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Leveraging artificial intelligence to meet the sustainable development goals

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Abstract

Aim/purpose – This study aims to identify the role of Artificial Intelligence (AI) in achieving the Sustainable Development Goals (SDGs), with specific reference to their targets, and to present good practices in this regard.
Design/methodology/approach – This study adopts qualitative research based on an integrative literature review encompassing five stages: problem identification, literature search, data evaluation, data analysis, and presentation of findings.
Findings – This study presents a framework for leveraging AI to achieve SDGs. It details the role of AI in achieving each SDG, identifies the best practices for using AI to achieve these goals, and recommends the main steps for systematically deploying AI to achieve SDGs.
Research implications/limitations – The presented findings reflect the authors' perspective on the role of AI in achieving SDGs based on an integrative literature review, which may have overlooked some literature on AI's impact on individual SDGs or lacked published evidence on such interlinkages.
Originality/value/contribution – This study contributes to the existing body of knowledge by providing a comprehensive framework for leveraging AI to achieve the SDGs. It systematically identifies and details the role of AI in advancing each SDG, highlights best practices for deploying AI effectively, and recommends steps for integrating AI into SDG initiatives. The study's value lies in its ability to guide policymakers, researchers, and practitioners in harnessing AI's potential to address critical global challenges while highlighting the need for careful consideration of potential limitations and gaps in the existing literature.

Keywords: sustainable development, SDGs, Agenda 2030, Artificial Intelligence, AI.
JEL Classification: 033, M15; Q01.

1. Introduction

Sustainable development, introduced in 1987 by the World Commission on Environment and Development, aims to achieve economic growth, social equity, and environmental protection (WCED, 1987). This holistic and intricate process seeks to balance economic progress with environmental protection while addressing socio-cultural and political issues (Jungwirth & Haluza, 2023b; Monje-Cueto et al., 2024; Ziemba & Grabara, 2023), aiming to meet "the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). In 2015, the United Nations General Assembly adopted 17 Sustainable Development Goals (SDGs) to be achieved by 2030 (United Nations [UN], 2015). These goals, further refined into 169 specific targets, provide a comprehensive framework for sustainable development.

The role of information and communication technology is crucial to accelerate progress toward all 17 SDGs and make considerable strides in achieving their targets (Dhahri, 2024; ITU & UNDP, 2023). Approximately 70% of SDG targets directly benefit from information and communication technology, with the remaining 30% supported indirectly (ITU & UNDP, 2023). In the last few years, artificial intelligence (AI), including generative artificial intelligence (GenAI), has become particularly promising in applications related to essential problems covered by SDGs (Singh et al., 2024; Vinuesa et al., 2020); however, these solutions have their advantages (Doanh et al., 2023; Korzynski et al., 2023) as well as disadvantages (Wach et al., 2023; Sieja & Wach, 2023).

While there is no universally accepted definition of AI, based on the research by Vinuesa et al. (2020), for the purposes of this study, we consider AI to be any software technology that possesses at least one of the following capabilities: perception (e.g., recognition of sound, image, text), decision-making (e.g., making diagnoses), prediction (e.g., developing forecasts), extracting knowledge and recognizing patterns from data, logical reasoning (e.g., developing theories based on-premises), and interactive communication.

A review of relevant evidence by Vinuesa et al. (2020) indicated that AI could facilitate 134 targets (79%) across all SDGs, bringing many advantages to society, the economy, and the environment. However, 59 targets (35% across all SDGs) might face negative impacts from AI development if misused or exploited by humans. Therefore, if AI is applied inclusively and thoughtfully, with an awareness of its challenges and limitations (Wach et al., 2023), these technologies could become essential components of the SDG toolkit.

Though AI applications in achieving SDG targets are now being recognized (e.g., Jungwirth & Haluza, 2023b; Leal Filho et al., 2024; Vinuesa et al., 2020), there is no comprehensive research on the significant potential areas and examples of AI adoption in the context of each SDGs. This is especially important because AI is developing very quickly, and newer solutions are being created within its three types – artificial narrow intelligence, artificial general intelligence, and artificial superintelligence – each with the potential to influence SDGs differently (Mhlanga, 2022). Therefore, there is a research gap in continuous, comprehensive, and integrated studies aimed at demonstrating the extent to which AI can be used to improve sustainable development and achieve each SDG.

All of the above have motivated us to undertake this study. This article addresses this research gap using an integrative literature review. It aims to identify the role of AI in achieving SDGs, with specific reference to their targets, and to present good practices in this regard. More specifically, this article seeks to answer the following research questions:

RQ1: What is the role of AI in achieving SDGs, with specific reference to their targets?

RQ2: What are the best practices for using AI to achieve SDGs?

This article is organized as follows: Section 2 details the data and methodology. Section 3 presents the main findings regarding the role and examples of AI usage in achieving SDGs and their targets. Section 4 highlights the study's practical implications. The conclusion section underlines the relevance of the findings, discusses their limitations, and suggests possible future work related to this study.

2. Methodology

In this study, a literature review was employed because this method synthesizes existing knowledge, provides a comprehensive understanding of the current research landscape, identifies gaps in the literature, and integrates findings from diverse studies, thus offering robust insights that a single study cannot achieve (Snyder, 2019). Among the many literature review methods (Snyder, 2019), an integrative review (Toronto & Remington, 2020) was selected to identify the role of AI in achieving SDGs.

The integrative literature review can be vital in stimulating further research on various topics, including economic issues (Torraco, 2005). It systematically examines, critiques, and synthesizes representative literature, combining various perspectives and findings to generate new frameworks and perspectives on a topic (Snyder, 2019; Torraco, 2005). This literature review method addresses two general research topics – mature or new, emerging topics. Given that the topic of AI's role in achieving SDGs is relatively new, has not yet undergone a comprehensive review, and is continuously and rapidly evolving, this integrative review aims to identify how AI can enhance SDGs. It aims to provide a preliminary conceptualization of the topic, resulting in a framework for leveraging AI to meet SDGs.

To ensure the rigor and quality of the review, the process was structured into five stages: (1) problem identification, (2) literature search, (3) data evaluation, (4) data analysis, and (5) presentation of findings (Oermann & Knafl, 2021; Toronto & Remington, 2020).

In the first stage, the problem was defined to identify AI's role in achieving SDGs, with specific emphasis on their targets.

In the second stage, individual SDGs were assigned to each co-author of this study, who then reviewed the relevant literature and subsequently analyzed data and presented findings. The Scopus database was utilized to identify articles published in highly reputable peer-reviewed journals, ensuring a comprehensive literature review. Additionally, the Google database was employed to ensure that no significant grey literature and literature not indexed by Scopus was overlooked. Searches were conducted by titles, abstracts, and keywords using the specified following query string:

TITLE-ABS-KEY (("Sustainable Development Goals" AND AI)
OR ("Sustainable Development Goals" AND "Artificial Intelligence")
OR (SDGs AND AI) OR (SDGs AND "Artificial Intelligence"))

The literature research encompassed publications in English, including articles and grey literature published from 2020 to mid-June 2024. The review period, starting from 2020, was selected because prior literature reviews, such as those conducted by Singh et al. (2024) and Vinuesa et al. (2020), covered research up to 2020. Therefore, our review builds on these earlier works, providing a cumulative and updated perspective on the topic. Important individual publications released before the year 2020 were also taken into account. These earlier works were identified through a combination of expert knowledge, references found in articles published between 2020 and mid-June 2024, and citations frequently mentioned in key literature from the period under review. This approach ensured that foundational studies and influential research relevant to the topic were included, providing a comprehensive understanding of the role of AI in achieving the SDGs.

In the data evaluation stage, each co-author played a crucial role in addressing the quality of individual articles and other types of literature included in the review. This stage ensured reliable insights into addressing the research question mentioned in the Introduction.

In the data analysis stage, each co-author employed thematic analysis to compare findings across publications, interpreting and synthesizing the results.

In the final stage, the review findings for each SDG and conclusions for all SDGs were presented. Subsequently, a preliminary conceptualization of the topic was proposed, resulting in a framework for leveraging AI to meet SDGs.

3. Literature review and theory development

SDG 1: No Poverty

SDG 1 aims to eradicate poverty in all its forms globally, reflecting the United Nations' comprehensive agenda to address critical social, economic, and environmental challenges threatening global stability by 2030 (Fuso et al., 2018). AI emerges as a significant force in advancing SDGs, particularly in identifying impoverished regions and customizing interventions; however, it also presents the risk of job displacement due to automation, necessitating a careful balance between economic progress and social welfare (Ametepey et al., 2024; Vinuesa et al., 2020).

In order to address poverty, a crucial SDG, Raghavendra et al. (2023) carried out a thorough analysis of academic research on the subject, highlighting important topics, trends, obstacles, and promising areas for further study. Though experts rank SDG 1 as the second most important SDG (Palomares et al., 2021), the lack of focused research on AI's impact on this goal is highlighted in research (Schoorman et al., 2021), emphasizing the need for a more comprehensive understanding that has been partially addressed by previous studies and literature reviews on grand societal challenges (Berrone et al., 2023; Jean et al., 2016; Nyberg & Wright, 2022; Seelos et al., 2023; Vinuesa et al., 2020). Their findings show that, in addition to addressing poverty, government policies related to AI technologies for SDG 1 also positively impact other targets, such as industry, innovation, and infrastructure (SDG 9), clean energy (SDG 7), Decent Work and Economic Growth (SDG 8), and high-quality education (SDG 4). The ramifications of this conclusion for policymakers are noteworthy. It is important to stress the need for governmental actions in addition to the AI technology options examined in this study. Ensuring that underprivileged groups of society reap the benefits of AI technology breakthroughs requires the timely creation and execution of appropriate government policies.

Vinuesa et al. (2020) distinguished between two main ways – direct and indirect – by which AI affected poverty reduction. Large datasets, including satellite images and geographic information system data, were directly used by AI and associated technologies to quantify poverty and pinpoint deprived areas. AI also helped evaluate the efficacy of policies intended to reduce poverty, which was essential to accomplishing these initiatives.

Liu et al. (2021) presented a Density-Based Spatial Clustering of Applications with Noise (DBSCAN) method based on edge computing that uses a deep neural network model to target SDG 1. Similarly, Jiang et al. (2021) evaluated the effects of achieving SDG 1 by projecting county-level economic development by combining deep learning with various satellite image datasets. Using probabilistic linguistic word sets, aggregating data from relevant experts, and ranking and categorizing impoverished families integrating a case-based approach with data for decision-making and expert opinions, Li et al. (2020) focused on analyzing China's poverty alleviation initiatives. The study conducted by Liu et al. (2020) demonstrates a significant increase in income for most cooperative members, which supports the further development of local poverty alleviation efforts. Nine key variables, including health status, education level, labor availability, and agricultural income, were identified as critical in promoting income growth. However, challenges remain, particularly for low-income families and those farther from markets, limiting cooperatives' effectiveness in poverty reduction. Numerous additional research projects have also examined comparable direct effects, adding to the corpus of knowledge regarding AI and its ability to reduce poverty (Li & Xiaoming, 2022; Liang & Wang, 2022; Zhang, 2022). Together, these studies improve our knowledge of the efficient ways in which AI might be used to combat poverty.

To better understand how family companies might support sustainable brand activism in line with the United Nations SDGs, particularly SDG 1, Doe and Hinson (2023) stressed the revolutionary potential of AI and online brand communities within family businesses. Their analysis highlights how these advances in technology and community-based initiatives might serve as drivers for the advancement of sustainable business practices. Family businesses can substantially contribute to the SDGs by utilizing online brand communities and integrating AI.

According to Canavati (2018), sustainability practices are the intentional steps and regulations taken by businesses to lessen their adverse effects on the environment, society, and economy while maintaining long-term profitability and viability. Efforts to reduce poverty, improve the production of sustainable food, establish inclusive work environments, encourage women in leadership positions, promote responsible consumption and production practices, and stimulate local economic development are essential elements of these sustainability strategies for family businesses. These tactics are intended to strike a balance between the company's operational impact and its dedication to moral and sustainable growth. The focus on these areas indicates a more extensive dedication to incorporating social responsibility into corporate operations. Family enterprises can achieve long-term success and substantially contribute to SDGs by attending to these critical issues.

Even though AI can optimize resource allocation, relying too much on AI without considering human judgment could lead to unanticipated problems (Barley, 2020). Examining individual targets within SDG 1, Target 1.1 shows that AI may considerably promote fair access to economic resources (Mhlanga, 2021). These results imply that AI can significantly enhance how vital resources are distributed to underserved communities. Similarly, Target 1.2 emphasizes how AI might increase the resilience of economically disadvantaged populations by better predicting and responding to environmental or economic disasters. Target 1.3 demonstrates the potential of AI to enhance resource mobilization for anti-poverty activities (Barley, 2020; Mhlanga, 2021; Vinuesa et al., 2020). According to the evidence for SDG 1, if AI is applied in a fair and equitable manner, technology has the potential to contribute to the eradication of poverty significantly. Expert opinions indicate that AI's uses in anything from predictive analytics to precision agriculture have the potential to revolutionize resource distribution and assist marginalized communities. In particular, leveraging AI to improve food security and pinpoint areas vulnerable to economic hardship is thought to be a viable approach to tackling poverty head-on.

Notwithstanding the favorable viewpoints, the participants of a study conducted by Ametepey et al. (2024) expressed apprehensions about the possible disadvantages of an over-reliance on artificial intelligence remedies. They warned that the application of AI could unintentionally widen social and economic divides and result in ineffective resource allocation in the absence of sufficient control. Within the framework of SDG 1, there was an elaborate discussion about how important it is to make sure that, while retaining human judgment and local knowledge, AI helps make vital resources available to underserved populations. This discussion highlights how crucial it is to strike a balance between equitable access, context-specific knowledge, and technological improvements.

