

**AI AS A KNOWLEDGE-CREATION TOOL: INSIGHTS INTO
INDUSTRY 4.0, INFRASTRUCTURE DEVELOPMENT, AND
SUSTAINABILITY IN EMERGING MARKETS**

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ABSTRACT

In the era of the Fourth Industrial Revolution, artificial intelligence increasingly demonstrates its potential to generate tangible value, driven by large-scale data, advanced computational capabilities, and sophisticated algorithms. Framed as a research tool, this study examines how AI transforms knowledge creation to support the Sustainable Development Goals (SDGs), with a focus on poverty reduction (SDG 1) and the development of industry, innovation, and infrastructure (SDG 9) in emerging economies. Using content analysis, the findings show that artificial intelligence plays a crucial role in advancing sustainable development by enhancing data-driven insights, improving the reliability and efficiency of vital infrastructure such as transportation systems, and enabling informed decision-making that supports economic growth. The study emphasises that AI-driven research tools aid poverty reduction through better poverty mapping, data collection, and analysis, while also revolutionizing agriculture, education, and finance by promoting financial inclusion. Additionally, artificial intelligence fosters inclusive knowledge creation in education and finance, allowing previously marginalized populations to participate more fully in the mainstream economy. The study concludes that increased investment in artificial intelligence and AI-based research is vital for governments in emerging economies to accelerate innovation, strengthen infrastructure, and effectively achieve key Sustainable Development Goals.

Keywords: artificial intelligence; Industry 4.0; innovation; infrastructure development; Sustainability; Knowledge-Creation tool.

1. INTRODUCTION

Industry 4.0, also known as the fourth industrial revolution (4IR), is gaining significant attention, especially regarding its potential impacts on humanity [1]. Schwab [1] argues that 4IR will transform the way people live, work, and how economies and governance function. It is believed that industrial revolutions date back to the 17th century, with Britain playing a key role in what became known as the first industrial revolution [2,3]. The term "industrial revolution" can be defined as an economic upheaval that caused a shift in people's livelihoods from rural, agrarian settings to urban environments [3]. According to Blinov [2], before Britain led the first industrial revolution, economic activities were limited, resulting in widespread poverty, with people depending on small farms for sustenance, which made life difficult for the average person [4]. During this period, production was primarily for personal use, using basic hand tools, and was mostly home-based [3,4]. The first industrial revolution marked the transition from animal power to steam engines, representing a move from agrarian lifestyles to industrialization, where specialized machinery was used, beginning in

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Britain at the start of the 18th century [5]. The steam engine allowed the mechanization of manufacturing and services, driving social change as urbanization increased [5]. Products such as textiles, iron rail transport, and coal became widespread during this revolution. Conversely, the second industrial revolution was characterised by the rise of the electricity, steel, and petroleum industries, along with other scientific advancements that enabled mass production [6,7].

In the 1950s, the third industrial revolution was initiated by the advent of computers and digital technology, which enabled automation in the manufacturing industry. Despite causing disruptions in sectors like banking, energy, and communications, these innovations also paved the way for advancements in space research and biotechnology, offering new opportunities to those impacted by the changes, as noted by Ooi et al. [7]. Scholars such as Schwab [6], Ooi et al. [7] (2018), and Radziwill [8] 2018 assert that we are now experiencing the fourth industrial revolution, or Industry 4.0. This new era builds upon the foundations laid by the previous three industrial revolutions. Schwab [6] describes Industry 4.0 as a transformative period for nations worldwide, prompting them to prepare for its effects on humanity, economies, and businesses. Although literature on Industry 4.0's societal impact is growing, there is still limited research on how AI influences poverty reduction, infrastructure development, and the achievement of the SDGs [8–10]. Historically, each industrial revolution has forced society to adapt, transitioning from rural, agricultural communities to urban, industrial, and eventually post-industrial societies, which grappled with the decline of traditional industries and employment sources [2]. Scholars also suggest that the 4IR will not only lead to job losses but will also alter the delivery of public and private goods and services [3,11]. In a study on AI's value in agriculture, Smith [12] highlighted that AI is beginning to fulfill its

potential due to the availability of relevant data, computational power, and algorithms. Smith [12] further argued that AI can enhance agricultural productivity by improving disease detection and measurement precision on farms. Eli-Chukwu [13] also demonstrated AI's significant role in addressing challenges in the agricultural sector, particularly in helping farmers maximize yields. Consequently, this study aims to explore AI's impact on achieving the SDGs, focusing specifically on poverty reduction (goal one) and industry, innovation, and infrastructure development (goal nine) in emerging economies.

