Analyzing the Impact of Artificial Intelligence Approaches on Sustainability

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ABSTRACT
Artificial Intelligence is the science and engineering of making intelligent machines, aimed at providing machines with the ability to think, reach, and surpass human-level intelligence. Three essential terms *Automation*, i.e., reducing human interaction in operations, *Intelligent*, i.e., ability to extract insights or usable knowledge from data, and *smart computing*, i.e., self-monitoring, analyzing, and reporting, known as self-awareness, have evolved into essential standards for creating modern systems and applications in all area of our life, as we live in a technologically dependent society. AI offers creative, scalable, and reasonably priced solutions; it enables underdeveloped nations to overcome conventional developmental obstacles. AI reduces inequality, increases resilience to environmental challenges, and promotes equitable growth. This paper highlights ideas and capabilities of potential AI techniques that can be applied to create intelligent and smart systems that improve productivity, make better decisions, manage resources, etc. in a range of real-world domains, including cyber security, smart cities, finance, business, and agriculture. This study examines the relationship between AI and the Sustainable Development Goals (SDGs), emphasizing how important AI is to advancing sustainability.

Keywords
Artificial intelligence (AI); Sustainable development goals (SDGs), Machine learning (ML) · Deep Learning (DL). Natural Language Processing (NLP), Robotics, Expert systems

1. INTRODUCTION
There are many different ways to define artificial intelligence (AI). Some define it as the technology that was developed to enable computers and other machines to behave intelligently. Some view it as a system that works for men and produces faster and more effective results than human labor. Some view it as "a gadget" that can accurately analyze external statistics, learn from them, and then use those lessons to fulfill specific obligations and aspirations through flexible adaptation. Regardless of specific definitions, artificial intelligence (AI) is generally understood to refer to the use of machines and computers to assist humankind in problem solving and operational strategies. The main objective of artificial intelligence (AI) is to make it possible for computers and other devices to carry out cognitive tasks including perception, problem-solving, decision-making, and understanding human language [1]. The development process of AI includes perceptual intelligence, cognitive intelligence, and decision-making intelligence. Perceptual intelligence indicates that it has the same basic senses as people, such as vision, hearing, touch, etc. Cognitive intelligence is a higher-level ability of induction, reasoning and acquisition of knowledge [2]. It is motivated by brain-like intelligence, cognitive science, and brain science to give machines human-like reasoning and cognitive capacities. When a machine possesses sensory and cognitive abilities, it is frequently expected to make the best decisions, much like humans, to enhance industrial manufacturing, people's lives, etc. To make the best decisions possible, decision intelligence necessitates the expansion of data science through the use of applied data science, social science, decision theory, and managerial science [3]. This technology has emerged as the next big technological advancement, influencing the future of almost every industry by improving, speeding up, and improving the accuracy of every process.

In support of sustainable development goals, artificial intelligence (AI) provides strong tools and technologies that help improve decision-making, optimize resource allocation, and spur innovation [4]. Predictive analytics, remote sensing, and natural language processing are examples of AI-enabled solutions in the field of environmental sustainability that enable more precise monitoring of environmental indicators, facilitating early detection of environmental risks, biodiversity conservation, and climate change mitigation efforts[5]. AI applications in healthcare have the potential to enhance healthcare delivery, expand access to high-quality healthcare services, and lessen healthcare inequities. Examples of these applications include medical imaging analysis, predictive modeling, and customized medicine. Healthcare professionals may improve disease diagnosis and treatment outcomes, maximize the use of healthcare resources, and advance preventative care programs by utilizing AI-driven insights. These actions will eventually improve health and well-being for both individuals and communities. In order to address global food concerns, promote sustainable agriculture practices, and guarantee fair access to nutrient-dense food supplies, artificial intelligence (AI) is driving breakthroughs in supply chain management, agriculture, and food security. Precision farming, crop monitoring, yield prediction, and other AI-powered agricultural technology help farmers maximize resource use, boost crop yields, and lessen the negative effects of climate change on agricultural production.

Artificial intelligence (AI)-driven adaptive learning platforms, virtual tutoring programs, and personalized learning experiences are revolutionizing education delivery, increasing access to high-quality education, and encouraging lifelong learning opportunities for people all over the world in the context of education and skill development. AI technologies enable learners to seek higher education, pick up new skills, and engage more successfully in the knowledge economy by customizing learning experiences and instructional materials to each learner's requirements and preferences [6]. The present analysis emphasizes the revolutionary potential of artificial intelligence (AI) in promoting sustainable development objectives. It also emphasizes the criticality of responsibly and ethically utilizing AI technology to tackle urgent global issues and establish a sustainable and prosperous future for all.