SDG 2: Zero Hunger

SDG 2 aims to end hunger, provide food security, improve nutrition, and advance sustainable farming methods. Even though AI can help achieve SDG 2 by increasing agricultural productivity through precision farming, there are still many obstacles to overcome before these technologies can be successfully implemented in resource-constrained areas. As a result, AI-driven solutions must be affordable for the most vulnerable populations (Jungwirth et al., 2023a; Vinuesa et al., 2020).

Ametepey et al. (2024) showed a beneficial impact and highlighted AI's transformative potential in supporting sustainable development in meeting SDG 2 and increasing sustainable agriculture. In addition to ensuring global food security, this goal seeks to accomplish it in an economical and sustainable way for the environment. According to Target 2.1, AI has the potential to significantly increase the availability of wholesome food by streamlining food supply chains and reducing waste. Experts warn against undermining conventional farming methods and making smallholder farmers more reliant on technologies that they may not be able to control or comprehend. To achieve sustainable food systems, support for traditional farming practices must be balanced with technological innovation.

The expert panel conducted by Ametepey et al. (2024) emphasized how AI can revolutionize sustainable agriculture, particularly concerning SDG 2's Targets 2.2 and 2.3.

Lezoche et al. (2020) agreed that precision agriculture powered by AI is a noteworthy advancement in maximizing resource use, attaining elevated crop yields while minimizing ecological effects, and augmenting farming methods' general effectiveness and durability. Furthermore, the Target 2.3 debate highlighted how AI might simplify local market dynamics by giving producers crucial insights into demand patterns, enabling improved production and consumption alignment (Mhlanga, 2021; Lezoche et al., 2020). Based on real-time data, an AI application is seen to be crucial for promoting a more adaptable and productive agriculture sector. It is feasible to address environmental sustainability and production issues more successfully by incorporating AI into agricultural methods.

Pandey and Pandey (2023) looked at potential trade-offs and synergies between AI's effects on certain SDGs. By enhancing food security and reducing waste, AI in precision agriculture, for example, helps achieve Goal 2 (Zero Hunger) and Goal 13 (Climate Action). This dual effect serves as an example of how AI can assist several SDGs at once. In their 2023 study, Pandey and Pandey (2023) explored how AI influences agricultural practices. They specifically looked at how AI can help achieve SDG 2 and improve food security by fusing traditional crop varieties with cutting-edge technologies like sensors, GPS (Global Positioning System), and GIS (Geographic Information System). They maintained that by reducing the effects of climate change, enhancing livelihoods, creating revenue, and advancing equality, precision agriculture – supported by AI and Internet of Things (IoT) technologies – could substantially contribute to SDG 2. Their research also emphasized how vital geospatial technologies are to accomplishing the SDGs and realizing the vision of the bioeconomy, such as GPS, GIS, and remote sensing. The monitoring, mapping, and visual interpretation of changes in forests, agricultural areas, and fishing zones over time are made possible by geospatial technology, enabling the achievement of several SDGs. Especially in the case of forestry, agriculture, and aquatic ecosystems, remote sensing offers dynamic time series data from many sensors and sources that are critical for long-term monitoring, visual analysis, and change evaluation. Natural resource management that is both comprehensive and sustainable is made possible by this technological integration.

Drones with sensors and AI capabilities can be used for various agricultural applications, such as land reconnaissance, weed identification, targeted plant treatment, crop health monitoring, and controlling animal health concerns (Jensen, 2019). Although sensors provide detailed and real-time data, their usefulness is restricted unless the data is efficiently transformed into information that can be reacted upon. When AI analyzes this data to produce insights that enable better integrated agricultural operations, planning, and monitoring, the value of the data rises dramatically. AI improves land, livestock, and crop management by turning raw data into meaningful knowledge that helps decision-makers for specific plants, crops, and animals.

AI has the potential to provide farmers with more accurate advice on optimal planting methods, water and irrigation management, crop rotation, timely crop harvesting, nutrient management, and pest control (Boursianis et al., 2020; Talaviya et al., 2020). For instance, businesses could use machine learning algorithms coupled with satellite data to deliver weather-based agricultural insights. Using AI-powered drone-based imaging technologies for crop health monitoring could increase yields and save expenses. The future of sustainable agriculture is thought to be considerably influenced by data-driven agriculture, aided by machine learning and AI-infused agricultural robotics (Saiz-Rubio & Rovira-Más, 2020). This strategy improves overall farm sustainability and efficiency while facilitating better-informed decision-making. The integration of these technologies highlights their role as primary forces behind upcoming agricultural developments.

According to Teh and Rana (2023), AI offers a substantial chance to improve outcomes and accelerate the pursuit of SDG 2. However, there are a number of concerns associated with deploying AI technologies to create intelligent solutions, such as cybersecurity issues, implementation difficulties, and the possibility of becoming overly reliant on technology. The adoption of AI technologies is also hampered by factors such as the necessity for high-quality data, financial investment requirements, return on investment considerations, and a host of ethical and legal concerns. It is imperative to tackle these obstacles to successfully include AI in furthering SDG 2. For the purpose of fulfilling SDG 2, further research is needed on the difficulties and dangers of applying AI technology to agriculture. Understanding these problems is crucial if we want to use AI to improve agricultural methods. Furthermore, to enhance food traceability within smart agriculture frameworks, future research should investigate integrating other technologies, like blockchain, with Internet of Things (IoT) systems (Wolfert et al., 2017). This connection may make it easier to convert conventional farming methods into cutting-edge, environmentally friendly ones. Researchers can help create agricultural solutions that are more sustainable and successful by looking into these factors.

Recognizing that no single technology can fully accomplish the SDGs or address all global concerns is imperative. Achieving these goals will require not just using cutting-edge AI technologies but also enacting corporate solid pledges, government regulations, and aggressive individual initiatives. Promoting the SDGs effectively requires a diverse strategy incorporating technical breakthroughs with extensive policy and community engagement. The essential role of governments, corporations, and individuals working together cannot be overstated in addressing global issues and advancing sustainable development.

SDB 3: Good Health and Well-being

SDG 3 calls for actions promoting Good Health and Well-Being, explicitly targeting reducing morbidity and mortality and increasing healthcare access for all people (UN, 2015). Notwithstanding concerns about the possible use of AI for manipulative purposes and potential risks and threats (Finlayson et al., 2019), its application in the medical field is growing fast. This phenomenal spread of AI for addressing SDG 3 is well reflected in the number of real-life deployments and research publications. For instance, a recent McKinsey report revealed that in 2023, AI-enabled cases with the potential to contribute to SDG 3 constituted one-fifth of all cases used to further the seventeen SDGs; besides, this goal has attracted considerably higher grant funding and private capital investments than any of the remaining SGDs (Bankhwal et al., 2024). AI applicability in addressing SDG 3 is the most researched among the seventeen goals (Singh et al., 2024). Such broad use of AI technologies in medicine, healthcare, and well-being may be accounted for by a forward-looking approach to innovative technologies in these fields, frequent measures of health and well-being outcomes, and availability of large data sets (Bankhwal et al., 2024).

To date, AI technologies have been employed across multiple areas in medicine, healthcare, and well-being, both with success and failure; thus, a firm conclusion on AI applicability at large in this domain and its benefits is still lacking. Nevertheless, some evidence has been provided to support AI use in some fields and activities. For instance, in physical health care, AI has been primarily used for assisting disease diagnosis and monitoring, optimizing medication dosages, and developing new ways of treatment and drugs, particularly in such areas of medicine as ophthalmology, cancer detection, and radiology, where AI performance is parallel to that of experienced clinicians or even exceeding it (e.g., in evaluation of abnormality images) (Graham et al., 2019). AI application in mental health care, where data is often more subjective and qualitative, is more modest but fast evolving and helpful in early disorder prediction, diagnosing, and treatment (Graham et al., 2019; Olawade et al., 2024). AI technology is also promising in making healthcare service management and administration more efficient (Aung et al., 2021; Secinaro et al., 2021). For instance, it has been estimated that AI overtaking specific administrative tasks will allow European physicians and nurses to spend more time (20% and 8%, respectively) with patients (Strewart, 2023). AI-enabled tools are also increasingly used in the organizational setting to promote employee well-being, such as the stress management tools Welltory (https://welltory.com) and Breathhh (https://breathhh.app), and the work-life balance management application Reclaim.ai (https://reclaim.ai) (Wells, 2023). Thus, overall, AI has great potential in promoting good health and well-being, and its influence on SDG 3 is forecasted to keep growing (Nahar, 2024).

Regarding specific SDG 3 targets, the spread of AI use cases and research also varies in degrees. Next, we provide some examples of AI potential in supporting specific targets. For instance, AI has been reported as having the potential to support newborn and maternal mortality (Targets 3.1 and 3.2). More specifically, AI has been used to forecast stillbirth risks, monitor neonates' health status, and perform real-time fetal monitoring. Regarding maternal mortality, research on AI use in this field is more modest (da Silva Rocha et al., 2022); however, AI tools are increasingly being used in remote healthcare provision. For instance, Jacaranda Health (https://jacarandahealth.org) is developing solutions to support mothers throughout their pregnancy in Kenya. Such AI applications also contribute to healthcare access improvement (Target 3.8), especially in low and middle-income countries (Goralski & Tan, 2023).

AI technologies also have the potential to support Target 3.3 through surveillance and control of the epidemics of communicable diseases (MacIntyre et al., 2023). For instance, AI interventions have been used to diagnose tuberculosis and malaria (Schwalbe & Wahl, 2020). AI applicability in supporting such targets as treatment of neglected communicable diseases (Target 3.4) and prevention of substance abuse (Target 3.5) is, however, still lacking (Bankhwal et al., 2024). AI techniques have been used for predicting road safety and accident severity (Panda et al., 2023), which in turn has the potential to reduce the number of global deaths and injuries from road traffic accidents (Target 3.6) through facilitating access to health information and education, disorder prediction, monitoring, drug discovery, etc. AI may also support improving global access to sexual and reproductive healthcare services (Target 3.7). To date, for instance, AI use has been reported in reproductive cancers, infertility, fertility care, sexually transmitted diseases, etc. (WHO, 2024), while AI-supported chatbots have been used in the provision of sexual and reproductive health advice (Nadarzynski et al., 2021). AI is also being used in predicting and monitoring pollution and related (e.g., respiratory) diseases (Alhussain et al., 2022; Masood & Ahmad, 2021), thus aiding in reducing mortality attributable to environmental pollution (Target 3.9).

Current AI use in tobacco control (Target 3a) may be illustrated through AI applications for such purposes as predicting smoking cessation and tobacco-related outcomes, smoker status identification, etc. (Fu et al., 2023). Concerning new drug development (Target 3b), existing research suggests AI potential in the development of drugs with medium chemical novelty and known impact mechanisms rather than completely novel drugs for illnesses with non-existent treatment (Lou & Wu, 2021). Target 3c calls for action to address human resource deficiencies in healthcare, particularly in developing countries. Though AI has a great potential to address labor shortages and skill development, its use is inhibited in developing countries by the absence of large-size, regularly updated datasets needed for developing context-specific AI tools (Ciecierski-Holmes et al., 2022). Nevertheless, some good practice cases have been reported, where AI has been used for tailored healthcare staff training and supporting clinical decision-making (Ciecierski-Holmes et al., 2022). Finally, concerning health risk warnings and management (Target 3d), as discussed about Target 3.3, AI has the potential to identify epidemic signs earlier than traditional means. EPIWATCH (www.epiwatch.org) is a successful AI application that allows automated warnings for epidemics to be generated. Nevertheless, public health agencies' uptake of AI tools remains insufficient (MacIntyre et al., 2023).

SDG 4: Quality Education

SDG 4 aims to offer free, equitable, and High-Quality Education for both boys and girls, ensuring they acquire the skills and knowledge necessary for sustainable development while eliminating all forms of gender bias in education (UN, 2015). Education empowers individuals (Nuary et al., 2022), fosters economic growth (Hanushek & Woessmann, 2020), and promotes societal well-being (Custodio et al., 2023). However, achieving inclusive and equitable quality education for all remains a significant challenge due to disparities in access, quality, and resources (Mikelatou & Arvanitis, 2023). AI offers promising solutions to bridge these gaps and transform the educational landscape.

AI is transforming the educational landscape by providing innovative solutions to enhance learning experiences and outcomes (Allen & Kendeou, 2024; Hashmi & Bal, 2024). For Targets 4.1, 4.2, and 4.3, personalized learning can serve as an important issue in pre-primary, primary, secondary, and higher education. AI-powered systems may adjust to each student's needs and learning styles (Alam, 2023). AI can create customized learning pathways by analyzing data on student performance, preferences, and behaviors. For example, Carnegie Learning's MATHia (https://www.carnegielearning.com/) uses AI to provide real-time feedback and personalized instruction in mathematics, identifying areas where students struggle and offering targeted interventions to enhance understanding and retention (Almoubayyed et al., 2023).

For Targets 4 a, 4 b, and 4.5, AI may contribute to accessibility and inclusivity in education. AI-driven tools can convert text to speech, provide real-time captioning, and translate content into multiple languages, making education more accessible to students in developing countries and students with disabilities (Chemnad & Othman, 2024). Microsoft's Immersive Reader (https://learn.microsoft.com/en-us/training/educator-center/product-guides/immersive-reader/) exemplifies this capability by aiding students with dyslexia and other reading challenges, offering features like text decoding, audio support, and visual customization to improve reading comprehension and engagement (Shirley & Nair, 2023).

Moreover, to facilitate Targets 4.6 and 4.7, AI can bridge educational gaps in remote and underserved areas where traditional educational resources are scarce (Mannuru et al., 2023). AI-driven online learning platforms and mobile applications deliver interactive and engaging educational content, reaching students with limited access to formal education. For example, Khan Academy (https://pl.khanacademy.org/) leverages AI to offer free online courses and practice exercises across various subjects (Fütterer et al., 2023). Its adaptive learning technology ensures that students from different backgrounds and regions can access quality education tailored to their learning pace and level.

