International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 12 | Dec - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Role of Robotics & Automation in Achieving Sustainable Development Goals

Birendra Kumar[1], Unni Kisan[2], Dr. Syed Asghar Husain Rizvi[3]

[1,2,3]*Department of Mechanical Engineering & Khwaja Moinuddin Chishti Language University, Lucknow*

Abstract - Robotics and automation transforming society by applying emerging techniques to improve productivity, optimise use of resources and reduce the waste generation. Automation and robotics play major role in achieving sustainable development goals like soft robotics in farming, disaster response, energy generation, heath care sector and sustainable manufacturing etc. Healthcare, agricultural production, and biodiversity management are all being transformed by robotics and automation systems. Although they will be essential to achieving the UN Sustainable Development Goals. The way the Sustainable Development Goals are accomplished will probably change as a result of robotics and autonomous systems, which will support and encourage innovation, improve remote access, and improve monitoring. In this paper we study the how robotics and automation contribute the achieving SDGs by the use of various techniques.

Key Words: Soft robotics, SDGs, Productivity, Sustainable manufacturing

1. INTRODUCTION

At the 2015 UN General Assembly, 93 countries adopted the Sustainable Development Goals (SDGs) to help improve the future for all of humanity. The SDGs essentially tackle global issues that affect our countries, such as poverty, inequality, productivity, climate change, environmental degradation, prosperity, justice, and peace. Since robots has become a megatrend and has the ability to help achieve development goals, it is debatable whether or not it will have a major impact on our nation and the world economy. It might, however, provide a variety of difficulties [1]. It has recently been suggested that robotics could either help or hinder the achievement of the SDGs. An assessed Artificial Intelligence (AI) as an enabler for achieving SDGs in industrial activities [2].

Healthcare, agricultural production, and biodiversity management are all changing as a result of robotics and autonomous systems. Although they will be essential to achieving the UN Sustainable Development Goals, related opportunities and risks have not yet been thoroughly examined [3]. Over the past ten years, advances in artificial intelligence (AI), machine learning, sensor technologies, and more general digitalisation trends related to Industry 5.0 have greatly expedited the adoption of robots across industries. Robots are now integrated into diverse sectors, including manufacturing, healthcare, logistics, hospitality, and retail, performing functions that range from surgical assistance to customer service and warehouse management [4]. AI-powered industrial robotics has spread widely across a number of industries to improve output precision, increase efficiency, and ensure worker safety, resulting in more sustainable practices. For example, in manufacturing, robotics can optimise resource usage, reduce energy consumption, and lower waste levels by accurately and consistently performing high-level tasks.

The Latin word "sustinere" (tenere: to hold; sus: up) is where the idea of sustainability originates. When the World Commission on Environment and Development expressed worries about "our common future" in 1987, this idea—which entails sustaining specific conditions or capacities over time—gained international attention [5]. Governments pledged during the 2012 United Nations Rio +20 meeting in Brazil to develop a set of Sustainable Development Goals (SDGs) that would be incorporated into the Millennium Development Goals' successor beyond their 2015 deadline [6]. Technology is currently permeating every aspect of life and has a significant and wide-ranging impact on society. However, with rising energy demands, contributions to greenhouse gas (GHG) emissions, deforestation, and environmental pollution, this progress has a detrimental impact on our ecosystems. In order to fulfil some of the Sustainable Development Goals (SDGs) of the United Nations (UN) and the Paris Climate Agreement, mitigating these negative impacts is one of the major issues of our time and a compelling reason to advance the field of sustainable material robotics research [7]. AI-powered industrial robotics has greatly expanded across a number of industries to improve output accuracy, boost productivity, ensure worker safety, and promote more sustainable practices. For example, by performing high-level activities accurately and consistently, robotics may optimise resource utilisation, cut energy consumption, and minimise waste levels in the industrial sector. However, energy consumption and potential long-term electronic waste are additional issues brought about by the widespread use of industrial robots [8]. The goal of sustainable building is to lessen the adverse effects of construction on the environment at every stage of the process, from project planning to construction to operation. Sustainable building encompasses a wide range of factors, including social, ecological, and financial ones. The idea of sustainable development fulfils the present desires for progress in a way that will allow future generations to accomplish the same objectives. The interpenetration of many fields and sciences, including social and natural sciences, is a unique aspect of sustainable construction in order to care for natural resources and shape the proper future for future generations.

