INTI JOURNAL | Vol.2024:39
eISSN:2600-7320

The Role of Engineers in Advancing Sustainable Development Goal 9 in Underdeveloped Communities through Leveraging Fourth Industrial Revolution Technologies

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Abstract

In underdeveloped communities, achieving Sustainable Development Goal 9 (SDG9) poses significant challenges. Underdeveloped communities lack essential services such as water purification, electricity, sanitation, health facilities and many more. Inclusivity in development stands out as one of the key drivers of SDG9. It is then quite unfortunate that underdeveloped communities have been excluded in almost all aspects of development and advancement. However gloomy the situation might look, most of the challenges faced by underdeveloped communities can be overcome if engineers are to leverage Fourth Industrial Revolution (4IR) technologies in coming up with innovative solutions for sustainable development. In 4IR technologies lie a lot of opportunities to change lives in underdeveloped communities thereby contributing significantly to the attainment of SDG9 by the year 2030. The integration of 4IR technologies such as Artificial Intelligence (AI), Internet of Things (IoT), and Renewable Energy solutions offer engineers the tools to address complex challenges and create more efficient, inclusive, and sustainable infrastructure systems. This paper explored academic literature, policy documents, and reports from reputable sources such as the United Nations (UN), and relevant engineering journal articles. Findings underscore the pivotal role that engineers should play in leveraging 4IR technologies in order to advance SDG9 through the upliftment of underdeveloped communities. A case in point where engineers have leveraged 4IR technologies in order to improve the livelihoods of the backward communities is the use of mobile money platforms in place of brick and mortar banks. Examples are, Ecocash in Zimbabwe, and Mpesa in Kenya Africa. These platforms have enabled people in underdeveloped communities to access banking facilities through their mobile phones. These banking platforms do not rely on brick-and-mortar facilities. They are solely based on 4IR technologies.

Keywords

Sustainable Development Goal 9 (SDG9), Fourth Industrial Revolution (4IR) Technologies, Artificial Intelligence (AI), Renewable Energy, Underdeveloped Communities.

Submission: 13 August 2024; **Acceptance:** 23 October 2024

Introduction

Sustainable Development Goal 9 (SDG 9) is part of the seventeen (17) interconnected United Nations' agenda 2030 goals (adopted in September 2015) for sustainable development. These seventeen (17) goals are meant to address global challenges through promotion of sustainable development in economic, social, and environmental spaces. SDG9 specifically focuses on "Industry, Innovation, and Infrastructure." The clarion call by the United Nations is that, when it comes to sustainable development, no country should be left behind. Developed countries are responding well to the SDGs since they already have thrived economies and a well-developed infrastructure. A serious threat to the achievement of the SDGs by the year 2030 is posed by underdeveloped countries which have small economies and not so developed infrastructure. To mitigate this challenge and advance the achievement of the SDG 9 and some of the SDGs that are intertwined with the SDG 9, engineers can play a pivotal role by taking advantage of the opportunities being availed by the Fourth Industrial Revolution technologies. Fourth Industrial Revolution (4IR) technologies present unprecedented opportunities for underdeveloped communities to leapfrog and catch up with the rest of the developed world. Constructing brick and mortar infrastructure in developing countries can be a pipe dream due to lack of financial resources. An affordable 4IR technological infrastructure can be rolled out more easily and within a short space of time. The 4IR technological infrastructure is exactly what the developing world needs in order to leap-frog and catch up with the rest of the world. An example is where remote areas can benefit from internet coverage by star link satellites. This does not require a large, physical and difficult-to-build infrastructure. One only needs a satellite modem/router and a personal computer to connect with the rest of the world. Children in very remote schools can benefit from tutorship by lecturers in the developed world via Internet through online learning. Therefore, 4IR technologies can be leveraged in the quest to address global challenges, particularly SDG 9, which calls on us to "build resilient infrastructure, promote inclusive and sustainable industrialisation, and foster innovation. "The critical role of engineers in leveraging 4IR technologies in order to advance socio-economic development in underdeveloped communities cannot be overemphasised", (United Nations, 2015).

The Fourth Industrial Revolution, characterised by the integration of digital technologies such as, Artificial Intelligence (AI), Robotics, and Internet of Things (IoT), has the potential to transform traditional engineering practices and catalyse sustainable solutions (Schwab, 2017).

Methodology

This paper adopted a qualitative research approach to explore the role of engineers in leveraging the Fourth Industrial Revolution Technologies to advance sustainable development goal 9 in underdeveloped communities. A comprehensive review of peer-reviewed journal articles, conference papers, policy papers and reports related to engineering, 4IR technologies and SDGs was conducted. Selecting, categorizing, and analyzing literature are key steps in a systematic literature review or general research process. The following steps were undertaken for selection, categorizing and analyzing literature.

Selecting literature

The most relevant and credible sources of literature were systematically selected by following a structured process. First, the research questions or objectives were clearly defined. Next, inclusion and exclusion criteria were developed to guide the selection of studies. A comprehensive literature search was then conducted, followed by a detailed screening process to filter the results. Finally, a quality assessment was performed to ensure the relevance and reliability of the selected sources.