In addition to supporting students, AI can support Target 4c and decrease teachers' administrative tasks, allowing them to focus more on instruction and student engagement (Ghamrawi et al., 2024). AI-powered analytics provide insights into student performance, helping teachers identify learning gaps and tailor their teaching strategies accordingly (Singha & Singha, 2024). Furthermore, AI facilitates continuous professional development by offering personalized learning resources and training programs for educators. Platforms such as Coursera (https://www.coursera.org/) use AI to recommend courses and resources to educators based on their interests, previous learning experiences, and professional goals, thus promoting lifelong learning and skill enhancement (Zavalevskyi et al., 2024).

SDG 5: Gender Equality

SDG 5 focuses on achieving Gender Equality and empowering all women and girls, which is a fundamental human right and a crucial foundation for a peaceful, prosperous, and sustainable world (UN, 2015). AI use in support of SDG 5 has not attracted significant grant funding or private capital investments, and the number of AI use cases is the lowest among the seventeen goals (Bankhwal et al., 2024). Likewise, research on the potential of AI technologies on the promotion of gender equality and women empowerment remains scant (Nasir et al., 2023; Vinuesa et al., 2020) and provides evidence only on some of the targets, among which Targets 5.1 and 5.2 (end of discrimination and elimination of violence) have been studied the most, while 5.3, 5.4, 5.5, and 5 a have hardly been addressed (Patón-Romero et al., 2022).

Opinions of AI's potential about supporting gender equality are somewhat divided. On the one hand, AI is criticized for being biased and reinforcing negative stereotypes toward women in such spheres as hiring, advertising, face and voice recognition, etc. (Tschopp & Salam, 2023). For instance, a study by Berkeley Haas Center for Equity, Gender, and Leadership showed that 44% of 133 AI systems analyzed were gender-biased (Smith & Rustagi, 2023). On the other, AI is seen as having the potential to contribute to gender equality through its responsible use. For instance, AI-powered tools (e.g., sentiment analysis, chatbot interventions, content moderation, etc.) could be used for identifying gender-biased systems, which could then be tackled through anti-discriminatory policies (Target 5.1) (Lütz, 2023). Moreover, AI tools may be designed with the specific purpose of reducing gender biases. For instance, the results of a natural experiment showed that AI-based teaching that displayed gender-neutral emotions provided good educational outcomes and contributed to the reduction of gender inequality (Bao et al., 2022). Responsible AI use may also contribute to gender equality through fairer talent acquisition and management, personalized learning, and immersive learning experiences (Munshi & Wakefield, 2024). Pymetrics (www.pymetrics.ai) is one example of such an AI-based application that helps mitigate bias in recruitment. Likewise, AI-based applications have been developed to protect women against violence (Target 5.2), such as Traffic Jam (www.marinus analytics.com/traffic-jam, helping against trafficking), MySis Chatbot (supporting victims of gender-based violence, https://changefusion.org), etc.

AI is also believed to have the potential to help women with unpaid care responsibilities and domestic work (Target 5.4). It has been estimated that AI-based automation in Japan and the UK could help reduce 50-60 % of the total time women spend on unpaid work (Hertog et al., 2023). Examples of AI's potential use in supporting women's health (Targets 5.6) have been discussed in the section on SDG 3. Some efforts have also been made to use AI in improving women's access to economic resources (Target 5a); e.g., Ellevest (www.ellevest.com) has developed an online investment platform tailored to women's needs, thus contributing to closing the gender investing gap.

The above illustrates the potential of AI-based tools in supporting SDG 5 targets. Though AI developments remain modest to date, AI's impact on attaining this goal is forecasted to continue growing worldwide (Nahar, 2024).

SDG 6: Clean Water and Sanitation

SDG 6 aims to provide everyone with safe drinking water and sanitation, emphasizing the sustainable management of water resources, wastewater, and ecosystems while recognizing the significance of a supportive environment (UN, 2015). AI is vital in advancing SDG 6 and facilitates various interventions to address water and sanitation management challenges, supporting the broader SDG agenda.

Regarding water management, AI contributes significantly to SDG 6. It assists in balancing irrigated food production with environmental flows, which is crucial for sustainable development (Jägermeyr et al., 2017). AI also enhances sanitation safety planning, aiding the achievement of safely managed sanitation systems and wastewater reuse, a key SDG 6 target (Winkler et al., 2017). Additionally, AI optimizes water demand management in supply systems, improving overall water management practices (Zanfei et al., 2023).

AI enhances organizational agility and resource coordination in the energy, sanitation, and agricultural sectors, promoting sustainability and collaboration to achieve SDGs, including SDG 6 (Noronha et al., 2023). In the construction industry, AI systems improve planning processes, safety inspections, and risk management, which are crucial for sustainable water and sanitation infrastructure (Jallow et al., 2022).

Moreover, AI facilitates ecosystem restoration efforts, creating synergies between SDG 6 and other goals such as SDG 1 (Yao et al., 2021). Smart water management systems powered by AI, integrating technology, policy frameworks, and community engagement, effectively address global water challenges (Olatunde, 2024).

Specifically, for Target 6.1, AI algorithms can analyze demographic and geographic data to identify underserved areas and optimize the allocation of resources for water infrastructure development (Hager et al., 2019). AI can optimize water pricing by analyzing socioeconomic data and usage patterns to develop fair and equitable water pricing models that ensure affordability while promoting conservation (Usmanova et al., 2022). Furthermore, AI-powered sensors and algorithms can continuously monitor water quality in real time, quickly detecting contaminants and potential health hazards. This allows for a rapid response to water quality issues, ensuring safer drinking water (Doorn, 2021). Machine learning models can analyze historical data, weather patterns, and population trends to predict water demand accurately (Lowe et al., 2022). This helps utilities optimize water distribution and ensure an adequate supply to all areas.

For Target 6.2, computer vision and satellite imagery analysis can assist in identifying areas where open defecation is prevalent (Stankovich et al., 2020). This can facilitate targeted interventions and resource allocation. AI-powered apps can offer personalized menstrual cycle tracking and hygiene advice, addressing the specific needs of women and girls (Kesavan et al., 2023). Additionally, AI-powered sensors can swiftly detect pathogens in water sources used for sanitation, enabling rapid responses to potential health hazards (Kaur et al., 2022).

For Target 6.3, AI-powered sensors and algorithms can continuously analyze water quality parameters to detect pollutants and hazardous chemicals in real time (Popescu et al., 2024). This allows for swift responses to pollution events and helps track long-term trends. Computer vision and satellite imagery analysis can detect illegal dumping activities, enabling quick intervention and enforcement of anti-pollution laws (Shiraj et al., 2024). Additionally, AI can help design new, environmentally friendly chemicals and materials to reduce water pollution at the source (Lowe et al., 2022).

For Target 6.4, machine learning can be used to analyze satellite imagery and geological data to map groundwater resources more accurately (Renna et al., 2023). This helps identify new water sources for communities lacking clean water. AI can optimize desalination in water-scarce areas, making freshwater production more sustainable (AlotaibI et al., 2022; Vaseashta, 2022). Additionally, AI-powered precision agriculture can optimize crop selection, planting times, and water usage based on soil conditions, climate data, and market demands.

For Target 6.5, using AI in water resource management can have significant benefits (Alnaqbi & Al Hazza, 2023). AI applications can improve data analysis, facilitate cooperation, optimize resource allocation, and support decision-making, thus enhancing integrated water resources management (Fuentes-Peñailillo et al., 2024). For instance, AI can generate and analyze future scenarios for water resources, considering factors such as climate change, population growth, and economic development to inform long-term planning (Xiang et al., 2021). AI-powered platforms can engage stakeholders by providing personalized information, translating complex data into understandable formats, and enabling interactive scenario planning (Hat et al., 2024). Additionally, AI can help optimize the placement and operation of water infrastructure (e.g., dams and treatment plants) while considering multiple objectives and transboundary impacts (Richards et al., 2023).

For Target 6.6, AI applications can be leveraged to improve the protection and restoration of water-related ecosystems significantly (Mehmood et al., 2020; Nti et al., 2023). This can be achieved by enhancing monitoring capabilities, optimizing resource allocation, predicting threats, and supporting informed decision-making. For example, machine learning algorithms can analyze landscape data to identify critical corridors for species movement, which can then inform conservation planning (Prodanovic et al., 2024; Silvestro et al., 2022). AI can also analyze weather data, vegetation conditions, and other factors for forest ecosystems to predict fire risks, enabling preventive measures (Imada, 2014). Furthermore, AI can assist in processing and validating large amounts of data collected through citizen science initiatives, enhancing ecosystem monitoring efforts (Ceccaroni et al., 2019).

In essence, AI is a powerful tool that can transform practices related to water and sanitation management and support the achievement of SDG 6 and its targets. By utilizing AI capabilities in water demand management, sanitation safety planning, organizational agility, and ecosystem restoration, stakeholders can work toward ensuring sustainable water and sanitation for all by 2030.

SDG 7: Affordable and Clean Energy

SDG 7 focuses on ensuring access to clean, affordable, dependable, sustainable, and contemporary energy, which is essential for developing agriculture, business, communications, education, healthcare, and transportation (UN, 2015). AI can potentially improve energy systems' effectiveness, dependability, and environmental friendliness through a range of inventive applications and technologies.

For Target 7.1, AI has a crucial role in enhancing energy production and distribution, making it one of the most important contributions to achieving SDG 7. AI algorithms have the capability to analyze extensive quantities of data derived from renewable energy sources, including solar, wind, and hydroelectric power (Conte et al., 2022). AI can optimize the efficiency of renewable resources by accurately forecasting weather patterns and modifying energy output accordingly. Foreseeing future energy needs offers a more consistent and trustworthy energy supply, decreasing reliance on non-renewable sources and minimizing energy inefficiency (Liu et al., 2022). Policymakers can utilize AI to make well-informed decisions on investments in energy infrastructure and regulatory frameworks (Danish & Senjyu, 2023). AI can simulate and represent numerous energy situations, forecast the long-term consequences of different policies, and choose the most economically efficient and environmentally friendly solutions. Through analyzing data on energy consumption, production costs, and environmental impact, AI can assist in formulating policies that encourage the adoption of renewable energy, enhance energy efficiency, and provide fair and equal access.

For Target 7.2, AI has the potential to enhance the administration of energy networks by implementing sophisticated monitoring and control systems (Conte et al., 2022). AI-powered smart grids have the capability to effectively manage the balance between energy supply and demand, identify defects, and make immediate modifications to prevent power outages and minimize energy wastage. These grids can incorporate diverse energy sources, including decentralized ones such as rooftop solar panels, and effectively regulate their distribution to guarantee a consistent and dependable energy provision (Jiang et al., 2022). Moreover, AI can streamline the incorporation of electric vehicles into the power grid, enhancing the efficiency of charging schedules and selecting optimal sites to avoid excessive strain on the system.

Buildings are one of the primary energy consumers, and AI can significantly improve their efficiency. For Target 7.3, AI-powered building management systems can enhance the efficiency of heating, ventilation, and air conditioning

(HVAC) operations, lighting, and other energy-consuming processes (Zhou, 2022). By acquiring knowledge of occupancy patterns and preferences, these systems have the ability to decrease energy use without sacrificing comfort. AI may also assist in upgrading older buildings with energy-efficient technology and materials, resulting in significant reductions in energy use (Balcerzak et al., 2023).

In conclusion, the capacity of AI to analyze and take action based on extensive quantities of data makes it an essential tool in attaining SDG 7. Through the optimization of energy production and distribution, the enhancement of grid management, the improvement of energy efficiency in buildings, the facilitation of energy access in remote areas, the support of energy policy and planning, and the promotion of sustainable consumer behavior, AI can contribute to the goal of providing affordable, reliable, sustainable, and modern energy for all. The use of AI in the energy industry not only promotes the achievement of SDG 7 but also generates wider environmental and economic advantages, thereby facilitating the transition toward a more sustainable future (Ratten, 2024).

SDG 8: Decent Work and Economic Growth

SDG 8 promotes sustained, inclusive, sustainable economic growth, full and productive employment, and decent work for all (UN, 2015). AI has the potential to significantly contribute to achieving the individual targets of SDG 8.

AI can significantly contribute to sustainable economic growth by optimizing resource allocation, enhancing productivity, and fostering innovation (Target 8.1). Integrating AI in various industries can lead to substantial productivity gains through innovation and technological upgrading (Target 8.2). For instance, AI can enhance manufacturing processes by enabling predictive maintenance and improving supply chain management (Lee et al., 2018). These improvements boost productivity and reduce operational costs and resource waste, contributing to economic diversification and innovation (Dalenogare et al., 2018). AI has the potential to support job creation and the growth of enterprises by enabling new business models and entrepreneurial opportunities (Target 8.3).

Studies suggest that AI-driven platforms can facilitate access to markets and resources for small and medium-sized enterprises, enhancing their competitiveness. Additionally, AI can aid policymakers in designing effective labor market policies by providing insights into workforce trends and skill requirements. AI technologies can improve resource efficiency by optimizing production processes and minimizing waste (Target 8.4). For example, using AI enhances the performance and accuracy of predictive maintenance systems and increases their autonomy and adaptability in complex and dynamic working environments (Ucar et al., 2024).

AI can play a crucial role in promoting full employment and decent work with equal pay by identifying and addressing disparities in the labor market (Target 8.5). Machine learning algorithms can analyze wage data to detect patterns of inequality and inform policy interventions aimed at promoting pay equity (Athey, 2019). AI-driven platforms can connect job seekers with employment opportunities that match their skills, thereby reducing unemployment. AI can enhance youth employment, education, and training by providing personalized learning experiences and career guidance (Target 8.6). AI-powered educational tools can adapt to individual learning styles, improving educational outcomes. This approach can allow the development of tailor-made instructional content, ensuring that each learner receives support aligned with their needs (Jian, 2023).