Automation and digital technologies are starting to be widely used in the construction sector. The building process is

made simpler and more cost-effective by the introduction of modern technology. Technological innovations have a positive impact on businesses' financial aspects. The use of new technology increases the company's competitiveness in the market, resulting in the successful acquisition of project tenders [9].

Robotics and artificial intelligence (AI) are becoming more and more integrated into ecological and environmental fields, raising urgent concerns about how they could either strengthen or weaken sustainability. Although AI systems are frequently presented as instruments to help achieve sustainable development goals (SDGs), such monitoring climate change or optimising energy consumption, there is increasing awareness that the environmental effects of robotics and AI itself need to be carefully considered. The twin difficulty of comprehending AI for sustainability and the sustainability of AI is addressed in this study. I will specifically look at the larger category of intelligent systems, which includes modular and bio-inspired robots.

"Sustainable AI is a movement to promote change throughout the whole lifecycle of AI products (i.e., idea generation, training, fine-tuning, implementation, and governance towards greater ecological integrity and social justice)." Instead of focussing only on its applications, it discusses the "whole sociotechnical system of AI." AI for sustainability, which uses AI to accomplish sustainable development objectives like inexpensive and clean energy, is becoming more and more popular. In actuality, there are substantial environmental costs connected with the usage and training of AI, especially when it comes to the energy and carbon emissions involved in training big AI models [10].

2. Role of Robotics and Automation

With the help of several stakeholders, proper planning and governance are required to fully realise robots' promise in advancing the SDGs. In the near future, this may lead to the development of new business models and legislative frameworks that promote a more sustainable future and lessen the hazards that climate change poses to the earth and its people. Table 1 illustrates how robotics and automation contribute to particular SDGs.

Robotics and Automation for urban farming: By precisely planting and harvesting crops in urban areas, encouraging sustainable consumption (SDG-11), keeping an eye on crop health, and supplying safe food (SDG-3), robots can increase food security and decrease poverty (SDG-2). Additionally, it may provide jobs and support urban economic growth (SDG-8) while lowering the carbon footprint of farms and the food chain (SDG-15). such as rooftop hydroponics in New York, vertical farms in Singapore, etc.

Robotics and Automation for disaster response: A soft pneumatic robot with the capacity to grow in length and dynamically adapt its shape to different terrains, including crossing small cracks, using onboard sensing of environmental stimuli was proposed. Robots can be used for search and rescue missions in the aftermath of natural disasters, promoting safety and reducing the impacts of natural disasters (SDG-11,15), providing timely assistance to affected populations (SDG-3), rebuilding and repairing infrastructure, and improving transportat

Robotics and Automation for energy production: Energy production might be revolutionised by incorporating renewable energy sources into robotic bodies. This integration might greatly improve research for clean, adaptable, and accessible energy generation in almost every site, notwithstanding its challenges (SDG-7, 9). The research on plant-hybrid wind energy systems, which draw inspiration from real plant leaves, is one such example.

Robotics and Automation for healthcare: Robotic exosuits, wearables, and manipulators can support minimally invasive surgery (MIS) and physical therapy, increasing the mobility and independence of people with impairments and shortening the recovery period for patients (SDG-3). Hydraulically operated devices with submillimeter diameters have been designed to allow microcatheter tips to actively steer. They provided safety and user-friendliness in endovascular intervention by demonstrating guidewire-free navigation, access, and coil placement in vivo.

Table -1: Contribution of Robotics and Automation to specific SDG

S.No.	SDG	How to help	Example
1.	SDG-7, affordable and clean energy.	Intelligent sensors and AI optimized control systems.	Smart micro grid.
2.	SDG-8, Decent work and economic growth.	Collaborative robots.	Automotive plants.
3.	SDG-9, Industry, innovation and infrastructure.	Robots enable flexible production lines.	3D printed aerospace parts.
4.	SDG-11, Sustainable cities and communities.	Autonomous delivery vehicles and warehouse robot.	Electric carts.
5.	SDG-12, Responsible consumption and production.	Precision robotics	Robotics pick and place systems.
6.	SDG-13, Climate action.	Predictive maintenance powered by machine learning.	Wind turbine inspection drone.
7.	SDG-14 & 15, Life below water and life on land.	Automated monitoring stations and under water robot.	Autonomous underwater vehicles that map coral reefs.

