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Emerging Trends in Robotics and Automation for Sustainable Development in Nigeria

Henry Azuka Ifeachor[1*], Agha Ikechukwu Chukwukadibia[1], Onwualia Promise Ebubechukwu[1], Eneh Christian Chukwuemeka[1], Okoye Ikechukwu Francis[1], Omulu. C. Clara[1]

[1] School of Engineering Technology, Federal Polytechnic Ngodo-Isuochi, Abia State, Nigeria

ORCID: **HAI** 0009-0002-3407-7906[1*]

Correspondence should be addressed to Henry Azuka Ifeachor: ih.azuka@fpi.edu.ng

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Abstract: Nigeria faces significant developmental challenges in agriculture, healthcare, waste management, and infrastructure, which hinder progress toward the Sustainable Development Goals (SDGs). Emerging trends in robotics and automation offer transformative solutions to enhance efficiency, reduce human error, and optimize resource utilization. This article explores four key trends: autonomous agricultural robots for precision farming, automated waste-sorting systems for the circular economy, drone-based healthcare logistics, and AI-driven infrastructure monitoring. Using a mixed-method approach combining case study analysis and secondary data from Nigerian pilot projects (2019–2025), the study evaluates the feasibility, socio-economic impacts, and sustainability potential of these technologies. Findings indicate that robotics can increase crop yields by up to 40%, reduce post-harvest losses by 25%, improve medical supply delivery times by 70%, and enhance waste recycling rates from 10% to 45%. However, challenges such as high initial costs, inadequate power supply, low digital literacy, and policy gaps remain pervasive. The article presents a table of seven ongoing automation initiatives in Nigeria and discusses their outcomes. Recommendations include government-backed innovation hubs, public-private partnerships for renewable-powered robotics, and curriculum reforms in tertiary institutions. Conclusively, strategic deployment of robotics and automation aligns with SDGs 2 (zero hunger), 3 (good health), 9 (industry innovation), 11 (sustainable cities), and 12 (responsible consumption). Nigeria must adopt a phased, inclusive automation roadmap to achieve sustainable development.

Keywords: Robotics, Automation, Sustainable Development, Nigeria, Precision Agriculture

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1. Introduction

Nigeria, with a population exceeding 220 million and projected to become the third most populous nation by 2050, faces immense pressure on food systems, healthcare delivery, and urban waste management (Adewumi & Olaniyi, 2022). The Sustainable Development Goals (SDGs) provide a blueprint for addressing these challenges, yet conventional methods have proven insufficient. For instance, post-harvest losses in staple crops like yams and cassava range from 30–50% due to poor storage and manual handling (Eze & Okafor, 2021). Similarly, only 10% of municipal solid waste is recycled, with the remainder clogging drains and waterways (Nnaji & Uzochukwu, 2023). Healthcare access in rural areas is hampered by poor road networks, leading to vaccine stock-outs and maternal mortality rates of 512 per 100,000 live births (Federal Ministry of Health, 2024).

Emerging trends in robotics and automation, including autonomous tractors, drone delivery systems, robotic arms for sorting, and AI-powered inspection robots, present viable pathways to address these inefficiencies. Globally, robotics has contributed to a 6% annual productivity increase in manufacturing and logistics (World Robotics Report, 2025). In Nigeria, several pilot projects have demonstrated proof of concept. For example, the "AgriBot Naija" project in Kaduna State reduced manual weeding labor by 80% (Bello & Ibrahim, 2023). However, adoption remains fragmented due to infrastructural deficits and low digital skills penetration (only 40% internet access in rural areas) (NCC, 2024).

This article aims to answer the following research questions:

1. What emerging robotics and automation trends apply to Nigeria's development challenges?
2. How can these technologies contribute to specific SDGs?
3. What are the barriers and enablers for scaling automation in Nigeria?

The scope covers four domains: agriculture, healthcare logistics, waste management, and infrastructure monitoring. The significance lies in providing evidence-based policy recommendations for a nationally coordinated automation strategy.

2. Literature Review

Robotics and automation have evolved from industrial manufacturing to socio-economic development tools. According to Bogue (2021), autonomous systems now integrate computer vision, machine learning, and IoT sensors, enabling adaptation to unstructured environments critical for developing countries. In agriculture, robots like "AgBot" perform selective harvesting, reducing chemical use by 30% (Zhang & Wang, 2022). In healthcare, drone networks (e.g., Zipline) reduced blood delivery time in Rwanda from 4 hours to 15 minutes (Smith et al., 2023).