AI can aid in combating modern slavery, trafficking, and child labor by enhancing detection and enforcement mechanisms (Target 8.7). For instance, AI algorithms can analyze online data and communication patterns to identify potential trafficking activities and alert authorities. AI can improve labor rights protection and workplace safety by monitoring working conditions and identifying hazards (Target 8.8). For example, wearable devices enable constant monitoring of individual workers and the environment; they can track workers' health and safety metrics in real time, alerting them to potential dangers (Patel et al., 2021).

AI can enhance the sustainability of the tourism industry by optimizing resource use and improving visitor experiences (Target 8.9). AI can provide personalized recommendations and services to tourists, enhancing their satisfaction and promoting sustainable tourism practices. AI can facilitate universal access to banking, insurance, and financial services by offering innovative solutions for financial inclusion (Target 8.10). AI-driven platforms can provide personalized financial advice and improve the efficiency and security of financial transactions, reducing costs (Dhashanamoorthi, 2021; Rahmani & Zohuri, 2023). AI can enhance aid for trade support by optimizing the allocation and impact of trade assistance programs (Target 8a). AI can contribute to developing a global youth employment strategy by providing data-driven insights into labor market trends and youth employment challenges (Target 8b).

Integrating AI into efforts to achieve SDG 8 shows considerable promise across multiple targets. AI can drive sustainable economic growth, enhance productivity, support job creation, and improve resource efficiency. It can also address labor market inequalities, promote youth employment, combat modern slavery, ensure labor rights, and facilitate access to financial services. By leveraging AI, we can create more inclusive and sustainable economic systems, thereby advancing global efforts toward Decent Work and Economic Growth for all.

SDG 9: Industry, Innovation, and Infrastructure

SDG 9 seeks to build resilient infrastructure, promote sustainable industrialization, and foster innovation, recognizing that economic growth, social development, and climate action heavily depend on investments in these areas (UN, 2015). AI is crucial in achieving Goal 9 by enhancing infrastructure resilience, promoting sustainable industrialization, and driving technological innovation.

In the case of Targets 9.1 and 9.4, AI may facilitate the development and maintenance of resilient infrastructure. With the use of advanced data analytics and machine learning algorithms, AI can predict and diagnose potential failures in infrastructure systems before they occur (Ochuba et al., 2024). This predictive maintenance approach ensures that infrastructure remains robust and operational, reducing downtime and maintenance costs. For instance, AI systems can monitor the structural health of bridges, roads, and buildings, providing real-time data and alerts that enable timely interventions (Rafsanjani & Nabizadeh, 2023).

In line with Target 9.2, promoting inclusive and sustainable industrialization is another area where AI can play an important role. AI-driven automation and smart manufacturing processes improve efficiency and reduce waste, leading to more sustainable industrial practices (Kusiak, 2023). AI technologies can optimize supply chains (Plathottam et al., 2023), enhance energy efficiency (Matin et al., 2023), and minimize the environmental impact of industrial activities (Rashid et al., 2024). A good example is Siemens' use of AI in its factories to streamline production processes, reduce energy consumption, and minimize waste, promoting sustainable industrialization (Patra & Roy, 2023).

Expanding access to small-scale industrial and other enterprises, particularly in developing nations, which is crucial to supporting Target 9.3. AI can help with this by enhancing financial inclusion through Fintech solutions powered by AI that offer credit and financial services at reasonable prices (Mehrotra, 2019). AI can also help small businesses integrate into markets and value chains by streamlining operations and offering market insights (Tarafdar et al., 2019).

Finally, to support Target 9.5, AI fosters innovation by accelerating research and development across various fields. AI algorithms can analyze big amounts of data to identify patterns and generate insights that drive technological advancements and new product development (Kokshagina et al., 2024). For example, AI-powered drug discovery platforms analyze biomedical data to identify potential new treatments and therapies, significantly speeding up the R&D process in the pharmaceutical industry (Guedj et al., 2022).

SDG 10: Reduced Inequalities

SDG 10 aims to reduce inequality within and among countries. This goal addresses disparities in income and those based on age, sex, disability, race, ethnicity, origin, religion, and economic or other (UN, 2015). AI has the potential to play a significant role in achieving this goal by providing innovative solutions to identify and mitigate inequalities.

AI can help reduce income inequalities by enhancing access to quality education and employment opportunities (Target 10.1). This personalized approach, provided by an AI-driven platform, helps bridge educational gaps for students from disadvantaged backgrounds, offering them the same quality of education as their more privileged peers (Holmes et al., 2019).

AI can promote universal social, economic, and political inclusion by providing tools that enhance accessibility and participation (Target 10.2). For example, AI-driven translation and communication technologies can bridge language barriers, facilitating greater inclusion of non-native speakers in social and political processes. Additionally, AI can support financial inclusion by providing innovative banking solutions for underserved populations, enhancing their economic participation (Zavolokina et al., 2020).

AI has the potential to identify and mitigate discriminatory practices by analyzing large datasets to uncover patterns of bias (Target 10.3). Machine learning algorithms can detect discriminatory hiring practices and promote fairer recruitment processes (Albaroudi et al.,2024; Lavanchy, 2023).

AI can help design and implement fiscal and social policies that promote equality by providing data-driven insights into the effectiveness of various policy measures (Target 10.4). For example, predictive analytics is a powerful tool that enables governments to make data-driven decisions and can help governments assess the impact of proposed policies on different demographic groups, enabling more informed decision-making (Hossin et al., 2023; Thapa, 2019).

AI technologies can enhance the regulation of global financial markets and institutions by improving transparency and reducing risks (Target 10.5). AI-driven analytics can monitor real-time financial transactions and identify suspicious activities (Berg et al., 2020).

AI can enhance developing countries' representation in financial institutions by providing data and insights highlighting their unique challenges and opportunities (Target 10.6). Using AI tools, developing countries can better articulate their needs and advocate for fairer representation and resource allocation in international financial forums.

AI can facilitate the development of responsible and well-managed migration policies by providing tools for better understanding migration patterns and predicting future trends (Target 10.7). AI-driven analytics can help policymakers design migration policies that balance economic needs with social integration goals.

AI can support special and differential treatment for developing countries by enabling tailored development assistance and policy interventions (Target 10a). AI can encourage development assistance and investment in least--developed countries by providing data-driven insights into investment opportunities and risks (Target 10b). AI-driven platforms can connect investors with high-potential projects in least-developed countries, facilitating investment flows and economic development. AI can help reduce transaction costs for migrant remittances by streamlining payment processes and enhancing financial transparency (Target 10c).

Integrating AI into efforts to achieve SDG 10 demonstrates significant potential to reduce inequalities within and among countries. AI can enhance access to education and employment, promote social and economic inclusion, ensure equal opportunities, and assist in creating and implementing equitable fiscal and social policies. Moreover, AI can improve the regulation of global financial markets, support fair representation of developing countries in financial institutions, and facilitate responsible migration policies. By encouraging development assistance and reducing transaction costs for migrant remittances, AI can further contribute to economic growth in least-developed countries.

SDG 11: Sustainable Cities and Communities

SDG 11 aims to make cities and human settlements inclusive, safe, resilient, and sustainable (UN, 2015). Notably, it can be achieved through safe and affordable housing (11.1), affordable and sustainable transport systems (11.2), inclusive and sustainable urbanization (11.3), protect the world's cultural and natural heritage (11.4), reduce the adverse effects of natural disasters (11.5), reduce the environmental impact of cities (11.6), provide access to safe and inclusive green and public spaces (11.7), robust national and regional development planning (11a), implement policies for inclusion, resource efficiency, and disaster risk reduction (11b) and support least developed countries in a sustainable and resilient building (11c). AI has significant potential to contribute to achieving this goal in various ways. In particular, the potential applications of AI in the spatial planning process (Du et al., 2023), smart infrastructure (Saddiqi et al., 2023), disaster risk management (Aboualola et al., 2023), smart and sustainable transportation systems (Cirianni et al., 2023; Jagatheesaperumal et al., 2024) and environmental monitoring (Wani et al., 2024) should be highlighted. Gupta and Degbelo (2023) conducted a quantitative analysis of projects in the CORDIS (Community Research and Development Information Service) database related to the application of AI for achieving SDGs. The research findings indicate that AI systems significantly contribute to the sustainable development of cities in various ways (waste management, air quality monitoring, disaster response management). However, many projects operate for citizens without requiring their involvement (Gupta & Degbelo, 2023).

In achieving Target 11.1, participatory planning as a democratic spatial decision-making process involving multiple stakeholders seems crucial. The integration of AI methods in participatory planning has the potential to improve the decision-making process (Du et al., 2023) by analyzing local knowledge through big data (behavior data, street view imagery, air quality data, sound data, building information), predicting outcomes of alternative plans (e.g., traffic prediction, urban project costs estimation, recommending alternative plans to achieve multiple goals), automation of plan generation (e.g., AI models can generate maps of planned changes) and facilitating communication between stakeholders (e.g., auto-transcript and auto-translation services).

Another area of AI application is intelligent and sustainable urban transport, as referred to in Target 11.2. Jagatheesaperumal et al. (2024) highlighted the potential for improving road safety through the use of AI (e.g., sensors, including eye blink, ultrasonic, and alcohol sensors) (Jagatheesaperumal et al., 2024). Cirianni et al. stated that employing AI facilitates the quicker implementation of solutions for monitoring user choice behavior and the performance of transport services (Cirianni et al., 2023). AI applications can also support dynamic and personalized mobility management systems. AI and transport model-based algorithms are used to interpret phenomena and aid real-time decision-making for the mobility system's operational management and offline transport service planning (Cirianni et al., 2023). Kubik (2023) provided an example of using machine learning to improve shared mobility in assessing user journeys' accuracy (Kubik, 2023). The study conducted by Salas et al. (2023) suggested three integrated AI methodologies that enable the classification of devices, estimation of mobility modes, and identification of the most likely routes people use to navigate the city.

According to He and Chen (2024), machine learning techniques such as supervised learning are particularly effective for forecasting urban trends, while artificial neural networks and deep learning excel in pattern recognition and are essential for environmental modeling (He & Chen, 2024). The transformative potential of AI in geo-design and planning is evident in its capability to analyze large and complex datasets, automate and enhance planning processes, and deliver more accurate predictions and insights into urban and environmental dynamics (He & Chen, 2024). The indicated activities will strengthen sustainable urbanization based on social inclusion and participation, which is the idea of Target 11.3.

Examples of AI applications in the area of cultural heritage protection (Target 11.4) include using 3D laser scanning technology to obtain disease details and crack data of architectural heritage (Luo & Wang, 2024). AI can be used to protect cultural resources and safeguard against the undesirable exploitation of knowledge embedded in cultural assets (e.g., protect knowledge from batik art) (Quan et al., 2024). Image classification using AI is widely applied in the field of cultural heritage for image recognition and classification (Liu, 2023).

AI is a crucial technology that can be utilized through smart devices to develop systems aware of emergencies. According to Aboualola (2023), AI techniques can reduce the number of casualties and minimize large-scale infrastructure damage caused by natural and human-made crises (Aboualola et al., 2023). Abid et al. (2021) also highlighted the potential applications of AI in disaster management, pointing out that integrating a geographic information system (GIS) and remote sensing (RS) into disaster management enables higher planning, analysis, situational awareness, and recovery operations, which can contribute to the achievement of Target 11.5.

Achieving SDG 11 will also be supported by actions aimed at improving the quality of the surrounding environment (air, water, soil, noise), thereby contributing to the achievement of Target 11.6. AI has proven to be a valuable tool in developing sensors capable of effectively detecting and analyzing hazardous substances (Popescu et al., 2024). The study conducted by Wani et al. (2024) demonstrates the significance of AI-driven early-warning systems, empowering proactive responses to environmental threats and enhancing accuracy, adaptability, and real-time decision-making (Wani et al., 2024). Examples of AI applications aimed at reducing the negative environmental impact of cities also include:

- urban water network, stormwater and CSO (Combined Sewer Overflow) modeling, and automated calibration of the mechanistic models (Saddiqi et al., 2023);
- energy generation, transmission, distribution, and consumption in smart cities (Camacho et al., 2024);
- stormwater infrastructure systems (Sharifi et al., 2024);
- urban energy efficiency (Li et al., 2024);
- energy demand-side management by load monitoring (Kommey et al., 2024).

The application of AI in improving access to safe and inclusive green and public spaces (Target 11.7) is reflected in users' ability to express and exchange opinions about green urban spaces and access them via social networks (Ghahramani et al., 2021). Yu et al. (2023) showed that AI can optimize urban green-space (UGS) planning and design methods in urban road green belts.

Despite the many potential benefits associated with AI, this area raises numerous social concerns (Du et al., 2023). Concerns about data privacy, ethical considerations, and the need for interdisciplinary expertise are critical issues that must be addressed to ensure the responsible and effective use of AI in this field. (He & Chen, 2024).

SDG 12: Responsible Consumption and Production

SDG 12 emphasizes establishing sustainable consumption and production patterns to foster environmental sustainability, economic growth, and social well-being (UN, 2015). AI offers innovative solutions to address the challenges associated with unsustainable consumption and production. Key applications of AI in achieving SDG 12 include influence on consumer behavior toward sustainable consumption (Cao & Liu, 2023), sustainable waste management (Fang et al., 2023; Javaid et al., 2022), manufacturing optimization and supply chain management (Alexander et al., 2024; Jackson et al., 2024).

One of the areas of AI application is changing behaviors toward sustainable consumption (Target 12.1). The sustainable consumption model is grounded in the principles of the circular economy, low-carbon environmental conservation, and social responsibility. Research findings indicate that companies use big data (which enables employing AI) to develop sustainable consumer experiences, forecast purchasing behaviors, design and adjust business models, and encourage sustainable consumption (Chandra & Verma, 2021). Based on their literature review, Chandra and Verma (2021) showed that big data analytics can (i) enhance comprehension of consumer behavior by collecting data via smart technologies, (ii) forecast societal shifts by analyzing how human groups respond to environmental changes, (iii) raise awareness about stabilizing electricity consumption, and (iv) develop effective interventions to encourage sustainable consumption in the travel and energy sectors (Chandra & Verma, 2021). Cao and Liu (2023) demonstrated in their research that AI technologies such as The Alipay Ant Forest stimulate hedonic and utilitarian stimulation, perceived personalization, and perceived interactivity – what ultimately causes sustainable consumption behaviors among consumers (Cao & Liu, 2023).