The Industry 4.0 the Fourth Industrial Revolution

Industry 4.0 stands out distinctly when compared to earlier Industrial Revolutions [1]. Schwab [6] highlights that Industry 4.0 differs significantly from the previous three industrial revolutions in terms of its scale, scope, complexity, and transformative nature, making it unlike any other revolution. Schwab [6] contends that this revolution will be unprecedented for humanity, as it represents a completely new revolution rather than a mere continuation of the previous one [6,10]. One of the primary distinctions of Industry 4.0 from past revolutions is the generation of information, where individuals can create new information and knowledge through data mining [6,10]. This is facilitated by the widespread connectivity of people through mobile devices with powerful processing capabilities, ample storage, and limitless access to information [14,15]. Consequently, the ongoing accumulation and analysis of data are enhancing machine intelligence. Another factor that sets Industry 4.0 apart from other industrial revolutions is that it involves not only significant technological advancements but also a transformation of existing production relationships [16,17]. Industry 4.0 enables the manufacturing sector to align with the information age by facilitating communication at every stage of production. Some scholars also suggest that Industry 4.0 is introducing new

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economic models in various sectors, such as the sharing economy, where services like transportation, toys, and sports equipment are shared [15,18]. Conversely, some researchers argue that Industry 4.0 may exacerbate inequality by disrupting labor markets. The increasing automation, use of robots, and computers are expected to replace jobs in many industries, with the most concerning aspect being the potential disappearance of low-skill/low-pay jobs, which could pose significant challenges for the economically disadvantaged and lead to heightened social tensions [10,19]. However, Schwab [6] notes that inequality is not unique to Industry 4.0; historically, all previous revolutions began with significant inequality, followed by periods of political and institutional change. Nonetheless, the most alarming aspect of Industry 4.0 is not just the shift of labor from one sector to another but the replacement of human labor by robots and computers, effectively taking over people's jobs [1,6]. Additionally, the technological revolution will impact material and ideological aspects, as new devices and systems reshape human culture. Figure 1 below illustrates the progression of the four industrial revolutions from the first to the current one.

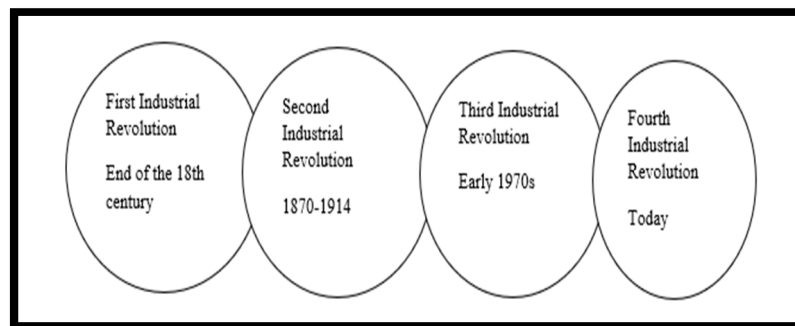


Figure 1. The Four Industrial Revolutions. Source: [9,20].

The diagram above illustrates the progression of the four industrial revolutions, beginning with the first and leading up to the current one. The initial industrial revolution emerged in the late 1700s, succeeded by the second industrial revolution, which spanned from 1870 to 1914. The third industrial revolution took place in the early 1970s. Presently, we are experiencing the fourth industrial revolution, characterized by the influence of various technologies such as AI, robotics, blockchain, and distributed ledger technology, among others.

2. Literature Review

2.1. A Brief History and Definition of AI

The concept of artificial intelligence (AI) was initiated in 1955 by John McCarthy, who proposed that machines could replicate all facets of learning and intelligence [8,20]. Conversely, Haenlein and Kaplan [21] noted that while pinpointing AI's origins is challenging, its roots can be traced back to the 1940s, particularly 1942, when American science fiction writer Isaac Asimov released his short story "Runaround," which featured a robot created by engineers. The term "Artificial Intelligence" was officially introduced in 1956 by Marvin Minsky and John McCarthy, a computer scientist at Stanford. AI is defined as "the study of intelligent problem-solving behavior and the development of intelligent computer systems. Essentially, AI refers to the processes in machines that would require intelligence if executed by humans" [20]. According to Wisskirchen et al. [20], AI is categorized into two types: weak AI and strong AI. Weak AI involves "the computer serving

