelligence systems are employed to oversee manufacturer compliance, observe market dynamics, and assess waste trends to determine the effectiveness of the policy.

**Challenges in Implementing AI**

**High Costs of Technology**

AI systems require sophisticated hardware, software, and skilled personnel, making



**Conference “Innovation and Intelligence: A Multidisciplinary Research on Artificial Intelligence and its Contribution to Commerce and Beyond”**  
**Held at IQAC – KHMW College of Commerce-December 2025**

adoption expensive for low-income regions.

#### **Lack of Waste Data**

Developing nations often lack reliable waste data, making it difficult to train high-quality AI models (CPCB, 2021).

#### **Skill Shortage**

AI systems require trained professionals, yet India faces a shortage of experts in machine learning, robotics, and waste science

#### **Ethical and Legal Issues**

AI surveillance raises concerns about data privacy, requiring governments to balance environmental protection with civil rights.

#### **Future of AI in Combating Plastic Waste**

##### **Growth of Green AI**

Green AI advocates for energy-efficient computing, ensuring that AI technologies aid in environmental protection while not exacerbating carbon footprints.

##### **AI in Circular Economy Models**

AI enhances circular systems by forecasting product lifecycles, optimizing reverse logistics, and facilitating material.

##### **AI for Global Development**

Innovations driven by AI in sectors such as agriculture, education, healthcare, and waste management enhance living standards and bolster environmental resilience in developing countries.

##### **Integration with Emerging Technologies**

The collaboration of AI with IoT, robotics, blockchain, and renewable energy systems improves waste detection, tracking, and recycling efficiency.

#### **Conclusion**

Plastic pollution continues to be a multifaceted global issue that necessitates innovative and scalable solutions. Artificial Intelligence presents remarkable opportunities to modernize waste management, improve recycling systems, identify illegal dumping, and empower communities through technology-driven awareness. The situation in India illustrates that even developing countries can leverage AI to reshape their environmental landscape. Although challenges related to cost, ethics, and data infrastructure remain, the combination of AI with circular economy systems and green technologies offers a hopeful route toward a plastic-free future.

#### **Reference**

1. Banyan Nation. (2022). Data intelligence for high-quality recycled plastics. Banyan Nation. <https://banyannation.com>



**Conference “Innovation and Intelligence: A Multidisciplinary Research on Artificial Intelligence and its Contribution to Commerce and Beyond”**

**Held at IQAC – KHMW College of Commerce-December 2025**

2. Central Pollution Control Board. (2021). Annual report on plastic waste management in India. CPCB. [https://cpcb.nic.in/uploads/Projects/PlasticWaste/Annual\\_Report\\_2020-21.pdf](https://cpcb.nic.in/uploads/Projects/PlasticWaste/Annual_Report_2020-21.pdf)
3. Debnath, B., & Roy, S. (2021). Impact of plastic waste on Indian rivers and potential AI solutions. *Environmental Science and Pollution Research*, 28(45), 63529–63544. <https://doi.org/10.1007/s11356-021-15438-8>
4. Ellen MacArthur Foundation. (2019). Artificial intelligence and the circular economy: AI as a tool for creating a waste-free world. Ellen MacArthur Foundation. <https://ellenmacarthurfoundation.org>
5. European Space Agency. (2021). AI-driven plastic detection using Sentinel satellite data. ESA Earth Observation Programme. <https://esa.int>
6. Ishitva Robotics Systems. (2023). AI-powered waste sorting solutions. Ishitva Robotics. <https://ishitva.com>
7. Kaur, H., Kumar, R., & Singh, J. (2023). AI-enabled circular economy models for sustainable development in India. *Sustainable Computing: Informatics and Systems*, 38, 100837. <https://doi.org/10.1016/j.suscom.2023.100837>
8. Ministry of Environment, Forest and Climate Change. (2022). Guidelines on single-use plastic ban in India. Government of India. <https://moef.gov.in>
9. NASA. (2020). Machine learning for plastic detection in oceans. NASA Earth Science Division. <https://nasa.gov>
10. Rahman, A., & Sarkar, B. (2022). Deep learning-based waste classification systems in developing nations. *Waste Management*, 150, 123–135. <https://doi.org/10.1016/j.wasman.2022.05.012>
11. Sharma, S., & Chandra, A. (2021). AI and robotics in India’s waste management sector: Emerging trends and challenges. *Journal of Environmental Management*, 285, 112070. <https://doi.org/10.1016/j.jenvman.2021.112070>
12. The Ocean Cleanup. (2022). The Interceptor: Autonomous river cleanup technology. The Ocean Cleanup. <https://theoceancleanup.com>
13. United Nations Environment Programme (2021). From pollution to solution: A global assessment of marine litter and plastic pollution. UNEP. <https://www.unep.org>
14. World Economic Forum. (2020). How AI can be utilized to combat plastic pollution. WEF. <https://www.weforum.org>
15. Zambrano-Monserrate, M. A., Ruano, M. A., & Sanchez-Alcalde, L. (2020). Marine pollution on a global scale: An overview of causes, effects, and remedies. *Marine Pollution Bulletin*, 159, 111450. <https://doi.org/10.1016/j.marpolbul.2020.111450>



**International Journal of Research and Technology (IJRT)**

**International Open-Access, Peer-Reviewed, Refereed, Online Journal**

**ISSN (Print): 2321-7510 | ISSN (Online): 2321-7529**

**Conference “Innovation and Intelligence: A Multidisciplinary Research on Artificial Intelligence and its Contribution to Commerce and Beyond”**

**Held at IQAC – KHMW College of Commerce-December 2025**

16. Shaikh, S. A., & Jagirdar, A. H. (2026). *Beyond AI dependence: Pedagogical approaches to strengthen student reasoning and analytical skills*. In S. Khan & P. Pringuet (Eds.), *Empowering learners with AI: Strategies, ethics, and frameworks* (Chapter 8, pp. 1–16). IGI Global. <https://doi.org/10.4018/979-8-3373-7386-7.ch008>
17. Shaikh, S. A. (2024). *Empowering Gen Z and Gen Alpha: A comprehensive approach to cultivating future leaders*. In *Futuristic Trends in Management* (IIP Series, Vol. 3, Book 9, Part 2, Chapter 2). IIP Series. <https://doi.org/10.58532/V3BHMA9P2CH2>
18. Chougale, Z. S., & Shaikh, S. (2022). To understand the impact of Ayurvedic health-care business & its importance during COVID-19 with special reference to “Patanjali Products”. *In Proceedings of the National Conference on Sustainability of Business during COVID-19, IJCRT, 10(1)*,
19. Bhagat, P. H., & Shaikh, S. A. (2025). Managing health care in the digital world: A comparative analysis on customers using health care services in Mumbai suburbs and Pune city. *IJCRT. Registration ID: IJCRT\_216557*.