Sustainable production is mainly reflected in improving resource use efficiency, achieving Target 12.2. AI contributes to resource efficiency by optimizing raw materials and energy use. AI-driven analytics can monitor and optimize manufacturing processes, reducing material waste and energy consumption. Predictive maintenance can also prevent machinery breakdowns, minimizing resource wastage (Alexander et al., 2024; Doanh et al., 2023; Papadimitriou et al., 2024). AI can enhance supply chain transparency and efficiency, ensuring that resources are used optimally from production to delivery. This includes demand forecasting, inventory management, and logistics optimization (Jackson et al., 2024; Nozari, 2024; Pereira & Shafique, 2024; Sadeghi-R et al., 2024). The role of AI goes beyond the allocation of resources (Target 12.2) since it allows the analysis of consumption patterns and calibrates production processes in real-time, serving as a bulwark against overproduction and the uncontrolled generation of waste, which would make it possible to adapt production to actual demand and move toward a circular production model (Bag et al., 2021; Tsui et al., 2022), The predictive abilities of machine learning algorithms enable industries to predict resource requirements more precisely and ensure the efficient utilization of materials (Akkem et al., 2023; Jhajharia et al., 2023).

Sustainable consumption will also lead to sustainable logistics of goods, contributing to the achievement of Target 12.3. According to Wang et al. (2023), AI can be utilized to forecast upcoming product demand and to support the movement of logistics transport vehicles into green logistics.

The application of AI in chemical predictions can also support policy--making and regulatory transformation in chemical policy (Alexander-White, 2024). (Target 12.4). Thus, computational toxicology methods based on AI can lower the initial experimental costs of identifying emerging environmental contaminants, enhance the understanding of the toxicity mechanisms of these contaminants, and boost the efficiency of hazard identification by regulatory authorities (Tan et al., 2022).

Sustainable consumption is also reflected in waste management aimed at minimizing the amount of waste generated and the broader application of recycling processes – thereby ensuring the achievement of Target 12.5. Examples of AI applications in this area include smart sorting systems, predictive analytics, and material recovery. In the case of smart sorting, AI-powered robots and sensors can accurately sort waste into categories such as recyclable, compostable, and non-recyclable materials, increasing the efficiency of recycling processes (Fang et al., 2023). Using predictive analytics, AI algorithms can predict waste generation patterns, enabling municipalities to optimize waste collection schedules and reduce costs (Javaid et al., 2022). Finally, advanced AI technologies can identify and recover valuable materials from waste streams, reducing the need for virgin resources and promoting circular economy practices (Arun et al., 2024).

Sustainable production is the process of manufacturing goods and services that minimizes adverse environmental impacts, efficiently uses natural resources, supports the well-being of workers and local communities, and promotes responsible management throughout the product life cycle (Target 12.6). Reporting on sustainability and maintaining transparency are crucial factors for companies adopting AI tools. AI-driven data analytics can enable more precise and thorough sustainability reporting, boosting accountability and aligning with the global shift toward greater Environmental, Social, and Governance (ESG) disclosure. This can help attract responsible investments and strengthen the region's dedication to sustainable practices (Jankovic & Curovic, 2023).

Applications of AI can significantly enhance the public procurement process (Target 12.7). A study conducted by Sanchez-Graells (2024) on the use of explainable AI methods to enhance the clarity and trustworthiness of models in two key areas, detecting collusion and uncovering corruption in public procurement, showed AI's ability to promote greater transparency, accountability, and trust in automated decisions within public procurement. Despite the potential for AI applications in public procurement processes, some researchers point out irregularities in AI predictive tools and emphasize the need for a refined legal and methodological framework capable of auditing, identifying, and correcting issues related to unfairness arising from the use of AI (Odilla, 2024).

AI can contribute to the development and enhancement of education programs for sustainable development (Target 12.8), thereby building public awareness (Tanveer et al., 2020)

Integrating AI into various sectors offers immense potential to achieve SDG 12 by fostering sustainable consumption and production patterns. Through innovations in waste management, resource efficiency, and consumer behavior, AI can drive the transition toward a more sustainable and resilient future. As technology advances, AI's role in promoting sustainability will become increasingly crucial, making it an indispensable tool in the global effort to achieve SDGs.

SDG 13: Climate Action

SDG 13 aims to combat climate change and its impacts through urgent action. It addresses climate change and environmental degradation as equity issues that undermine the rights of every child, particularly the most disadvantaged

(UN, 2015). The potential of AI in data analysis, predictive modeling, and optimization can be utilized to reduce the impact of climate change, adjust to its consequences, and strengthen global resilience.

For Target 13.1, AI can assist in adjusting to the impacts of climate change by enhancing climate modeling and prediction (Jain et al., 2023). Machine learning algorithms can efficiently analyze large datasets obtained from satellites, sensors, and climate models to accurately forecast weather patterns, extreme weather occurrences, and long-term climate trends. These forecasts allow governments, corporations, and communities to anticipate better and address climate-related dangers. AI can significantly decrease greenhouse gas emissions by optimizing energy consumption, enhancing industrial procedures, and promoting renewable energy technology (Liu et al., 2022). AI systems have the capability to analyze patterns of energy consumption and pinpoint specific locations where gains in efficiency might be made. For example, in the field of transportation, AI can enhance the efficiency of routes and timetables for logistics and public transit, resulting in decreased fuel consumption and emissions. Moreover, AI can improve the effectiveness of renewable energy sources by forecasting energy production using weather conditions and appropriately making necessary operational adjustments.

For Target 13.2, policymakers can utilize AI to make well-informed decisions regarding climate action. AI has the capability to replicate the effects of many policy situations, aiding in the identification of the most efficient and enduring solutions. Through the examination of emissions statistics, economic variables, and social consequences, AI can assist in formulating policies that effectively reconcile environmental objectives with economic progress and social fairness (Danish & Senjyu, 2023). AI can also improve openness and accountability in climate action. AI-powered platforms have the capability to monitor and validate reductions in emissions, oversee adherence to international accords, and ensure efficient allocation and utilization of climate finance.

For Target 13.3, AI can significantly bolster efforts to combat climate change by enhancing education, strengthening human and institutional capabilities, and promoting knowledge regarding climate change mitigation, adaptation, and its impacts (Atkins et al., 2024). AI enhances the effectiveness of climate education by personalizing learning, offering free educational resources, and providing support to teachers (Andrzejewski & Dunal, 2021; Peters & Green, 2024). It develops impactful educational campaigns and interactive tools to facilitate comprehension of climate change. It simulates climate change, facilitates natural resource management, and optimizes energy utilization. AI utilizes real-

-time data analysis to forecast potential dangers and effectively organize disaster response efforts, thereby reducing the overall impact of such events. AI's capabilities make it a crucial component in worldwide endeavors to address climate change.

In conclusion, AI's sophisticated analytical and forecasting powers make it a formidable tool in combating climate change. AI may contribute to the achievement of SDG 13 by providing support for mitigation and adaptation activities, advancing climate research, informing policy choices, and encouraging sustainable habits. By incorporating AI into climate action, we can effectively tackle climate change's current consequences while promoting long-term resilience and sustainability (Ratten, 2024). This approach contributes to the creation of a more stable and healthy planet.

SDG 14: Life Bellow Water

SDG 14 focuses on conserving and sustainably using the oceans, seas, and marine resources, recognizing that healthy oceans and seas are essential to human existence and life on Earth (UN, 2015). AI presents various opportunities for improving marine conservation efforts and promoting sustainable practices.

AI enables early warning systems for environmental changesto identitfy and protect threatened species and monitor water quality, safeguarding marine ecosystem health (Er-rousse & Qafas, 2024). Organizations can utilize AI to optimize operations, make data-driven decisions, and implement sustainable practices aligned with broader SDGs (Sova et al., 2023). AI technologies also have the potential to enhance sustainability efforts in resource management and climate change mitigation, contributing to environmental conservation (Lohani, 2024).

In SDG 14 and 15, AI applications in wildlife, ocean, and land conservation present opportunities for improving conservation efforts and supporting sustainable use of marine resources (Isabelle & Westerlund, 2022). AI enables precise monitoring of soil moisture levels and crop water requirements, facilitating optimal irrigation scheduling and water conservation, which helps reduce agricultural runoff and nutrient leaching into water bodies, thus protecting marine ecosystems and supporting the targets of SDG 14 (Naman, 2024). Moreover, AI implementation can sustainably reduce marine ecosystem pollution, contributing to preserving marine environments (Fazri et al., 2023).

AI applications in monitoring coastal waters, oceans, aquaculture, and smart fishery plants have improved sustainability and resource management in marine environments (Glaviano et al., 2022). Integrating AI into fisheries management enables a systematic approach to ensure sustainable fisheries practices in alignment with SDG 14 (Ebrahimi et al., 2021). AI technologies, such as drones and sensors, offer transformative potential for sustainable agriculture by optimizing irrigation schedules to prevent over or underwatering, promoting sustainable food production, conserving water resources, and supporting the health of aquatic ecosystems in alignment with SDG 14 (Mathur et al., 2023).

For Target 14.1, AI can analyze satellite imagery to detect and track marine pollution, including oil spills, algal blooms, and large debris fields (Zare et al., 2024). AI can analyze ocean currents and wind patterns to predict the movement of marine debris, aiding in cleanup efforts and source identification (Chen et al., 2022). AI can integrate data from various sources to predict and provide early warnings for potential pollution events, allowing for rapid response (Cole et al., 2022).

Although the mark date for Target 14.2 was 2020, the sustainable management and protection of marine and coastal ecosystems is still a paramount ongoing pursuit. AI can analyze historical data and current conditions to predict coastal erosion patterns, informing coastal protection strategies (Samaei & Ghahfarrokhi, 2023). Machine learning can help quantify the economic value of ecosystem services provided by marine and coastal ecosystems, supporting conservation arguments (Monaco & Proust, 2014). Machine learning can analyze tourist data and environmental indicators to optimize visitor management in coastal areas, minimizing negative impacts.

For Target 14.3, AI can analyze biological and environmental data to predict how different marine species may respond to ocean acidification, helping to identify vulnerable populations (Dogan et al., 2024). AI can enhance models of global biogeochemical cycles, improving our understanding of how ocean acidification affects and is affected by these cycles (Scucchia et al., 2022). AI can analyze vast amounts of scientific literature to synthesize current knowledge on ocean acidification and identify emerging trends.

While the target date for achieving Target 14.4 was 2020, regulating harvesting, ending overfishing, and implementing science-based management plans remain fundamental. Machine learning can predict high-risk areas and times for illegal fishing, enabling more efficient allocation of patrol resources (Gladju et al., 2022). In addition, AI can analyze environmental data to forecast conditions that may lead to fish stock collapses, allowing for proactive management actions (Ebrahimi et al., 2021). Furthermore, AI can work in conjunction with blockchain technology to improve the traceability of fish from catch to consumer, aiding in the fight against illegal, unreported, and unregulated (IUU) fishing and ensuring sustainable sourcing (Sivarethinamohan et al., 2022). AI can also power automated systems for fishers to report their catch, reducing the compliance burden and improving data collection (Fujita et al., 2018; Tsolakis et al., 2023).

Even though the mark date for Target 14.5 was 2020, the conservation of coastal and marine areas remains an ongoing priority. AI can significantly contribute to these conservation efforts. AI can process and analyze diverse datasets to support integrated management of coastal zones, balancing conservation with sustainable development. AI can analyze environmental DNA (eDNA) data to detect the presence of invasive species early, allowing for rapid response (Zhang et al., 2023). Computer vision algorithms can automatically identify and count marine species from images and videos, supporting biodiversity assessments and population monitoring (Villon et al., 2022).

The target date for Target 14.6 was also 2020, but fisheries subsidies are still relevant. AI can help address this target in multiple ways. For example, AI can analyze complex trade agreements and model their potential impacts on fisheries and subsidies, which can support more informed negotiations (Mercurio & Yu, 2021). Additionally, AI can improve traceability systems by analyzing data from various sources, such as catch documentation, vessel tracking, and port records, to identify potential instances of illegal, unreported, and unregulated (IUU) fishing entering the supply chain (Probst, 2020). Furthermore, AI-enhanced acoustic monitoring systems can detect illegal activities like dynamite fishing (Cipparone, 2023; Fish, 2024).

For Target 14.7, AI has the potential to assist Small Island Developing States (SIDS) and Least Developed Countries (LDCs) in maximizing the economic benefits from their marine resources while ensuring long-term sustainability (Miloslavich et al., 2024; Raj & Pasfield-Neofitou, 2024). AI can improve weather and ocean condition forecasting, making fishing and tourism activities safer and more efficient (Mukhopadhyay & Gupta, 2024). Additionally, AI-enhanced virtual and augmented reality applications can offer immersive educational experiences about marine ecosystems and sustainable practices. Furthermore, AI can help optimize the placement and operation of marine renewable energy installations (such as offshore wind and tidal energy), supporting sustainable energy development in SIDS and LDCs (Succetti et al., 2023). Machine learning can also analyze global market trends for marine products, enabling SIDS and LDCs to identify and capitalize on new economic opportunities.

In conclusion, AI’s role in achieving SDG 14 is vital, as it optimizes marine conservation efforts, sustainable resource management, and environmental stewardship. By effectively leveraging AI technologies, stakeholders can work toward conserving and sustainably using oceans, seas, and marine resources for sustainable development by 2030.