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as a tool for exploring cognitive processes, simulating intelligence." In contrast, strong AI involves "processes where computers engage in intellectual, self-learning activities. With appropriate software/programming, computers can comprehend and enhance their behavior based on past actions and experiences" [20]. Strong AI also includes automatic networking with other machines, resulting in a significant scaling effect [22]. The most prominent economic fields of AI include deep learning, robotization, dematerialization, the gig economy, and autonomous vehicles, among others [20]. Benko and Sik Lányi [23] suggest that despite decades of study, AI remains one of the most complex and elusive topics in computer science due to its vast and ambiguous nature. AI is believed to encompass everything from machines capable of thinking to search algorithms used in board games. In essence, AI is implied to have applications in nearly every way humans utilize computers in society, including subtle uses like analyzing purchase histories and influencing marketing strategies [23]. Buchanan [22] points out that robots have long been associated with the public's perception of intelligent computers, but early robotics focused more on mechanical engineering than intelligent control. However, AI has empowered robots to become more effective tools for testing ideas about intelligent behavior worldwide. Nonetheless, it is argued that AI is not solely about robots; it also involves understanding the essence of intelligent thought and action using computers as experimental tools [22].

2.2. The Theoretical Definitions of Poverty

Historically, poverty has been understood primarily through an economic lens, but contemporary scholars are increasingly recognizing it as a multidimensional phenomenon encompassing factors such as political participation and social exclusion [24] (Davis and Sanchez-Martinez, 2014). This reflects the understanding that poverty results from multiple interconnected factors rather than a single cause. The United Nations (UN) distinguishes between two forms of poverty: absolute and overall poverty. Absolute poverty refers to the deprivation of fundamental human needs including food, healthcare, housing, clean water, sanitation, education, and access to information [25,26]. Thus, poverty stems from various factors beyond just income [26]. Overall poverty describes circumstances in which individuals lack access to income and productive resources. It is characterized by, though not limited to, "hunger and malnutrition, ill-health, inability to access education, a rise in morbidity and mortality from illness, shortage of housing, unsafe environments, social exclusion and discrimination" [24]. Additionally, overall poverty "involves a lack of participation in decision making in civil, social and cultural life" [27].

The UN further developed the multidimensional poverty index as an additional framework for understanding poverty [26]. This 2010 UN definition incorporates multiple dimensions including education, health, living standards, and other variables. In 2013, the Joseph Rowntree Foundation (JRF) characterized poverty as a state in which individuals' material resources are insufficient to meet minimum needs, including those related to social participation [26,28] (Mhlanga, 2020b, Mhlanga, and Ndhlovu). The World Bank emphasizes individual consumption and income as key determinants of poverty, particularly when individuals fall below a specified income or consumption threshold known as the poverty datum line [26]. Drawing from these diverse conceptualizations of poverty, this study will examine how AI can impact poverty across multiple dimensions.

2.3. Poverty Statistics in The World

The global fight against poverty persists, with progress being slow despite a decrease in

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extreme poverty levels. In 2015, the percentage of people living in extreme poverty dropped to 10%, down from 16% in 2010 and 36% in 1990 [29,30] (Guterres, 2019; World Bank, 2019). However, current statistics suggest that the world is unlikely to meet the 2030 goal of eradicating extreme poverty [30]. Projections indicate that 6% of the world's population will still live in extreme poverty in 2030, missing the target [29] (Guterres, 2019; World Bank, 2019). Those in extreme poverty often experience ongoing deprivation, often worsened by violent conflicts and disaster risks. Experts emphasise that robust social protection systems and significant government investments in essential services are vital to lifting people out of poverty, though these services require further expansion and strengthening [29] (Guterres, 2019). In 2018, Guterres reports that despite having jobs, 8% of households remained in extreme poverty. The situation is particularly severe in Sub-Saharan Africa, where about 38% of the working poor were living in poverty that same year [29].

The World Bank also confirmed that poverty remains most concentrated in Sub-Saharan Africa. In 2019, the World Bank reported that, despite a global decline in poverty rates, progress was uneven [30]. Estimates indicate that over half of the world's extremely poor live in Sub-Saharan Africa, with 413 million people surviving on less than \$1.90 daily. In 2015, the number of impoverished households in the region rose by 9 million, surpassing the total in all other regions combined [26, 30]. If current trends continue, Sub-Saharan Africa could account for nearly 90% of the world's extreme poor by 2030 [31]. A significant portion of these impoverished individuals reside in rural areas. According to the World Bank, most are under 18, work in agriculture, and have limited education [30, 32].