For Nigeria, literature highlights three thematic areas:

- **Agricultural robotics:** Oyedeji & Afolabi (2021) tested a low-cost weeding robot in Oyo State, achieving 85% weed removal accuracy but noted battery recharging challenges due to grid instability.

- **Waste automation**: Adeleke & Oyebode (2022) designed a conveyor-based sorting system for plastic and metal; efficiency reached 70% in controlled lab conditions, but dropped to 40% in real open dumpsites due to moisture and mixed debris.
- **Drone logistics**: Nwachukwu & Eze (2023) simulated drone delivery of antivenom in Taraba State; coverage improved by 60%, but regulatory approval delays hindered operations.

Gaps identified: (a) lack of indigenous manufacturing of robotics components, (b) absence of national automation policy, (c) minimal research on socio-economic displacement effects. This review underscores the need for localized, low-power, and durable designs suited to Nigeria's tropical climate and irregular power supply.

3. Methodology

This study employs a descriptive case study and secondary data analysis approach. Data sources include:

- Published project reports from Nigerian research institutes (NITDA, NASENI)
- Pilot program evaluations (2019–2025)
- International benchmark comparisons (Rwanda, Kenya, India)

Inclusion criteria: automation projects with measurable SDG indicators, operational for at least 6 months, located in Nigeria.

Exclusion criteria: purely theoretical proposals, projects without quantitative outcomes.

The following table summarizes the selected cases:

Table 1: Selected Robotics and Automation Pilot Projects in Nigeria (2019–2025)

Project Name	Domain	Location	Technology Type	Sustainable Development Goal (SDG)	Source
AgriBot Naija	Agriculture	Kaduna State	Autonomous weeding & seeding robot	SDG 2 (Zero Hunger)	Bello & Ibrahim (2023)
SortNaija	Waste Management	Lagos State	AI-driven conveyor sorting arm	SDG 12 (Responsible Consumption)	Adeleke & Oyebode (2022)
MedDrone NG	Healthcare Logistics	Anambra State	Quadcopter drone for vaccine delivery	SDG 3 (Good Health)	Nwachukwu & Eze (2023)

BridgeBot	Infrastructure	Rivers State	Underwater inspection robot for bridges	SDG 9 (Industry, Innovation)	Okafor & Nnamdi (2024)
SolarWeed	Agriculture	Kano State	Solar-powered weeding robot	SDG 7 (Affordable Clean Energy)	Yusuf & Abubakar (2025)
RecycArm	Waste	Oyo State	Robotic arm for PET bottle sorting	SDG 11 (Sustainable Cities)	Adeleke & Oyebode (2022)
AgroDrone Spray	Agriculture	Benue State	Autonomous spraying drone	SDG 2 (Zero Hunger)	Bello & Ibrahim (2023)
Source: Compiled from NITDA (2025) project database and peer-reviewed case reports.					

4. Results and Discussion of Findings

4.1 Agricultural Robotics Impact

AgriBot Naija and SolarWeed collectively covered 450 hectares. Results showed:

- Weeding time reduced from 80 person-hours/hectare to 12 robot-hours/hectare.
- Yield increase of 38% for maize and 42% for rice (compared to manual farming).
- Post-harvest loss reduction from 35% to 10% due to timely harvesting.

Table 2: Comparative Performance Metrics in Agriculture

Metric	Manual Farming	Robotics-Assisted	Percentage Improvement	Source
Labor (hrs/hectare)	80	12	85%	Bello & Ibrahim (2023)
Water usage (liters/hectare)	1,200	840	30%	Yusuf & Abubakar (2025)
Fertilizer efficiency (%)	55	78	42%	Bello & Ibrahim (2023)
Yield (tons/hectare maize)	2.1	2.9	38%	Yusuf & Abubakar (2025)
Source: Field trial data from Kaduna and Kano States (2024–2025).				

Discussion: The gains align with global findings (Zhang & Wang, 2022). However, robot downtime averaged 3 hours/day due to power cuts, necessitating diesel generators to offset carbon gains. Also, the initial cost per robot (₦8 million) is prohibitive for smallholder farmers (80% of Nigerian farms are <2 hectares).

4.2 Waste Management Automation

SortNaija and RecycArm processed 120 tons of waste in Lagos and Oyo. Key results:

- Manual sorting rate: 0.5 tons/man-hour; robotic sorting: 3.2 tons/robot-hour.
- Purity of recycled plastic increased from 60% (manual) to 89% (automated).
- Overall, the recycling rate rose from 10% to 45% in pilot zones.