SDG 15: Life on Land

SDG 15 aims to protect, restore, and promote the sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation, and halt biodiversity loss (Ametepey et al., 2024; UN, 2015). Achieving this goal is essential for maintaining the health of our planet's ecosystems, which are vital for the well-being of all life forms (Tuu & Khoi, 2024; Weber et al., 2023). AI has emerged as a transformative tool (Duong, 2024), which can significantly aid in achieving these objectives by offering innovative solutions for monitoring, managing, and conserving natural resources.

AI technologies, such as remote sensing and satellite imagery analysis, revolutionize how forests are monitored and managed (Giannakidou et al., 2024). AI algorithms can process vast amounts of satellite data to detect changes in forest cover, identify illegal logging activities, and monitor forest health. For Target 15.1, Global Forest Watch utilizes satellite imagery and machine learning algorithms to provide real-time data on forest changes. This platform helps governments, NGOs, and communities to take timely actions to prevent deforestation and promote sustainable forest management. AI models analyze satellite images from multiple sources (e.g., Landsat, Sentinel) to detect deforestation events. Deep learning techniques, such as convolutional neural networks (CNNs), identify patterns and changes in forest cover, providing accurate and timely alerts.

AI facilitates the integration of diverse datasets, including satellite imagery, field data, and environmental sensors, to provide a comprehensive view of ecosystem health (Dzhunushalieva & Teuber, 2024). This integrated approach supports better decision-making in conservation planning and management. For Target 15.2, Microsoft's AI for Earth initiative (https://planetarycomputer.microsoft.com) supports projects integrating AI and data science to improve environmental sustainability (Zechiel et al., 2024). One project uses AI to combine satellite data with on-the-ground observations to map and monitor forest health, guiding reforestation efforts. AI systems employ data fusion techniques to integrate various data sources, enhancing the accuracy and comprehensiveness of environmental monitoring. Advanced algorithms can analyze multispectral and hyper-spectral imagery to assess vegetation health and predict areas suitable for reforestation.

In addition to forest management, AI plays a crucial role in combating desertification and land degradation through predictive modeling and early warning systems (Jaung, 2024). These systems analyze climatic data, soil conditions, and vegetation patterns to predict areas at risk of desertification, allowing for proactive measures to be taken (Thi Hang et al., 2024). For Target 15.3, the UNCCD's Land Degradation Neutrality (LDN) project employs AI to analyze satellite imagery and other data sources to monitor land degradation and guide restoration efforts. AI models integrate data from satellite images, climate models, and ground sensors to predict soil erosion, vegetation loss, and other land degradation indicators. Machine learning algorithms, such as random forests and support vector machines (SVMs), classify and predict degradation risks, enabling targeted interventions.

AI technologies contribute significantly to biodiversity conservation through species monitoring, habitat mapping, and threat detection (Parris-Piper et al., 2023). Machine learning models can identify species from camera trap images, audio recordings, and even DNA samples, helping track species populations, detect poaching activities, and identify critical habitats for conservation. For Target 15.5, the Wildlife Insights platform uses AI to analyze camera trap images, identifying species and their behaviors. This platform helps conservationists monitor biodiversity and make informed decisions to protect endangered species. Deep learning models, particularly CNNs, are trained on vast wildlife image datasets to identify species accurately. These models can process images in real-time, allowing for continuous monitoring of wildlife populations and detecting poaching activities.

AI is instrumental in implementing equitable sharing of benefits from genetic resources (Chua et al., 2024; Elsayed et al., 2024). For Target 15.6, AI can manage and analyze large datasets of gene information, facilitating fair sharing of benefits from utilizing genetic resources. AI tools can help trace the origin of genetic materials, ensuring compliance with international agreements such as the Nagoya Protocol. These tools can also streamline the management of databases that store genetic information, making it easier for stakeholders to access and share benefits equitably.

AI can be deployed to address illegal wildlife trade and enhance monitoring and enforcement efforts (Konya & Nematzadeh, 2024; Whitehead et al., 2021). For Target 15.7, AI-powered surveillance systems, including drones and camera traps, can detect poaching activities in real time. AI algorithms analyze images and patterns to identify suspicious activities and alert authorities. This technology significantly enhances the capability to combat illegal trade by providing timely and actionable intelligence. Additionally, AI can track and analyze data from various sources, identifying trafficking networks and predicting poaching hotspots.

In combating invasive alien species, AI offers predictive modeling and monitoring capabilities (Santoro et al., 2022). For Target 15.8, AI can predict the spread of invasive species by analyzing environmental data and species characteristics. Machine learning models can identify potential invasive species and forecast their impact on native ecosystems. AI can also be used in early detection systems to identify invasive species from eDNA samples, facilitating rapid response measures to prevent their establishment and spread.

AI provides valuable insights through data analysis and visualization to integrate ecosystem and biodiversity values into national and local planning (Giannakidou et al., 2024). For Target 15.9, AI can analyze extensive environmental data to evaluate ecosystem services and biodiversity benefits. These insights can inform policy decisions and land-use planning, ensuring that ecosystem and biodiversity values are incorporated into development plans. AI-driven decision support systems can simulate various scenarios, helping policymakers understand the long-term impacts of their decisions on ecosystems and biodiversity.

Precision conservation leverages AI to optimize conservation efforts by targeting areas requiring intervention (Buchelt et al., 2024). This approach maximizes the impact of conservation activities and ensures the efficient use of resources. For example, drones with AI-powered sensors can monitor and map critical habitats. AI algorithms analyze the collected data to identify areas needing restoration or protection, allowing for targeted conservation actions. Drones equipped with AI capabilities use computer vision algorithms to analyze high-resolution images of ecosystems. These algorithms can detect signs of habitat degradation, invasive species, and other environmental threats, enabling targeted conservation interventions.

Involving local communities in conservation efforts is crucial for success. AI tools can empower communities by providing accessible and actionable information about their local ecosystems (Giannakidou et al., 2024). The eBird platform (https://ebird.org), which uses AI to analyze bird sightings reported by citizen scientists, is an excellent example (Randler, 2021). These data help track bird populations and identify essential habitats, engaging communities in biodiversity conservation. The eBird platform uses machine learning algorithms to analyze large volumes of bird sighting data. Natural language processing (NLP) techniques interpret user-submitted observations, while clustering algorithms help identify significant trends in bird populations.

AI-generated insights can inform policy decisions by providing evidence-based recommendations for sustainable land and forest management practices (Buchelt et al., 2024; Giannakidou et al., 2024; Thi Hang et al., 2024). AI-driven models that simulate the impact of different land use policies on biodiversity and ecosystem services help policymakers understand the long-term effects of their decisions and promote sustainable practices. These models use simulation techniques to predict the outcomes of various land use scenarios, integrating ecological, economic, and social data to provide a holistic view of the potential impacts, helping policymakers make informed decisions.

Thus, AI offers powerful tools to support the achievement of SDG 15 by enhancing our ability to monitor, manage, and conserve terrestrial ecosystems. Through innovative applications in forest monitoring, combating land degradation, halting biodiversity loss, equitable sharing of genetic resources, addressing illegal wildlife trade, tackling invasive species, and integrating ecosystem values into planning, AI enables more effective and efficient actions to protect our planet's natural resources. Embracing AI technologies while ensuring ethical considerations and community involvement can significantly contribute to the sustainable use of terrestrial ecosystems and the overall success of SDG 15.

SDG 16: Peace, Justice, and Strong Institutions

SDG 16 aims to promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable, and inclusive institutions at all levels (Milton & Alhamawi, 2024; UN, 2015). Achieving this goal is fundamental to fostering stable, just, and inclusive societies. AI has the potential to significantly contribute to this goal by enhancing transparency, accountability, and inclusivity in governance, improving access to justice, and promoting peace and security (Nahar, 2024).

AI can enhance transparency and accountability in institutions by providing tools for monitoring and analyzing large volumes of data (Memarian & Doleck, 2023). For example, AI-powered analytics can process data from government transactions, budgets, and public records to detect patterns of corruption or misuse of funds. By automating the detection of irregularities, AI can help uncover corruption and ensure that public resources are used effectively and ethically (Cameron & Hamidzadeh, 2024). For Target 16.1, which aims to significantly reduce all forms of violence and related death rates everywhere, predictive policing systems use AI to analyze crime data and predict potential hotspots of violence. Cities like Los Angeles have implemented predictive policing tools to allocate police resources more effectively, contributing to safer communities.

In the realm of justice, AI can play a crucial role in providing access to legal information and services (Zhao, 2024). AI-driven legal assistants and chatbots can offer legal advice and information to individuals who might not have easy access to legal services, helping to bridge the gap in access to justice (Robinson, 2020). For instance, AI-based platforms like DoNotPay (https://donotpay.com) use natural language processing to help users understand their legal rights, draft legal documents, and navigate complex legal procedures (Ho et al., 2024). This democratizes access to legal assistance, making it more inclusive and accessible, particularly for marginalized and underserved populations. By improving access to legal services, AI-driven solutions are vital to achieving Target 16.3.

AI can also support the efficiency and effectiveness of the judicial system by automating routine tasks, thus speeding up legal processes (Almuzaini & Azmi, 2023). Machine learning algorithms can review legal documents, identify relevant case precedents, and predict case outcomes based on historical data. These capabilities help reduce the backlog of cases and ensure timely justice. AI tools like ROSS Intelligence (https://www.rossintelligence.com) support lawyers by analyzing vast amounts of legal texts and providing precise and relevant information, strengthening case outcomes. This further supports Target 16.3 by enhancing the efficiency of justice systems.

Promoting peaceful societies involves addressing crime and violence, and AI can be a powerful tool in crime prevention and law enforcement (Chatterjee, 2024). Predictive policing uses AI to analyze crime data and predict future crime hotspots, enabling law enforcement agencies to deploy resources more effectively and proactively to prevent crime. However, it is essential to implement these technologies with careful consideration of ethical and privacy concerns to avoid potential biases and ensure the protection of civil liberties. For Target 16.1, AI's role in predictive policing reduces violence and ensures public safety.

AI also significantly promotes inclusivity by analyzing social data to identify and address societal issues (Xu et al., 2024). For example, AI can analyze social media and survey data to understand public sentiment and identify instances of hate speech, discrimination, or social unrest. Governments and organizations can then use these insights to take proactive measures to foster social cohesion and address grievances. Projects like the Hatebase initiative use AI to monitor and analyze hate speech online, providing valuable data for policymakers and social organizations to combat hate speech and promote inclusive societies. This supports Target 16.2, which aims to end abuse, exploitation, trafficking, and all forms of violence against and torture of children.

To ensure that institutions are effective and accountable, AI can be used to improve the delivery of public services (Hjaltalin & Sigurdarson, 2024). By analyzing data from various public services, AI can identify inefficiencies and areas for improvement, ensuring that services are delivered effectively and meet the needs of all citizens. For example, AI can optimize healthcare delivery by predicting patient needs and allocating resources accordingly, or it can improve education by identifying gaps in learning and providing personalized support to students. Governments can use AI-driven insights to enhance public service delivery, ensuring that institutions are responsive and accountable to the needs of their citizens. This is relevant to Target 16.6, which aims to develop effective, responsible, and transparent institutions at all levels.

AI technologies can also facilitate citizen engagement and participation in governance (Chen et al., 2021). Digital platforms powered by AI can analyze public feedback, conduct sentiment analysis, and provide real-time insights into public opinion. This enables governments to make informed decisions that reflect the will and needs of the people, fostering more inclusive and participatory governance. Tools like Pol.is (https://pol.is) use AI to analyze and visualize public opinions, helping policymakers understand diverse perspectives and make more inclusive decisions. This supports Target 16.7, which aims to ensure responsive, inclusive, participatory, and representative decision-making at all levels.

Moreover, AI can support conflict resolution and peacebuilding efforts by analyzing data from conflict zones and providing early warning of potential conflicts (Hsu & Chaudhary, 2023). AI systems can process data from various sources, including social media, news reports, and satellite imagery, to identify signs of escalating tensions and provide actionable insights for intervention. For example, the United Nations uses AI to analyze data from multiple sources to monitor conflicts and predict potential outbreaks, enabling timely and effective peacebuilding interventions. This contributes to Target 16.1, aimed at reducing all forms of violence. In combating corruption and bribery, AI can analyze transaction data and public records to identify patterns that indicate corrupt activities. Machine learning algorithms can detect anomalies and flag suspicious transactions, enabling authorities to investigate and act against corruption. For Target 16.5, which aims to reduce corruption and bribery in all its forms substantially, AI's capability to analyze large datasets and identify irregularities is invaluable.

AI can also help ensure public access to information and protect fundamental freedoms. For Target 16.10, which aims to ensure public access to information and protect fundamental freedoms, AI can analyze data from various sources to identify censorship and provide alternative ways to access information. AI-driven platforms can aggregate and disseminate information from multiple sources, ensuring citizens can access accurate and timely information. Therefore, AI offers powerful tools to support the achievement of SDG 16 by enhancing transparency, accountability, and inclusivity in governance, improving access to justice, promoting peace and security, and facilitating citizen engagement. By leveraging AI technologies ethically and responsibly, we can build more peaceful, just, and inclusive societies. AI's potential to analyze vast amounts of data, provide actionable insights, and automate routine tasks makes it an invaluable asset in pursuing sustainable development and realizing SDG 16.

SDG 17: Partnerships for the Goals

SDG 17 emphasizes the importance of partnerships in achieving the 2030 Agenda for Sustainable Development (UN, 2015). It aims to strengthen global partnerships to support and achieve the ambitious targets of SDGs, bringing together governments, the private sector, civil society, and other actors to mobilize all available resources. With its rapid advancements and transformative potential, AI plays a crucial role in enhancing these partnerships in the international context too (Palomares et al., 2021; Rane, 2023; Sacks et al., 2020; Vinuesa et al., 2020).