2.4. Empirical Literature Review

The topic of AI and poverty is relatively recent, as there is still limited empirical research on AI's impact on poverty. Smith [12], in a study exploring AI's value in agriculture, argued that AI is beginning to fulfil its promises of delivering tangible benefits, thanks to the availability of relevant data, computational power, and algorithms. The study predicted that AI could significantly enhance agricultural productivity over the next decade by improving disease detection and measurement accuracy. It also found that robotics and automation could reduce the need for human decision-making, boost farm efficiency, and improve farm health. Additionally, AI enables farmers to better utilise information distributed across supply chains, including farm data.

Dharmaraj and Vijayanand [33] conducted research suggesting that with the global population projected to grow by 2 billion by 2050, artificial intelligence becomes essential for enhancing agricultural efficiency. They further noted that implementing AI or machine intelligence throughout agriculture represents a fundamental transformation in modern farming methods. Their research emphasized that AI-driven agricultural solutions frequently allow farmers to achieve greater output with fewer resources, improving product quality while accelerating market entry and optimizing go-to-market (GTM) strategies for their crops.

Vincent et al. [34] similarly contended that while global population is anticipated to rise by 2 billion by 2050, cultivable land will expand by merely 5%. Consequently, intelligent and efficient agricultural methods utilizing AI and machine learning are essential for boosting agricultural output. Their research underscored that evaluating land suitability represents one of several vital factors influencing agricultural advancement. Therefore, AI plays a significant role in farming as an approach for gathering and analyzing data via wireless sensor networks. The emergence of wireless sensor networks has facilitated the creation of affordable sensor

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devices integrated with the Internet of Things (IoT), serving as effective instruments for agricultural automation and decision-making. Vincent et al. [34] posited that combining sensor networks with AI technologies such as neural networks and Multi-Layer Perceptron (MLP) can facilitate the evaluation of land appropriateness for farming activities.

According to a different research by Eli-Chukwu [13], the agriculture industry has clearly seen the use of AI. According to Eli-Chukwu [13] in the study, AI is essential for resolving some of the issues facing the agriculture industry as they work to increase yields. AI can play a crucial role in addressing a number of issues facing the agriculture industry, including ensuring appropriate soil treatment, controlling disease and pest infestations, meeting big data requirements, addressing low output issues, and closing the knowledge gap between farmers and technology. Because AI is flexible, accurate, high-performing, and cost-effective, it can assist address some of these issues in agriculture, according to Eli-Chukwu [13].

Zavadskaya [35] explored the use of AI in finance, focusing on areas such as portfolio management, bankruptcy prediction, credit rating, exchange rate forecasting, and trading. The primary aim of the research was to assess stock market predictions and determine if Artificial Neural Networks (ANN), as representatives of AI, could provide investors with more precise forecasting outcomes. Zavadskaya [35] found that ANN outperformed many other models in predicting results for investors. The study also highlighted that integrating AI with big data concepts, like using Google Trends searches to gauge market sentiment, is beneficial for modeling returns. Cossy- Gantner et al. [36] noted that AI has been evolving over the past 60 years, with various applications being implemented in high-income countries, while its adoption in poorer nations remains a significant challenge. They further argued that despite the difficulties AI faces in low-income countries, it holds great potential for transforming healthcare in these regions.

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Additionally, How et al. [40] developed a research to evaluate a human-centric, no-coding AI-based technique in the analysis or prediction of the financial products' intentions. According to How et al. [40], in order to successfully help underprivileged populations, financial service providers need to comprehend their characteristics and behaviours. According to How et al. [40], using AI on historical data is essential for helping financial service companies predict how potential clients would react when presented with offerings. According to a research by How et al. [40], financial inclusion driven by AI is a crucial component in reducing poverty; nevertheless, financial service providers that lack the computer programming skills necessary to execute AI projects continue to face difficulties.

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3. Research Methodology

The study conducted secondary research to explore AI's impact on achieving SDGs, focusing on poverty reduction (goal one) and industry, innovation, and infrastructure development (goal 9) in emerging economies. To assess AI's influence on SDGs objectively, researchers used unobtrusive research methods, which Elo et al. [41] define as data collection techniques that do not interfere with subjects under investigation, mainly because these methods are non-intrusive [42]. The study employed content analysis, a technique that examines texts, media, or physical items to identify the presence of specific words, themes, or concepts within qualitative data. This method enabled the researchers to quantify and interpret the significance and relationships of these elements, forming the basis for the study's conclusions. Data sources included government reports, international statistics, media articles, peer-reviewed journal papers, and books, all critically reviewed to inform the discussion. A key limitation is that some official complex data, peer-reviewed articles, and books on AI's role in poverty, innovation, infrastructure, and sustainable development are still emerging. Nevertheless, the author utilised information available from scholars, private organizations, and governments. The advantage of content analysis lies in its non-invasive approach to studying social phenomena [42]. It includes three main approaches: conventional, directed, and summative. According to Elo et al. [41], these approaches facilitate interpreting meaning from text data within a naturalistic paradigm. This study primarily employed summative content analysis, which involves counting and comparing keywords, interpreting their context, and understanding the underlying meaning [42].