2. UNDERSTANDING VARIOUS TECHNIQUES OF ARTIFICIAL INTELLIGENCE

Artificial intelligence (AI), machine learning (ML), and deep learning (DL) are the three well-known terminologies that are used these days to describe intelligent systems or software. DL is a subset of ML which is also a subset of AI. Figure 1 shows the roles that machine learning and deep learning play in the field of artificial intelligence.

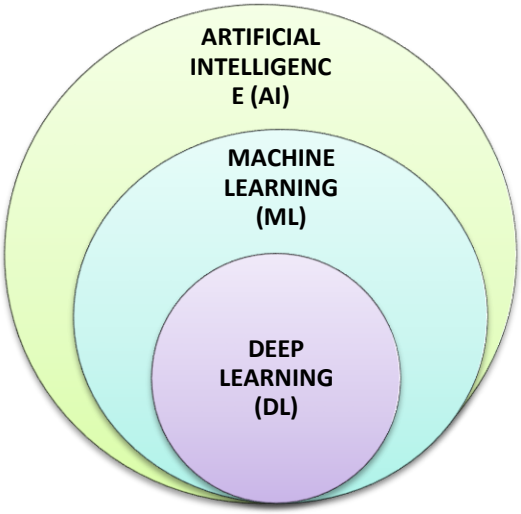

Fig 1: Relationship between AI, ML, DL

AI generally integrates intelligence and human behavior into computers or systems while machine learning (ML) automates the process of building analytical models by learning from data or experience [7]. Additionally, data-driven learning techniques that compute using multi-layer neural networks and processing are referred to as deep learning. "Deep" in the context of the deep learning technique refers to the idea of multiple levels or stages of data processing in order to create a data-driven model [8]. As a result, both machine learning (ML) and deep learning (DL) can be viewed as frontiers in AI that can help create intelligent systems and automate processes. Additionally, it advances AI to a new level through data-driven learning, dubbed "Smarter AI." Since both ML and DL can learn from data, there is also a strong connection to "Data Science" [9]. Besides ML and DL, other sub-fields of AI (Table 1)include robotics, expert systems, natural language processing and fuzzy logic, Computer vision, Case-Based Reasoning, Text mining. Table 1 provides a concise overview of several artificial intelligence techniques.

Table 1 Various AI techniques

Machine learning (ML)	Machine learning is a subset of AI that focuses on developing algorithms and models that enable computers to learn from data and improve their performance over time without being explicitly programmed. It includes techniques such as supervised learning, unsupervised learning, and reinforcement learning [7]. Reinforcement learning - an agent learns to make decisions by interacting with an environment and receiving feedback in the form of rewards or penalties. It is commonly used in applications such as game playing, robotics, and autonomous vehicle control [15].
Deep learning (DL)	Deep learning is a specialized form of machine learning that involves artificial neural networks with multiple layers (deep neural networks). It has been particularly successful in tasks such as image recognition, natural language processing, and speech recognition [11].
Natural Language Processing (NLP)	NLP is a text analysis technique that allows machines to interpret human speech. NLP tasks include speech recognition, also known as speech-to-text, word segmentation or tokenization, lemmatization and stemming, part of speech tagging, parsing, word sense disambiguation, named entity recognition, sentiment analysis, topic segmentation and recognition, and natural language generation, which is the task of converting structured data into human language [14]. Fake news identification, spam detection, machine translation, question answering, social media sentiment analysis, text summarization, virtual agents and chatbots, and other real-world applications use NLP techniques [10].
Text mining	Information retrieval, lexical analysis to investigate word frequency distributions, pattern recognition, tagging or annotation, information extraction, and data mining techniques such as link and association analysis, visualization, and predictive analytics are all part of text analysis. Text mining achieves this by employing several analysis techniques, such as natural language processing (NLP) [13].
Computer vision	Computer vision [99] is also a branch of AI that allows computers and systems to extract useful information from digital images, videos, and other visual inputs and act or make recommendations based on that data. This is concerned with the automated extraction, analysis, and comprehension of relevant information from a single image or a series of images. In terms of technology, it entails the creation of a theoretical and algorithmic foundation for achieving autonomous visual understanding by processing an image at the pixel level [12].
Robotics	Robotics combines AI with mechanical engineering to design and develop robots capable of performing tasks autonomously or semi-autonomously [16]. It encompasses areas such as robot perception, motion planning, manipulation, and human-robot interaction.
Expert Systems	Expert systems are AI systems designed to mimic the decision-making ability of human experts in specific domains [17]. They use a knowledge base of rules and heuristics to provide recommendations or solutions to problems within their domain of expertise.