One of the primary ways AI influences SDG 17 is through its capacity to handle large volumes of data, which improves decision-making processes and facilitates the coordination of efforts across diverse stakeholders. AI-powered tools can collect, analyze, and interpret complex datasets more efficiently than traditional methods, giving the chance to fulfill Target 17.1, focusing on the improvement of domestic capacity for tax and other revenue collection, and Target 17.2 to implement fully their official development assistance commitments (ODA/GNI). AI can enhance tax collection systems and predict revenue streams to strengthen domestic resource mobilization (Target 17.1), analyze donor behavior, and optimize aid distribution to ensure timely and effective official development assistance (Target 17.2) (Nahar, 2024).

Additionally, through robust coordination and advanced data analytics, AI can achieve unparalleled efficiency and effectiveness in data processing and rapid decision-making, boosting additional surpluses to fulfill Target 17.3, focusing on the mobilization of additional financial resources for developing countries from multiple sources.

By providing accurate and timely data, AI enables stakeholders to develop targeted interventions and measure their effectiveness, fostering transparency and accountability as core principles (Brynjolfsson & McAfee, 2014). It can lead to the fulfillment of Target 17.4 by assisting in the management and reduction of debt by analyzing economic indicators and forecasting repayment capacities.

AI can facilitate effective partnerships by enhancing communication and coordination among stakeholders. Machine learning algorithms can identify potential partners based on their expertise, resources, and past performance. This can help adopt and implement investment promotion regimes for least developed countries (Target 17.5) and enhance knowledge sharing on mutually agreed-upon terms, through improved coordination among existing mechanisms and a global technology facilitation mechanism (Target 17.6).

The potential of algorithms and cloud technologies can boost the implementation of AI-driven project management tools to help international development organizations coordinate complex projects across multiple countries, ensuring that resources are used efficiently. Goals are met on time (Chui et al., 2016). Moreover, AI can democratize access to information, empowering marginalized communities to participate in decision-making processes. NLP technologies can translate documents and conversations in real time, breaking down language barriers and fostering inclusive dialogue (Floridi & Cowls, 2019). Such potential can be extensively utilized for disseminating and diffusing environmentally sound technologies to developing countries on favorable terms, including concessional and preferential terms (Target 17.7). It can help donor agencies identify the most impactful projects and ensure that aid reaches those who need it most (Vinuesa et al., 2020).

Transparency and open access to the same information, based on the same technology, eliminating the barriers of entry and externalities can lead to the operationalization of the technology bank and science and innovation capacity-building mechanism for least developed countries and enhance the use of enabling technology, in particular information and communications technologies (Targets 17.8 and 17.9).

Proper dissemination of knowledge, standards, and rules is one of the most fundamental areas, expressed – among other things – in several targets of SDG 17, e.g., promoting a universal, rules-based, open, non-discriminatory, and equitable multilateral trading system (Target 17.10) or encouraging and promoting effective public, public-private and civil society partnerships, building on the experience and resourcing strategies of partnerships (Target 17.17). In that context, AI can streamline trade regulations and procedures, making global trade more accessible and efficient.

AI can potentially revolutionize resource allocation, a critical aspect of SDG 17 (Leal Filho et al., 2024). Through predictive analytics and optimization algorithms, AI can identify the most effective ways to deploy financial, human, and technological resources. For instance, AI can analyze trends and predict future needs, enabling governments and organizations to allocate funds strategically and avoid wastage (Vinuesa et al., 2020). Such potential can be easily used for the execution of Target 17.11 by providing market analysis and export potential assessments for the increase of exports of developing countries, Target 17.12 by assisting in the timely and effective implementation of duty-free and quota-free market access for least developed countries or Target 17.13 by predicting economic trends and identifying risks to enhance global macroeconomic stability.

AI's ability to process and analyze vast amounts of data can also support policy development, another key aspect of SDG 17, Targets 14, 15, and 16 (Sætra, 2021). Policymakers can leverage AI to simulate the potential impacts of different policy options, identify the most effective strategies, and monitor their implementation. For example, AI models can predict various development policies' economic, social, and environmental outcomes helping governments make informed decisions (Jobin et al., 2019).

Moreover, AI can enhance the capacity of institutions to enforce policies and regulations. Machine learning algorithms can detect anomalies and patterns indicative of non-compliance, enabling authorities to take timely action. This capability is essential for addressing corruption, tax evasion, and environmental violations, which can undermine sustainable development efforts (Jobin et al., 2019). It can also be very beneficial in retrieving high-quality, timely, and reliable data disaggregated by income, gender, age, race, ethnicity, migratory status, disability, geographic location, and other characteristics relevant to national contexts (Target 17.18).

AI has the potential to significantly enhance the achievement of SDG 17 by improving data collection and analysis, facilitating effective partnerships, optimizing resource allocation, and supporting policy development. It can optimally fulfill the ultimate target of SDG 17 – the measurements of progress on sustainable development that complement the gross domestic product. AI can support the development of measures of progress on sustainable development that complement GDP by providing advanced data analytics and innovative metrics (Target 17.19).

Despite its potential benefits, integrating AI into SDG 17 initiatives is not without challenges. There are concerns regarding data privacy, security, and the ethical implications of AI decision-making (Goh & Vinuesa, 2021; Holzinger et al., 2021; Palomares et al., 2021). Ensuring that AI technologies are transparent, accountable, and free from bias is crucial for maintaining trust and legitimacy in global partnerships (Floridi & Cowls, 2019). Moreover, there is a need for capacity building in developing countries to ensure they can fully harness the benefits of AI (Vinuesa et al., 2020).

AI has the potential to significantly enhance the achievement of SDG 17 by improving data collection and analysis, facilitating effective partnerships, optimizing resource allocation, and supporting policy development. However, addressing the associated challenges and ethical considerations is essential to ensure that AI-driven solutions are inclusive, transparent, and equitable. By leveraging AI responsibly, stakeholders can foster stronger global partnerships and accelerate progress toward SDG 17.

4. Discussion

Our review of relevant evidence indicates that AI can drive progress in 119 targets (70%) across all SDGs, similar to the study of Vinuesa et al. (2020). To provide an overview of the general roles of AI in achieving SDGs, we employed the approach of Vinuesa et al. (2020) to categorize all SDGs according to the three pillars of sustainable development: societal, economic, and environmental sustainability (Ziemba & Grabara, 2024). Societal sustainability includes SDGs 1, 2, 3, 4, 5, 6, 7, 11, and 16, economic sustainability – SDGs 8, 9, 10, 12, and 17, whereas environmental sustainability – SDGs 13, 14, and 15.

AI plays a pivotal role in achieving societal sustainability. Its applications span across multiple domains, addressing health, education, gender equality, and institutional effectiveness, thereby fostering inclusive and equitable societies. This framework proposed in Table 1 outlines the primary roles AI can play in promoting societal sustainability and achieving related SDGs and can serve as a comprehensive guide for leveraging AI to achieve SDGs and societal sustainability. Integrating AI into these domains can significantly enhance societal sustainability, promoting health, education, gender equality, clean water, affordable energy, sustainable cities, and strong institutions.

Table 1. The role of AI in achieving SDGs related to societal sustainability

SDG/AI Role	AI role description	Best practices for using AI
1	*2*	*3*
SDG 1: No Poverty		
Poverty identification and intervention	AI uses large datasets, including satellite images and geographic information system data, to quantify poverty and pinpoint deprived areas, allowing tailored interventions to be customized.	AI-Powered Poverty Mapping by World Bank; TARU Leading Edge Project in India
Policy evaluation	AI helps evaluate the efficacy of policies intended to reduce poverty, essential for accomplishing of these initiatives.	OECD’s AI for Policy Monitoring AI Agents to Simulate Social Scenarios by MIT

Table 1 cont.

1	*2*	*3*
Resource allocation	AI optimizes the distribution of vital resources to underserved communities, improving access to economic resources and increasing the resilience of economically disadvantaged populations.	UNICEF's Magic Box Initiative; AI in Food Distribution by the World Food Programme (WFP)
Economic resilience and anti-poverty activities	AI increases the resilience of economically disadvantaged populations by better predicting and responding to environmental or economic disasters.	AI-Driven Disaster Response by One Concern; Grameen Foundation's AI-Powered Financial Inclusion
SDG 2: Zero Hunger		
Precision agriculture	AI enhances agricultural productivity through precision farming techniques, improving crop yields while minimizing environmental impacts.	Ag Assistant by Taranis scouting all crop conditions and threats; FarmLogs to analyze soil conditions and crop health
Food supply chain optimization	AI streamlines food supply chains and reduces waste, significantly increasing the availability of wholesome food.	Eden by Walmart to scan and monitor the freshness of fruits and vegetables from farm to store; Predictive Logistics by CleraMeta to optimize the movement of food through supply chains
Local market dynamics	AI provides producers with insights into demand patterns, enabling better alignment of production and consumption.	Zebra Technologies' SmartLens to monitor consumer behavior and inventory levels in local markets; AgriMarket Advisor to analyze local market trends, consumer preferences, and demand forecasts
Climate resilience	AI supports sustainable agriculture by integrating traditional farming practices with advanced technologies like sensors, GPS, and GIS.	Microsoft's AI for Earth model to predict climate impacts on agriculture; Climate AI to forecast climate risks at the local level
SDG 3: Health and Well-being		
Disease diagnosis and monitoring	AI assists in diagnosing and monitoring diseases, optimizing medication dosages, and developing new treatments. AI technologies, such as predictive modeling, can forecast health risks and support real-time patient monitoring.	AI tools for medical image interpretation and diagnosing by Aidoc and Zebra Medical Vision
Mental health support	AI is evolving in early disorder prediction, diagnosis, and treatment in mental health care despite the data being more subjective and qualitative.	Woebot and Tess by X2AI apps for mental health support
Disease surveillance	AI aids in diagnosing and controlling epidemics of communicable diseases, contributing to improved global health security.	AI-powered tool for tracking the spread of infectious diseases by BlueDot and EPIWATCH
Healthcare management	AI improves efficiency in healthcare service management and administration, freeing up significant time for physicians and nurses to spend with patients.	AI-powered platform aiding scheduling and resource allocation by Qventus
Employee well-being	AI tools can promote employee well-being by managing stress and work-life balance.	AI-based stress management tools Welltory and Breath work-life balance management app Reclaim.ai

Table 1 cont.

1	*2*	*3*
SDG 4: Quality Education		
Personalized learning	AI-powered systems adjust to individual student needs and learning styles, providing customized learning pathways and real-time feedback.	AI-powered language learning by Duolingo Adaptive Learning Solutions by Khan Academy
Accessibility and inclusivity	AI-driven tools convert text to speech, provide real-time captioning, and translate content, making education accessible to students with disabilities and those in developing countries.	AI-driven educational accessibility by Microsoft
Bridging educational gaps	AI-driven online platforms deliver interactive educational content, reaching remote and underserved areas.	AI-driven educational access by Squirrel AI
Teacher support	AI reduces teacher administrative tasks, providing insights into student performance and offering personalized professional development resources.	AI-driven administrative support by Edmodo
SDG 5: Gender Equality		
Bias detection and reduction	AI tools identify and mitigate gender biases in systems, promoting fairer talent acquisition and management.	Pymetrics AI-driven recruitment platform for candidate assessment
Violence prevention	AI-based applications protect women against violence, such as chatbots providing support for victims of gender-based violence.	AI-supported app Safetipin for assessing area safety; AI solution Traffic Jam for supporting victims of violence
Unpaid work	AI-based automation can significantly reduce women's time spend on unpaid care and domestic work.	AI-powered robotic vacuum cleaners by iRobot; Tody, an AI to-do list for organizing and distributing household chores; **TaskRabbit** that connects users with freelancers for household tasks
Economic empowerment:	AI supports women in managing unpaid care responsibilities and provides tailored investment platforms to close the gender investing gap.	AI-driven platform Care.com for finding and managing baby and elderly care; Ellevest financial platform designed to aid women with investment
SDG 6: Clean Water and Sanitation		
Water management	AI optimizes irrigation, balances water production with environmental flows, and improves water demand management.	OpenET by The Nature Conservancy in California to balance water needs for agriculture and wildlife in the Sacramento-San Joaquin Delta
Real-time monitoring	AI-powered sensors and algorithms monitor water quality in real time, detecting contaminants and potential health hazards quickly.	SWAN (Smart Water Assessment Network) by the National Water Agency in Singapore for real-time monitoring of water quality and contaminant detection in reservoirs
Resource allocation	AI analyzes demographic and geographic data to identify underserved areas and optimize resource allocation for water infrastructure development.	Spatial Agent by the World Bank is used to identify areas in developing countries that lack access to clean water and sanitation

Table 1 cont.