Table 3: Waste Sorting Efficiency Comparison

Material Type	Manual Purity (%)	Robotic Purity (%)	Throughput (kg/hour)	Source
PET plastic	65	92	320 (robot) vs 50 (manual)	Adeleke & Oyebode (2022)
Aluminum cans	72	95	350 vs 55	NITDA (2025)
Glass	58	85	280 VS 45	Adeleke & Oyebode (2022)
Source: Lagos State Waste Management Authority (LAWMA) pilot report, 2024.				

Discussion: Although effective, the robotic system failed with wet or shredded waste, common in Nigerian dumpsites. Also, scavenger communities (over 100,000 persons) face livelihood threats. A just transition strategy is needed.

4.3 Healthcare Drone Logistics

MedDrone NG completed 350 vaccine deliveries to 12 primary health centers across Anambra's riverine areas. Outcome:

- Average delivery time reduced from 7 hours (road + boat) to 45 minutes.
- Vaccine wastage dropped from 22% to 4% due to temperature-controlled compartments.
- Maternal emergency referrals increased by 35% because drone data guided ambulance dispatch.

Table 4: Healthcare Access Metrics Before vs After Drone Integration

Metric	Pre-Drone (2022)	Post-Drone (2025)	Change	Source
Vaccine stock-out days/month	12	2	-83%	Nwachukwu & Eze (2023)

Response time for emergency meds (hrs)	8.5	1.2	-86%	Anambra State MOH (2025)
Routine immunization coverage (%)	61	89	+46%	WHO Nigeria (2025)
Source: Anambra State Ministry of Health and WHO Nigeria field reports.				

Discussion: Drone operations were constrained by Civil Aviation regulations (flight ceiling of 400m, no beyond-visual-line-of-sight without waiver). Also, battery swapping stations lacked grid electricity, relying on solar (often insufficient). Nevertheless, the model is replicable for hard-to-reach areas.

4.4 Infrastructure Robotics

BridgeBot inspected three river-crossing bridges in Port Harcourt, detecting corrosion and cracks with 92% accuracy compared to manual divers. Cost: ₦1.2 million per inspection vs ₦8 million for diver teams.

Table 5: Infrastructure Inspection Cost-Benefit

Method	**Time (hours/bridge)**	**Cost (₦ million)**	**Risk of accident**	**Detection accuracy (%)**
Human divers	24	8.0	High (crocodiles, debris)	78
Underwater robot	8	1.2	None	92
Source: Rivers State Public Works Agency (2025) pilot.				

Discussion: The robot requires trained operators currently; only 14 are certified in Nigeria. Local fabrication of such robots is absent; all units are imported.

5. Synthesis of SDG Contributions

From the findings, robotics contributes directly to:

- SDG 2: Yield increase +38%, post-harvest loss -25%.
- SDG 3: Vaccine delivery time -86%, wastage -82%.
- SDG 7: Solar-powered robots reduce diesel use by 70% (Yusuf & Abubakar, 2025).
- SDG 9: Bridge inspection cost -85%, time -67%.
- SDG 11: Recycling rate +35 percentage points.
- SDG 12: Sorting purity +30%.

6. Conclusion

Robotics and automation present actionable pathways to accelerate sustainable development in Nigeria. Evidence from seven pilot projects confirms significant efficiency gains in agriculture (38% yield increase), waste recycling (45% rate), healthcare logistics (86% time reduction), and infrastructure monitoring (85% cost saving). These outcomes advance progress toward SDGs 2, 3, 7, 9, 11, and 12. However, adoption barriers include high capital costs, unreliable power, skill deficits, and regulatory gaps. Without deliberate policy intervention, Nigeria risks deepening the digital divide and missing the Fourth Industrial Revolution opportunity. A phased, inclusive, and renewable-energy-integrated automation strategy is essential.

7. Recommendations

1. Establish a National Robotics for Development Agency (NRDA) to coordinate R&D, funding, and standards.
2. Deploy solar-powered microgrids dedicated to agricultural and waste robotics hubs (target: 500 sites by 2030).
3. Mandate robotics curriculum in 25 federal polytechnics and 10 universities within 2 years.
4. Create an automation transition fund to retrain informal waste workers and smallholder farmers.
5. Offer tax waivers on imported robotics components and locally assembled units.
6. Launch a regulatory sandbox for drone logistics with Civil Aviation Authority fast-track approvals.
7. Promote public-private partnerships (e.g., with Chinese and Indian robotics SMEs) for local assembly plants.

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