3. Challenges and mitigation strategies explain through the table 2.

S.No.	Challenge	Adverse effect	Mitigation
1.	High capital	Limits adaption by small scale enterprises.	Leasing, public private tie-up and focus on innovation.
2.	Cyber security	Safety and data integrity problems	Adoption of robust security standards.
3.	Technical skill gap	Lack of skill hamper effective deployment	Promote partnership between educational institution and industry.
4.	Job displacement	Could increase unemployment in low skill segment.	Targeted reskilling programmes.

4. CONCLUSIONS

When used carefully, with consideration for justice, security, and the talent ecosystem, robotics and automation may accelerate progress across a wide range of SDGs. They are effective tools for sustainable development because of their capacity to collect and act upon data, but government, business, and academia must work together to fully realise their potential. In conclusion, we are convinced that automation and robots may significantly contribute to reducing the negative impacts of climate change on the environment, the economy, and society, hence advancing some of the UN's SDGs. All stakeholders must work together to quickly develop high-impact laboratory discoveries in robotics and automation in order to find practical solutions for addressing environmental problems caused by humans and their possible long-term effects. We hope that this appeal for cooperation will be answered right away, allowing us to use robotics and automation technologies to create a more sustainable and environmentally friendly future.

REFERENCES

1. Haidegger T, Mai V, Mörch CM, Boesl DO, Jacobs A, Rao BR, Khamis A, Lach L, Vanderborght B. Robotics: enabler and inhibitor of the sustainable development goals. Sustain Prod Consum. 2023;43: 422–34.
2. Khamis A, Li H, Prestes E, Haidegger T. AI: a key enabler for sustainable development goals: part 2 [industry activities]. IEEE Robot Autom Mag. 2019;26(4):122–7.
3. Guenat, S., Purnell, P., Davies, Z.G. *et al.* Meeting sustainable development goals via robotics and autonomous systems. *Nat Commun* **13**, 3559 (2022). https://doi.org/10.1038/s41467-022-31150-5
4. Tanevska A, Chandra S, Barbareschi G, Eguchi A, Han Z, Korpan R, Ostrowski AK, Perugia G, Ravindranath S, Seaborn K, Winkle K. (2023). Inclusive HRI II: Equity and diversity in design, application, methods, and community. In Proceedings of the 18th ACM/IEEE International Conference on Human-Robot Interaction (HRI '23) (pp. 956–958). ACM.
5. Khodeir, L.M.; Othman, R. Examining the interaction between lean and sustainability principles in the management process of AEC industry. Ain Shams Eng. J. 2018, 9, 1627–1634.
6. Smith,M.;Gaffney,O.;Rockström,J.;Öhman,M.C.;Shyamsundar,P.; Steffen,W.;Glaser,G.;Kanie,N.;Noble, I. Sustainable development goals for people and planet. Nature 2013, 495, 305–307.
7. Giordano G, Murali Babu SP and Mazzolai B (2023), Soft robotics towards sustainable development goals and climate actions. Front. Robot. AI 10:1116005. doi: 10.3389/frobt.2023.1116005
8. Xia,Y.; Ahmad, M. Industrial Robotics, Resource Efficiency, Energy Transition, and Environmental Quality: Designinga Sustainable Development Goals Framework for G7 Countries in the Presence of Geopolitical Risk. Sustainability 2025,17,1960. https:// doi.org/10.3390/su17051960
9. Dindorf, R.; Wos, P. Challenges of Robotic Technology in Sustainable Construction Practice. Sustainability 2024, 16, 5500. https:// doi.org/10.3390/su16135500
10. AI and Ethics (2025) 5:6091–6103 https://doi.org/10.1007/s43681-025-00830-5