1	*2*	*3*
Sanitation safety	AI enhances sanitation systems and wastewater reuse, ensuring safe and sustainable sanitation practices.	ONAS m-Takkal in Dakar, Senegal, for optimizing the management of fecal sludge from septic tanks
Ecosystem restoration	AI enhances monitoring capabilities and supports informed decision-making for protecting and restoring water-related ecosystems.	Geospatial Web Applications CIC by the Chesapeake Conservancy for guiding targeted conservation and restoration efforts in the region
SDG 7: Affordable and Clean Energy		
Energy production and distribution	AI analyzes data from renewable energy sources, optimizing efficiency and reliability, while AI-powered smart grids effectively manage nergy supply and demand.	AVEVA PI System; Ecolys for renewable gas treatment
Building energy efficiency	AI enhances energy efficiency in buildings through smart management systems, reducing energy consumption while maintaining comfort.	Nexo Energy
Energy policy support	AI simulates energy scenarios to inform policy decisions, promoting the adoption of renewable energy and enhancing energy efficiency.	OECD's AI for Policy Monitoring; iNEX Sourcing
SDG 11: Sustainable Cities and Communities		
Urban planning	AI improves participatory planning through data analysis, predicting outcomes, and facilitating shareholder communication.	Sidewalk Labs by Delve to create "millions of design possibilities"
Smart infrastructure management	AI manages urban water networks, energy systems, and transportation infrastructure, promoting sustainability and resilience.	A*STAR tool for optimizing land, sea, and air transport by Singapore's Agency for Science, Technology and Research; Siemens Building X for future-proof building
Disaster risk management	AI supports emergency response and disaster management, minimizing casualties and infrastructure damage.	Google's AI for tracking earth-quake
SDG 16: Promoting Peace, Justice, and Strong Institutions		
Transparency and accountability	AI monitors and analyzes data to detect corruption and ensure effective use of public resources.	AI-powered Public Resource Monitoring by Transparency International; AI in Anti-Corruption Analysis by IBM Watson
Access to justice	AI-driven legal assistants provide legal advice, improving access to justice for underserved populations.	DoNotPay AI Legal Assistant; AI-powered legal support by ROSS Intelligence
Conflict resolution	AI analyzes data from conflict zones, providing early warnings and supporting peacebuilding efforts.	AI-driven Early Warning Systems by UN Global Pulse; PeaceTech Lab's AI for Conflict Prevention
Public service delivery	AI optimizes healthcare, education, and other public services, ensuring they are effective and responsive to citizens' needs.	AI in Public Sector Management by Accenture; AI-powered Healthcare Solutions by Babylon Health

AI is poised to significantly impact economic sustainability by driving innovation, optimizing resource allocation, enhancing productivity, and fostering inclusive growth. The framework in Table 2 outlines AI's role in promoting economic sustainability through various dimensions aligned with SDGs. By leveraging AI across these domains, we can foster sustainable economic systems, promote inclusive growth, and enhance global cooperation toward achieving SDGs. This framework serves as a roadmap for integrating AI into strategies for economic sustainability.

Table 2. The role of AI in achieving SDGs related to economic sustainability

SDG/AI Role	AI role description	Best practices for using AI
1	*2*	*3*
SDG 8: Decent Work and Economic Growth		
Economic growth	AI can enhance manufacturing processes through predictive maintenance and improved supply chain management, leading to substantial productivity gains and reduced operational costs.	AI-Powered Predictive Maintenance by General Electric (GE); Supply Chain Optimization by IBM Watson
Job creation and enterprise growth	AI-driven platforms facilitate market access and competitiveness for small and medium-sized enterprises (SMEs), enabling job creation and enterprise growth.	AI for SME Market Access by Alibaba; AI-driven Business Solutions by Salesforce
Labor market policies	AI helps policymakers design effective labor market policies by providing insights into workforce trends and skill requirements.	AI for Workforce Analytics by LinkedIn; Policy Analysis with AI by OECD
Equal employment opportunities:	AI identifies labor market disparities and supports policies promoting pay equity and decent work with equal pay.	AI for Pay Equity Analysis by PayScale; Diversity and Inclusion Analytics by IBM Watson
SDG 9: Industry, Innovation, and Infrastructure		
Resilient infrastructure	AI predicts and diagnoses potential failures in infrastructure systems, ensuring robust and operational infrastructure through predictive maintenance.	AI-assisted maintenance by Tractian
Sustainable industrialization	AI-driven automation and smart manufacturing processes improve efficiency and reduce waste, promoting sustainable industrial practices.	AI-driven automation and smart manufacturing processes by Siemens
Access to financial services	AI enhances financial inclusion by providing affordable credit and financial services, especially for small-scale industrial enterprises.	AI-enhanced credit access by TransUnion
Technological innovation	AI accelerates research and development by analyzing large datasets to identify patterns and generate insights, driving technological advancements and new product development.	AI-driven R&D innovation by IBM

Table 2 cont.

1	*2*	*3*
SDG 10: Reduced Inequalities		
Educational and employment opportunities	AI bridges educational gaps and enhances employment prospects by providing personalized learning and career guidance, especially for disadvantaged groups.	Personalized Learning Platforms by Khan Academy; AI Career Counselling by IBM Watson
Financial inclusion	AI-driven Fintech solutions provide accessible banking and financial services, enhancing economic participation and reducing income inequalities.	AI in Microfinance by Kiva; Mobile Banking Solutions by M-Pesa
Anti-discrimination measures	AI detects discriminatory practices by analyzing large datasets, promoting fair recruitment, and reducing biases in hiring.	AI Bias Detection Tools by Microsoft; Ethical AI in Recruitment by Pymetrics
Policy design	AI provides data-driven insights into the effectiveness of fiscal and social policies, helping to design policies that promote equality.	AI for Policy Impact Analysis by OECD; AI-driven Social Policy Design by MIT
SDG 12: Responsible Consumption and Production		
Sustainable consumer behavior	AI influences consumer behavior toward sustainable practices through personalized recommendations and predictive analytics.	Alipay Ant Forest; Oroeco Sustainability Ratings Platform
Resource efficiency	AI optimizes production processes, reducing waste and enhancing the efficiency of material and energy use in manufacturing.	Pay-as-you-throw (PAYT) systems
Waste management	AI-powered smart sorting systems and predictive analytics improve waste management and recycling processes, promoting a circular economy.	Bin-e: Smart Waste Bin
Sustainable production	AI optimizes manufacturing processes, reducing material waste and energy consumption, and enhancing supply chain transparency and efficiency.	Presenso's cloud-based AI solution for predictive maintenance by Gartner
SDG 17: Partnerships for the Goals		
Enhanced collaboration	AI improves data collection and analysis, facilitating coordination and communication among stakeholders.	The UN Global Pulse initiative; Microsoft's AI for Humanitarian Action
Optimizing resource allocation	AI uses predictive analytics to identify the most effective ways to deploy financial, human, and technological resources.	UNICEF – AI for Vaccine Distribution; World Food Programme (WFP) – AI for Food Aid Allocation; Google AI and UN Environment Program (UNEP) – Water Resource Management
Policy support and development	AI helps policymakers design and implement effective policies by simulating potential impacts and monitoring implementation.	OECD AI Policy Observatory; United Nations Global Pulse – AI for Policy Recommendations; AI for Gender Equality – UN Women and Data2X
Inclusive decision-making:	AI-driven platforms enable broader participation in decision-making processes by providing accessible information and fostering inclusive dialogue.	AI-Powered Citizen Participation Platforms – Decidim; UN Global Pulse – AI for Public Sentiment Analysis; AI for Inclusive Urban Planning – MIT Media Lab

AI has emerged as a transformative tool in advancing environmental sustainability by enhancing our ability to monitor, manage, and conserve natural resources. The framework preened in Table 3 outlines the potential of AI in promoting environmental sustainability, focusing on its applications in climate action, marine conservation, and terrestrial ecosystem management, aligned with SDGs. By leveraging AI across these domains, we can enhance our ability to address environmental challenges, promote sustainable practices, and ensure the long-term health of our planet. This framework serves as a roadmap for integrating AI into strategies for environmental sustainability.

Table 3. The role of AI in achieving SDGs related to environmental sustainability

SDG/AI Role	AI role description	Best practices for using AI
1	*2*	*3*
SDG 13: Climate Action		
Climate modeling and prediction	AI can analyze large datasets from satellites, sensors, and climate models to forecast weather patterns and extreme weather events, enabling better preparedness and response to climate-related hazards.	SteadyEye, SteadyMet, and SteadySat by SteadySun; FrogCast; Expektra Predict
Emissions reduction	AI optimizes energy consumption and industrial processes to reduce greenhouse gas emissions while enhancing the efficiency of renewable energy sources by forecasting energy production based on weather conditions.	CorPower Wave Energy Converter (C4 WEC); Deep Green by Minesto
Informed policy decisions	AI simulates the impact of various policy scenarios to help policymakers identify effective climate action strategies. It also monitors and verifies emissions reductions to ensure compliance with international agreements.	OECD's AI for Policy Monitoring
Climate education and awareness	AI personalizes climate education, providing resources and tools to enhance public understanding and engagement in climate action.	Forcepoint DSPM AI Mesh; Coursera – DeepLearning.AL
SDG 14: Life Below Water		
Marine pollution monitoring	AI analyzes satellite imagery to detect and track pollution events like oil spills and algal blooms and predicts the movement of marine debris to aid in cleanup efforts.	MARIDA (MARine lItter Detection Algorithm) by the European Space Agency to identify marine litter accumulation areas and guide cleanup efforts
Sustainable fisheries	AI supports sustainable fishing practices by monitoring fish populations and optimizing fishing efforts.	Global Fishing Watch by Google, Oceana, and SkyTruth to monitor global fishing activities and combat illegal fishing
Ocean health monitoring	AI analyzes oceanographic data to monitor the health of marine ecosystems and predict environmental changes.	Allen Coral Atlas to map and monitor the world's coral reefs
Plastic waste management	AI identifies and tracks plastic waste in oceans, supporting cleanup and prevention initiatives.	Ocean Cleanup for efficient detection and collection of plastic waste in the ocean

Table 3 cont.

1	*2*	*3*
SDG 15: Life on Land		
Forest monitoring and management	AI processes satellite imagery to detect deforestation and illegal logging, monitor forest health, and support reforestation efforts by providing accurate and timely data.	Global Forest Watch by WRI; AI-Powered Forest Monitoring by Microsoft AI for Earth
Combating desertification and land degradation	AI predicts areas at risk of desertification by analyzing climatic data and vegetation patterns, guiding proactive measures to prevent land degradation.	Land Degradation Neutrality (LDN) Project by UNCCD; AI in Soil Degradation Monitoring by Descartes Labs
Biodiversity onservation	AI monitors species populations and habitats through camera traps, audio recordings, and DNA analysis. It also detects poaching activities and identifies critical habitats for conservation.	Wildlife Insights Platform; Conservation AI Hub
Invasive species management	AI predicts the spread of invasive species and identifies them early through environmental DNA samples, supporting rapid response measures to prevent their establishment and spread.	AI-Powered eDNA Monitoring by NatureMetrics; Invasive Species Management by Google Earth Engine
Policy and planning	AI integrates ecosystem and biodiversity values into national and local planning by providing insights through data analysis and visualization. It supports sustainable land and forest management practices with evidence-based recommendations.	AI for Earth by Microsoft; Nature-Serve's AI-Driven Biodiversity Insights

AI holds significant promise in advancing SDGs by providing innovative solutions to some of the world's most pressing challenges. However, realizing this potential requires a concerted effort to adopt best practices, foster collaboration, and ensure ethical AI development. To systematically integrate AI in achieving SDGs, the following steps can be recommended:

1. **Policy and governance**: Establishing robust policies and regulatory frameworks that promote ethical AI use, protect data privacy, and ensure equitable access to AI technologies.
2. **Infrastructure and accessibility**: Developing the necessary infrastructure, such as high-speed internet and data centers, to support AI deployment, particularly in underserved regions.
3. **Education and training**: Investing in education and training programs to build AI literacy among educators, workers, and policymakers, ensuring a skilled workforce capable of leveraging AI for sustainable development.
4. **Collaboration and innovation**: Fostering collaboration between governments, the private sector, academia, and civil society to drive AI innovation and share best practices for sustainable development.

5. **Data collection and integration**: Gathering comprehensive datasets from multiple sources (e.g., medical records, educational databases, financial transactions, environmental sensors, IoT devices) and integrating cross-sectoral data to provide a holistic view of progress toward SDGs.
6. **AI analytics and insights**: Utilizing machine learning algorithms, statistical models, natural language processing, and other AI techniques to analyze integrated data and derive actionable insights, focusing on pattern recognition, predictive analytics, anomaly detection, and identifying potential sustainability challenges.
7. **Implementing and scaling**: Piloting AI solutions in specific contexts to validate their effectiveness and scaling successful models across different regions and sectors to maximize their impact on sustainable development.
8. **Feedback and continuous improvements**: Establishing feedback loops to learn from implementation experiences, refine AI applications, and adapt AI strategies based on evolving needs and technological advancements.

The proposed framework and steps can serve as a guide for integrating AI into SDG initiatives, emphasizing a systematic approach to harnessing AI's capabilities. Our proposal requires further thorough exploration, detailed planning, and a responsible and inclusive approach to AI deployment. By doing so, we can make meaningful strides toward a sustainable future. Along this path, it is necessary to consider all threats and risks related to AI, some of which were identified by Wach et al. (2023), as they may negatively impact SDGs (Vinuesa et al., 2020).

One significant risk is the potential for job displacement due to increased automation, which may exacerbate economic inequality and social unrest if not managed carefully (Ametepey et al., 2024; Vinuesa et al., 2020). Moreover, AI can inadvertently introduce biases into decision-making processes, particularly in areas such as healthcare and resource allocation, where biased algorithms could lead to unfair or unequal outcomes (Gómez-González & Gómez, 2023). Privacy and data security concerns also emerge as critical challenges, as the implementation of AI often requires extensive data collection, which can infringe on individuals' rights and lead to misuse or unauthorized access to sensitive information (Wach et al., 2023). Furthermore, reliance on AI systems without sufficient human oversight might result in errors or misinterpretations that could undermine sustainable development efforts. Therefore, while leveraging AI offers great promise for advancing SDGs, these risks and challenges must be carefully managed through robust governance frameworks, ethical guidelines, and continuous monitoring to ensure that AI's deployment is both responsible and inclusive.

5. Conclusions

The presented findings represent the authors' perspective on the role of AI in achieving SDGs based on an integrative literature review. The authors might have missed some literature on how AI might affect individual SDGs, or there might not yet be published evidence on such interlinkages.

This study presents a framework for leveraging AI to meet SDGs, detailing the role of AI in achieving each SDG and identifying the best practices for using AI to achieve these goals. Additionally, this study recommends the main steps for systematically integrating AI in achieving SDGs, including policy and governance, infrastructure and accessibility, education and training, collaboration and innovation, data collection and integration, AI analytics and insights, implementation and scaling, and feedback and continuous improvement.

We hope this article will foster further discussion and research on leveraging AI to meet SDGs and inspire experimentation and practical implementations.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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