3.1. *Discussion of the Impact of AI on Poverty, Innovation, and Infrastructure Development*

The Sustainable Development Goals (SDGs) can be achieved in large part because to AI technology. Goal 1 of the Sustainable Development Goals is to eradicate poverty in all of its forms, while Goal 9 is to promote industry, innovation, and infrastructure development. This study is evaluating the effect of AI on poverty.

3.2. *The Role of AI in Industry, Innovation, and Infrastructure Development*

A key factor in economic growth and development is investing in infrastructure and innovation [43]. Over half of the global population now lives in cities, making advancements in mass transportation and renewable energy essential [44]. Conde and Twinn [44] further argue that rapid urban population growth emphasises the importance of developing new industries, as well as expanding information and communication technologies (ICT) and AI. A persistent challenge remains: over 4 billion people lack internet access, with more than 90% residing in the developing world [45]. Bridging this digital gap requires extensive infrastructure development, increased access to information and knowledge, and promoting innovation and entrepreneurship fueled by AI [45]. Additionally, approximately 2.3 billion people worldwide cannot access basic sanitation due to infrastructural issues, which reduce business productivity in many low-income African countries by about 40% [46]. The United Nations reports that around 2.6 billion people in developing nations lack reliable electricity, while the renewable energy sector employs over 2.3 million people, a figure expected to reach 20 million by 2030 [47]. Another critical issue is that only roughly 30% of agricultural products in developing countries undergo industrial processing, compared to 98% in high-income nations [46,47].

Conde and Twinn highlight that AI is transforming the global economy, with estimates

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suggesting it could boost worldwide economic output by around 13 trillion dollars by 2030. In the transportation sector, the market for AI technologies related to transport has grown from \$1.2 to 1.4 billion, with projections indicating it will reach between \$3.1 and 3.5 billion by 2023—representing a 12 to 14.5% increase from 2017 to 2023. AI interventions can enhance multiple sectors, including transportation and agriculture, helping advance the Sustainable Development Goals (SDGs). The World Bank notes that AI's applications in transportation extend beyond autonomous vehicles to addressing safety issues for drivers and pedestrians. Road traffic accidents remain a significant health hazard, especially in developing countries. Conde and Twinn (2019) reported that road traffic-related deaths increased from 1.25 million in 2013 to 1.35 million in 2016, with most accidents occurring in low-income nations. Contributing factors include inadequate infrastructure, poor road conditions, vehicles lacking modern safety features, and human error.

According to one analysis by Conde and Twinn [44], over 90% of all traffic accidents in the European Union (EU) are caused by human error, speeding, distracted driving, and intoxicated driving. In the EU, these incidents claimed the lives of almost 25,000 individuals in 2017 alone. According to research, using AI in driverless cars can help cut traffic accidents by almost 90% in some wealthy countries by the year 2050. Upon activating self-driving systems, Tesla's initial effort at autonomous vehicles cut accident rates by 40%. Although implementation in emerging countries may take a while, it is true that autonomous vehicles will have certain advantages. However, some analysts predict that by 2030, there will be one driverless car for every four.

AI significantly enhances infrastructure reliability, especially in transport, by improving the accuracy of forecasting arrival and departure times. The World Bank highlights this as a key enabler for the safe and efficient movement of goods and people. Companies like Uber and Lyft utilise AI to ensure reliable pickup and drop-off timings, which can be extended globally to improve public transport. For example, New York City-based Via licenses its technology to the Department of Education to design smart bus routes that increase transparency. Additionally, AI helps protect the environment by optimising routes to reduce unnecessary trips, thereby saving fuel and lowering greenhouse gas emissions—contributing to the 23% of global energy-related CO₂ emissions from transportation. An eco-friendly AI application is truck platooning, where multiple trucks connect wirelessly to a lead truck, enabling closer, safer operation and greater fuel efficiency.

In emerging markets, several case studies highlight AI's role in enhancing industries and infrastructure. Many cities worldwide leverage AI to address traffic flow issues. For example, in India, Bengaluru's Siemens Mobility developed a monitoring system using AI-powered traffic cameras to assess traffic density. This data allows traffic lights to be adjusted in real time based on congestion levels. Another example is Alibaba in China, which launched City Brain to improve traffic efficiency and reduce congestion by analysing data from traffic lights, CCTV cameras, and video recognition systems for better traffic management. Additionally, China Post and Deppon Express are utilising AI driving technology from Fabu to deploy autonomous trucks. These trucks, tested successfully, have reached Level 4 autonomy, meaning they can operate independently under certain conditions.