Fuzzy logic-based approach	Fuzzy logic is a precise logic of imprecision and approximate reasoning. This is a natural generalization of standard logic in which a concept's degree of truth, also known as membership value or degree of membership can range from 0.0 to 1.0. The fuzzy logic approach is preferred when distinguishing features are vaguely defined and rely on human expertise and knowledge. Thus, the system may work with any type of input data, including imprecise, distorted, or noisy data, as well as with limited data. It is a suitable strategy to use in scenarios with real, continuous valued elements because it uses data acquired in surroundings with such properties [18].
Case-Based Reasoning	Case-based reasoning handle new problems by obtaining previously stored 'cases' that describe similar earlier problem solving experiences and customizing their solutions to meet new requirements. For example, patient case histories and treatments are utilized in medical education to assist diagnose and treating new patients [19].
Ethical AI	Ethical AI focuses on ensuring that AI systems are developed and deployed responsibly and ethically. It involves addressing issues such as bias and fairness, transparency and explain ability, accountability, privacy, and the societal impacts of AI technologies [16].

3. ARTIFICIAL INTELLIGENCE (AI) AND SUSTAINABLE DEVELOPMENT GOALS (SDGS)

The United Nations established the Sustainable Development Goals (SDGs) in 2015 as a series of 17 global objectives to address the social, economic, and environmental issues that nations worldwide face [20]. These goals address problems including poverty, inequality, climate change, environmental degradation, peach, and justice in an effort to build a better and more sustainable future for all. By 2030, the Sustainable Development Goals (SDGs) aim to eradicate poverty, safeguard the environment, and guarantee that everyone lives in peace and prosperity. Through a variety of techniques, artificial intelligence (AI) has the potential to greatly accelerate the achievement of the Sustainable Development Goals (SDGs) [6]. Table 2 illustrates 17 sustainable development goals (SDGs) [21].

Table 2. Sustainable development goals (SDGs)

1	No poverty
2	Zero hunger
3	Good health and well-being
4	Quality education
5	Gender equality
6	Clean water and sanitation
7	Affordable and clean energy
8	Decent work and economic growth
9	Industry, innovation, and infrastructure
10	Reduced inequality
11	Sustainable cities and communities
12	Responsible consumption and production
13	Climate action
14	Life below water
15	Life on land
16	Peace and justice strong institutions
17	Partnerships to achieve the goal

Artificial Intelligence has the potential to play a significant role in achieving Sustainable Development Goals (SDGs). The points below illustrate Connecting AI to the Sustainable Development Goals [22].

3.1 Poverty and Hunger

AI can aid in reducing poverty and hunger by enhancing resource allocation, forecasting crop yields, and optimizing agricultural operations [23].

3.2 Healthcare:

By facilitating early disease detection, individualized treatment regimens, and remote monitoring, artificial intelligence (AI) can improve healthcare systems and improve patient outcomes [24].

3.3 Education:

AI can help everyone have access to high-quality education in remote locations, customize learning experiences for each student, and create chances for lifelong learning [33].

3.4 Gender equality:

AI technologies can support diversity initiatives in the workplace, help detect and resolve prejudices in recruiting procedures, and guarantee that all genders have equal opportunity [34].

3.5 Clean energy:

In order to support sustainable energy practices, artificial intelligence (AI) can optimize energy use, enhance grid

management, and make it easier to integrate renewable energy sources [32].

3.6 Climate action:

AI can help with climate change adaptation and mitigation by analyzing climatic data, forecasting natural disasters, and providing insights for reducing environmental effects [25].

3.7 Sustainable cities:

AI can improve resource management, transit, and urban planning to make cities more livable and sustainable for all citizens [26].

3.8 Responsible consumption and production:

By 2030, AI can reduce greenhouse gas emissions worldwide by about 4%. AI can support efforts to increase supply and demand for sustainability. Predicting and preventing food waste with ML-based algorithms using the food waste app Karma [28].

3.9 Life below water:

Monitoring illegal, unreported, and unregulated fisheries to reduce waste in supply chains as well as identifying illegal, unregulated, and unreported catches by leveraging AI and ML approaches [27].

3.10 Life on land:

Monitoring illegal, unreported, and unregulated fisheries to reduce waste in supply chains as well as identifying illegal, unregulated, and unreported catches by leveraging AI and ML approaches [29].

3.11 Peace and justice strong institutions:

AI can enhance law enforcement's ability to make better decisions, make citizens safer, and make institutions more accountable if its advantages are utilized [30].