Drones exemplify a typical use of AI, particularly in regions with limited infrastructure, such as Sub-Saharan Africa, where they are applied in healthcare. Rwanda stands out as a prime example, having initiated a commercial drone delivery service. These drones are responsible for transporting medical supplies, such as blood. For example, the U.S. startup Zipline teamed

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up with the Rwandan government to establish the first commercial drone delivery system, allowing for quicker delivery of medical supplies compared to conventional road transportation. Another illustration is Sichuan Tengden Technology from China, which designed a drone capable of carrying 20 tons of cargo and traveling distances of up to 7500 km. In addition to drones, numerous countries are working on innovative airports that integrate smart navigation, facial recognition, and big data analysis to develop a paperless and more streamlined travel experience.

3.3. *Poverty Mapping and Poverty Data Collection*

The World Bank estimates that 736 million people worldwide live in extreme poverty, with half of them residing in five countries: India, Nigeria, the Democratic Republic of Congo, Ethiopia, and Bangladesh. Both the World Bank and the UN rely heavily on research and data to track progress toward this goal [48]. In their study, Strusani and Hounghonon [43] noted that AI technologies are developing new, efficient methods for monitoring and assessing development initiatives aimed at assisting the poor and vulnerable populations. A key challenge for emerging economies is the lack of essential data needed to refine these interventions [43] (Strusani and Hounghonon, 2019b). AI now has the capacity to utilise unstructured data- including images, texts, and audio- to generate the information necessary to improve development outcomes. The Decentralized AI Alliance in 2020 reported that poverty itself hampers data collection efforts. They emphasised that knowing the location of impoverished or needy populations is fundamental to ending poverty in all its forms worldwide [49]. Many countries are not collecting sufficient data or expanding traditional household surveys to identify the poor and their locations, largely because these surveys are costly for many nations [49].

AI can facilitate this process. A recent study at Stanford University employs satellite images as an alternative method to map poverty [50]. The research focused on five African countries: Nigeria, Tanzania, Uganda, Malawi, and Rwanda. Social scientists and computer experts collaborated to use high-resolution satellites to identify poverty levels through image analysis. To validate the study's predictions, the researchers compared their findings with accurate survey data [50]. AI can effectively map poverty by combining detailed satellite imagery with advanced machine learning algorithms to assess the economic status of specific locations worldwide. It can also provide valuable data such as distances to water sources, urban markets, agricultural fields, and other critical variables used in poverty measurement [49], ultimately enhancing the accuracy and efficiency of poverty mapping.

The Qatar Computing Research Institute (QCRI), affiliated with Hamad Bin Khalifa University, collaborates with organizations like the World Bank and UN to address global issues such as poverty through AI [48]. QCRI developed the AI for Digital Response (AIDR) platform, which analyses data during disasters like Hurricane Dorian. This helps identify areas most in need of aid and determines the required response efforts [48]. The institute also works directly with relief agencies to develop technologies for big data analysis during disasters, aiding resource allocation [48]. Using machine learning, QCRI creates poverty maps from anonymous Facebook advertising data [48]. In India, machine learning has been applied to value-added tax data to better target firms for audits. AI has also been used to forecast travel demand after hurricanes and to identify regions at high risk of food insecurity, enabling more effective interventions.

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3.4. *The Impact of AI on Agriculture in Rural Areas*

Poverty, as previously described, is a complex and multidimensional issue. It manifests through lack of income, education, social assistance, and food insecurity [49]. This problem is most common in rural areas where the majority of the poor live. According to the World Bank, agriculture is often the main livelihood in regions with high poverty rates [51]. Strusani and Hounghonon [43] noted that AI applications can help address the diverse challenges faced by those at the bottom of the income distribution, especially the bottom 40%. Although many poor individuals cannot afford AI-enabled devices, they can still benefit directly from AI services provided via mobile devices. For example, machine learning applications like Nuru have been used in Kenya, Mozambique, and Tanzania's agricultural sectors. Nuru helps farmers identify leaf damage from photos sent to authorities, aiding in pest monitoring that threatens farm productivity and food security across East Africa.