3.12 Partnerships:

By streamlining data exchange, decision-making procedures, and resource allocation for the SDGs, artificial intelligence (AI) can promote cooperation and partnership among stakeholders. [31]

4. ARTIFICIAL INTELLIGENCE EXAMPLES THAT ADVANCE SUSTAINABLE DEVELOPMENT OBJECTIVES

Artificial Intelligence (AI) solutions are being used more frequently to tackle a variety of issues and help diverse sectors accomplish the Sustainable Development Goals (SDGs). The following are some instances of artificial intelligence (AI) solutions that are enhancing the results of sustainable development [35]:

4.1 Environmental conservation:

4.1.1 Deforestation prevention: Artificial intelligence algorithms use satellite photos to track illicit logging activities, detect hotspots for deforestation, and measure changes in the forest cover in real time.

4.1.2 Wildlife protection: AI-powered image recognition and drones are used to monitor and protect endangered species, detect poaching activities, and track animal populations in remote areas.

4.1.3 Climate modeling: Climate models powered by artificial intelligence (AI) simulate intricate environmental processes, forecast the effects of climate change, and guide policy choices for reducing greenhouse gas emissions and preparing for climatic variability.

4.2 Healthcare:

4.2.1 Disease diagnosis: AI systems examine genomic information, medical pictures, and patient records to help doctors diagnose conditions like diabetes, TB, and cancer more quickly and accurately.

4.2.2 Drug discovery: AI-driven drug discovery tools speed up the process of finding new therapeutic candidates, foretell medication interactions, and improve drug formulations, all of which contribute to the creation of more efficient and reasonably priced illness treatments.

4.2.3 Personalized medicine: AI-based predictive analytics improves treatment outcomes and lowers adverse medication responses by customizing treatment plans and interventions to each patient's unique preferences, attributes, and genetic profiles.

4.3 Education:

4.3.1 Tutoring and Mentorship: AI-Chabot's and virtual assistants help students acquire difficult concepts and abilities by offering them individualized tutoring, feedback, and mentorship. This promotes self-directed learning.

4.3.2 Personalized Learning: AI-powered adaptive learning platforms deliver customized educational content and activities based on students' learning styles, abilities, and progress, enhancing engagement and retention.

4.3.3 Language Translation: AI-powered language translation tools break down language barriers, enable access to educational resources in multiple languages, and promote cross-cultural exchange and collaboration among students and educators worldwide.

4.4 Agriculture:

4.4.1 Crop Monitoring: AI systems examine sensor and satellite data to track crop health, find pest infestations, and determine when irrigation is needed. This helps farmers make data-driven decisions and run their operations more effectively.

4.4.2 Supply Chain Optimization: AI-driven analytics enhance supply chain logistics, crop distribution, and food storage to reduce food waste, increase food security, and ensure access to nutritious food for people worldwide.

4.4.3 Precision Farming: Drones, sensors, and IoT devices in agriculture with AI capabilities gather information on crop growth, soil health, and weather patterns to maximize crop yields, decrease resource consumption, and improve farming techniques all while lessening their negative environmental effects.

4.5 Financial inclusion:

4.5.1 Microfinance and credit scoring: AI-powered credit scoring models employ alternative data sources such as mobile phone usage and social media activity to assess creditworthiness, improve access to financial services, and boost entrepreneurship and economic development among underrepresented communities.

4.5.2 Digital payments and remittances: AI-driven mobile banking apps and payment platforms offer secure and convenient digital transactions, minimize transaction

costs, and facilitate access to financial services for unbanked and under banked individuals in remote places.

A summary of AI tasks and techniques that are utilized to solve in several real-world application areas are shown in Table 3.

Table 3. A summary of AI tasks and methods in several popular real-world applications areas

AI techniques	Application areas	Real-world Tasks
Machine learning	Healthcare Cyber security Smart city Recommendation systems	COVID-19 aid [36, 37], Anomaly and Attack Detection[38] Smart parking pricing system [39] Hotel recommendation [43]
Deep learning and Neural network	Healthcare Cyber security Smart cities Smart Agriculture Business and Finance Virtual Assistant Visual Recognition	Diagnosis of COVID-19 [36] Malware detection [41] Smart parking system [42] Plant disease detection [43] Stock trend prediction [44] An intelligent Chabot [45] Facial expression analysis [54]
Fuzzy logic-based approach	Healthcare Agriculture Cyber security Business	Heart disease diagnosis[46] Smart irrigation[23] Network anomaly detection system [18], Customer satisfaction[47]
Expert system modelling	Smart systems Cloud computing cyber security Mobile expert system	Smart traffic monitoring [48] Ontology data access control [49] Vulnerability management [50] Personalized decision-making [51]
Case-based reasoning	Healthcare Smart cities Smart Industry Recommendation Systems	Breast cancer management[19] Energy management [32] Fault detection system [52] Classification and regression tasks[53]
Natural language processing and Text mining	Sentiment analysis Business Cyber security	Sentiment analysis of tweets [68] Product reviews sentiment [96] Estimating security of events [60]
Computer vision	Healthcare Computer vision Visual Analytics	Cervical cancer diagnostics [54] Human fall detection [55] Navigation mark classification [56]