AI's significance extends to the fact that data from mobile phones can strongly correlate with individuals' financial status, education level, and health. This enables mobile apps to offer services like microlending, personalized tutoring, health diagnosis, and medication advice. A key AI application is breaking literacy barriers among the poorest by using speech recognition and speech-to-text features, especially when accessing text-based services. In remote rural areas far from cities, AI-driven image recognition can assist in assessing microinsurance claims from farmers. These AI tools help boost farmers' productivity, increasing their income and promoting food security. The Decentralized AI Alliance of 2020 also highlighted that AI can combat poverty by enhancing soil cultivation for crop production and improving livestock rearing, thus providing food and essential products. Additionally, AI-powered robots now aid in harvesting crops and predicting optimal farming methods.

Schmidt [50] also noted that AI, through robotics, is becoming a vital factor in combating world hunger. He believes progress is being made by organisations like Google and Stanford University's Sustainability and Artificial Intelligence Lab, which are developing AI applications in agriculture. These initiatives help improve farming by identifying plant diseases, predicting crop yields, and locating areas at risk of scarcity. An example is the FarmView programme from Carnegie Mellon University (CMU), designed to assist farmers in increasing food production with the same land area. This effort aims to address the urgent issue of population growth, with estimates predicting around 9.8 billion people by 2050, potentially intensifying food shortages. AI, combined with sensing and robotics technologies, can enhance farming techniques, plant breeding, and crop management [50]. Researchers utilise drones, robots, and stationary sensors to gather data and develop drought- and heat-resistant crops that can better survive in famine-affected regions [49,50]. Using AI and machine learning, researchers analyse data to identify factors that increase sorghum yields [49,50].

Another example of AI supporting agriculture is PlantMD, an application developed by high school students Shaza Mehdi and Nile Ravanell in Georgia, USA. This app helps farmers detect plant diseases [50] and was built using Google's open-source machine learning library, Tensorflow [50]. PlantMD was inspired by Nuru, an app created by a Penn State University research team called Plant Village, in collaboration with the International Institute of Tropical Agriculture. Nuru was designed to combat disease and pest susceptibility in cassava, a crop that feeds half a billion Africans daily [49,50]. Farmers often struggle to inspect and manage every crop, but AI and machine

learning now enhance this process. "A machine learning model was trained using thousands

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of classified cassava images, and this model was transformed into an app that allows farmers to send images of their crops and receive information to identify and manage diseases” [49]. In this way, AI helps make African agriculture more sustainable, supporting food security. Similarly, Stanford University uses machine learning to analyse and predict soybean crop yields. It is also believed that satellite technology and machine learning can identify areas in developing and underdeveloped countries facing food insecurity. The next section discusses how AI can benefit education. These advancements are backed by researchers like Vincent et al. [34], who noted that by 2050, the world's population is expected to increase by 2 billion, while arable land will grow by only 5%. Hence, smart farming techniques powered by AI are crucial for boosting agricultural productivity. Eli-Chukwu [13] also highlighted that AI is increasingly applied in agriculture to address challenges like soil treatment, controlling diseases and pests, managing big data requirements, increasing crop yields, and bridging the knowledge gap between farmers and technology.

3.5. *The Impact of AI on Education*

Poverty often correlates with households' lack of access to formal education. The World Bank estimates that about 39% of the world's poorest individuals lack formal schooling. Main barriers include the high costs and limited capacity of higher education institutions, which often have strict enrollment limits [52]. Artificial Intelligence (AI) can help improve educational access for poor children by employing techniques such as personalised learning algorithms that promote student interaction and tailor education to individual needs [49]. AI can identify each learner's specific requirements and accommodate them through various learning methods. In some cases, AI-powered chatbots serve as tutors, breaking down financial barriers for students in impoverished areas, thus addressing access and inequality. A study by Mhlanga and Moloji [18] showed that Industry 4.0 technologies supported learners during COVID-19 social distancing measures, allowing continuous education despite lockdowns. The study also noted that technology can expand access, especially through online education, where space is not a constraint. An example of AI in education is Eneza Education, a social enterprise that uses AI to tutor millions of rural students in Kenya, Ghana, and Côte d’Ivoire, significantly contributing to quality education [49]. This approach fosters inclusive, equitable learning opportunities and promotes lifelong learning for all [49,53]. Similarly, Chua and Valencia [54] highlighted AI's critical role in education during the COVID-19 pandemic lockdown, emphasising its potential while acknowledging that AI is unlikely to fully replace human educators in administration inclusion.

Reaching households that are not financially active—that is, those who are unable to access formal financial services that are intended to satisfy their needs—is thought to be possible through digital financial inclusion [8,55]. According to Mhlanga [8], women, young people, and the impoverished—particularly those living in rural areas—are the groups most excluded from the formal financial sector. According to Strusani and Hounghonon [43], AI is altering the cost of access to goods and services, altering how information is gathered, altering how goods are manufactured, and altering how people interact, all of which are technological disruptions to the conventional methods of lowering poverty and increasing shared prosperity. Strusani and Hounghonon

[43] continued by arguing that the problems of development are becoming more and more entwined with technology, and that utilizing the potential of technologies like artificial intelligence (AI) is becoming crucial to achieving the objectives of eradicating poverty and promoting shared prosperity.

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It has been proven that developing market nations are starting to apply basic artificial intelligence (AI) to solve important development difficulties, particularly when it comes to providing financial services to the underserved and unserved population [43]. Emerging economies may now leverage AI solutions like credit scoring and targeted advertising thanks to significant advancements in fundamental machine learning algorithms and an increase in the number of people using technology. By using machine learning to forecast the likelihood of default for prospective borrowers, M-Shwari made it feasible to provide modest loans to 21 million Kenyans by the end of 2017.

AI is driving innovation in financial services by leveraging non-traditional data, such as address books, text messages, mobile money transaction data, and phone call records, as well as improved data processing and a significant expansion in credit availability. AI also lessens information asymmetry in situations where borrowers don't have credit history, such as first-time borrowers and those without bank accounts. AI is also lowering the cost of financial services by automating credit scoring, a procedure that was previously handled by human resources in conventional financial institutions. Large volumes of mobile phone data can be parsed using machine learning algorithms to provide users in emerging economies with instantaneous credit scores. By incorporating credit history information, the scoring algorithm gets better after the user is presented with a loan offer. Offering microloans to f is one way that this strategy is being applied by Branch One of the fintech companies.

M-Pesa's success as one of the payment innovations that originated in Kenya [56] contributed to the rise in popularity of digital financial inclusion in Africa. The largest mobile phone provider in Kenya, Safaricom, launched M-Pesa, a mobile banking service that enables users to store and transfer money using their phones, in 2007. Digital financial inclusion, which encompasses digital investment, payments, and investment, is seen as more than just payment innovations in Asian nations such as China [56,57]. The capacity of digital finance to leverage information and communication technology (ICT) to expand the scope and utilization of financial services by the underprivileged and those shut out of the official financial market is what makes it so significant [8,58]. Financial inclusion became digital with the introduction of ICT and AI, enabling vulnerable populations to obtain financing [59]. Mhlanga [8] concurs with Wang and He [56] that there must be a successful business.

Numerous online services and products offer a wealth of information to users that would otherwise be unavailable without digital platforms. Peric noted that one of the advantages of digital financial inclusion is granting access to formal financial services for individuals who were previously excluded from financial systems. Another advantage is that digital financial inclusion contributes to safeguarding the disposable incomes of households, as digital financial services and products are typically available at a lower cost for both customers and service providers. The use of AI enables customers to conduct transactions in irregular small amounts, helping them manage their fluctuating incomes. Additionally, digital financial services help mitigate the risks of loss, theft, and other financial crimes associated with cash-based transactions.

4. CONCLUSION

Industry 4.0 is attracting significant attention for its potential impact on humanity, including how people live, work, and govern. This study examined AI's role in achieving the Sustainable Development Goals (SDGs), especially in reducing poverty, and advancing

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industry, innovation, and infrastructure in emerging economies. Content analysis showed that AI strongly influences SDG progress- particularly poverty reduction- through data collection via poverty maps, transforming agriculture, education, and financial sectors via digital inclusion. AI also enables researchers to use satellite imagery to identify areas with high poverty concentrations, improving targeted interventions. Additionally, AI tools like Google and Stanford's Sustainability and Artificial Intelligence Lab are developing agricultural solutions such as disease detection, yield prediction, and identifying scarcity- prone zones. In education, AI enhances learning through customised techniques that encourage student interaction. It also supports infrastructure development, increases access to information, and fosters innovation and entrepreneurship. Furthermore, AI improves the reliability of transport infrastructures, facilitating economic growth- since infrastructure and innovation are critical to development. The study recommends that governments, development agencies, and other organizations prioritise investing in AI, scaling its use to unlock its full benefits.

The primary limitation of the current study is that some of the official complex hard data and peer-reviewed journal articles and books on the impact of AI on poverty, innovation, infrastructure development, and sustainable development are still being developed. The study primarily concentrated on the impact of AI on the attainment of SDGs with a direct focus on poverty reduction, goal 1, industry, innovation, and infrastructure development, goal 9, in emerging economies. Future research on the distinctions in the impact of AI on SDGs in advanced and emerging nations in the context of the Industry 4.0 debate will be intriguing.

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