These examples illustrate the diverse ways in which AI solutions are driving progress towards sustainable development goals by leveraging data-driven insights, automation, and predictive analytics to address complex challenges and create positive social and environmental impact. In order to optimize AI's advantages and reduce any possible hazards to society, it is crucial to make sure that these technologies are implemented in an inclusive, ethical, and responsible manner.

Flowchart in Figure2 illustrates a high-level overview of how AI can be leveraged to address various sustainable development challenges and contribute to the achievement of the SDGs.

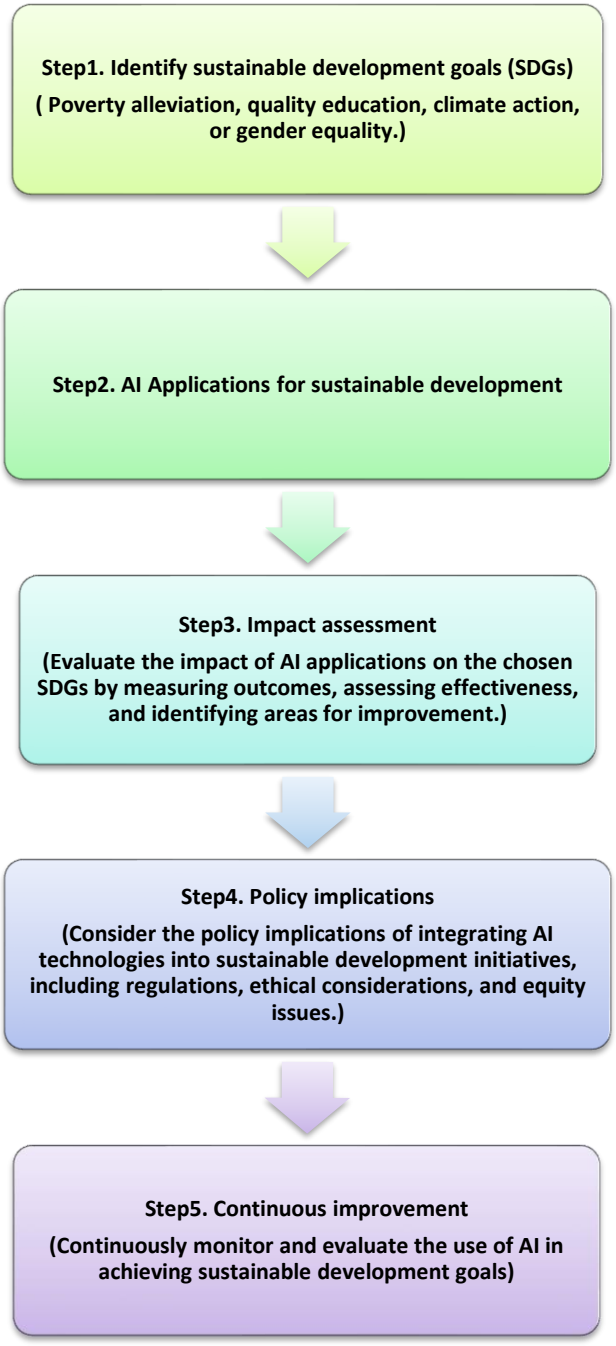

Fig 2. Steps to achieve SDGs

5. CONCLUSION

This article, tried to review the impacts of AI in achieving SDGs. The article was split into two sections for this purpose: Concepts and methods connected to AI are covered in the first section, while terminology relating to the SDGs is covered in the second section. In conclusion, artificial intelligence (AI) plays a critical role in accomplishing the Sustainable Development Goals (SDGs), which are essential for tackling global issues and promoting sustainable development in a variety of fields. AI solutions offer innovative approaches to precision agriculture, healthcare delivery, environmental conservation, climate change mitigation, smart city development, and disaster management, among others, thereby contributing to the advancement of SDGs. To expedite the attainment of the SDGs, it is concluded that technology, innovation, and data science must be utilized.

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