Categorizing literature

Categorizing literature helped organize it for better synthesis and analysis. Coding and categorization was done thematically using excel, which is one of the qualitative analysis tool.

Analyzing literature

Literature was analyzed so as to understand patterns, common findings, contradictions, and gaps in the research. A critical analysis was conducted, where results from different studies were compared. The Taguette open-source qualitative research analysis tool was used for analysis. The limitations were that since the Taquette is a free open-source tool, it does not have advanced features such as those found in other tools like NVivo, MAXQDA and ATLAS.ti. Failure to acquire and use more advanced analysis tools was due to financial constraints. The author undertakes to acquire more advanced analysis tools for his future works.

The Sustainable Development Goals developed by United Nations has 17 goals (United Nations, 2015). SDG 9 aims to build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation. Increase resource-use efficiency and greater adoption of clean and environmentally friendly technologies and industrial processes are necessary to make infrastructure and industries sustainable by 2030 (UN, 2015). Goal 9 aims to support technology development, research and innovation especially in developing countries, provide small-scale industrial and other companies with greater access to financial services including affordable credit, and increase the integration of these companies into value chains and markets. It also advocates providing universal and affordable access to the internet in the least developed countries of the world. Investment in sustainable infrastructure and in scientific and technological research increases economic growth, creates jobs and promotes prosperity (UNIDO, 2016). The Sustainable Development Goal 9 has the following targets:

Target 9.1: DEVELOP SUSTAINABLE, RESILIENT, AND INCLUSIVE INFRASTRUCTURE. Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all.

Target 9.2: PROMOTE INCLUSIVE AND SUSTAINABLE INDUSTRIALISATION. Promote inclusive and sustainable industrialisation and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries.

Target 9.3: INCREASE ACCESS TO FINANCIAL SERVICES AND MARKETS. Increase the access of small-scale industrial and other enterprises, in particular in developing

countries, to financial services, including affordable credit, and their integration into value chains and markets. Promote inclusive and sustainable industrialisation and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries. Promote the rule of law at the national and international levels and ensure equal access to justice for all.

Target 9.4: UPGRADE ALL INDUSTRIES AND INFRASTRUCTURES FOR SUSTAINABILITY.
By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities.

Target 9.5: ENHANCE RESEARCH AND UPGRADE INDUSTRIAL TECHNOLOGIES.
Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending.

Target 9.A: FACILITATE SUSTAINABLE INFRASTRUCTURE DEVELOPMENT FOR DEVELOPING COUNTRIES.
Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological and technical support to African countries, least developed countries, landlocked developing countries and small island developing States.

Target 9.B: SUPPORT DOMESTIC TECHNOLOGY DEVELOPMENT AND INDUSTRIAL DIVERSIFICATION.
Support domestic technology development, research and innovation in developing countries, including by ensuring a conducive policy environment for, inter alia, industrial diversification and value addition to commodities.

Target 9.C: UNIVERSAL ACCESS TO INFORMATION AND COMMUNICATIONS TECHNOLOGY.
Significantly increase access to information and communications technology and strive to provide universal and affordable access to the internet in least developed countries by 2030.

The Fourth Industrial Revolution (4IR) represents a convergence of emerging technologies that blur the lines between the physical, digital, and biological spheres, significantly altering industries and societies (Schwab, 2016). The following technologies are the key drivers of the Fourth Industrial Revolution:

Artificial Intelligence (AI): AI involves the development of systems that perform tasks typically requiring human intelligence, such as learning, reasoning, self-correction, decision-making, problem-solving, and language understanding. Machine learning, a subset of AI, allows systems to learn from data and improve over time without explicit programming. Applications

include autonomous vehicles, virtual/smart assistants, and predictive analytics (Russell & Norvig, 2020).

Internet of Things (IoT): IoT refers to a network of physical objects embedded with sensors, software, and other technologies to connect and exchange data with other devices and systems over the internet. IoT enables real-time monitoring and control of processes, from smart home devices and wearable health monitors to industrial automation and smart cities, enhancing efficiency and convenience (Ashton, 2009).

Blockchain: Blockchain provides a secure, tamper-proof, and transparent way to record transactions across a decentralised network. It is widely used in cryptocurrencies, supply chain management, finance, voting systems, and healthcare to enhance security, transparency, and traceability (Nakamoto, 2008).

3D Printing (Additive Manufacturing): 3D printing involves creating three-dimensional objects from digital models by layering materials. This technology allows for rapid prototyping, customisation, and production of complex designs with minimal waste. It is revolutionising industries such as manufacturing, healthcare (e.g., prosthetics and implants), and construction.

Augmented Reality (AR) and Virtual Reality (VR): AR overlays digital information onto the real physical world, while VR immerses users in a fully virtual environment. These technologies are transforming fields such as entertainment, education, healthcare, and training by providing immersive experiences and enhancing visualisation and interaction with digital content (Milgram & Kishino, 1994).

Robotics: Advancements in robotics involve creating more sophisticated and autonomous robots capable of performing complex tasks in various environments. Robots are used in manufacturing, healthcare (e.g., surgical robots), logistics, domestic settings, improving efficiency, precision, and safety (Bekey, 2005).

Quantum Computing: Quantum computing leverages the principles of quantum mechanics to perform complex calculations at speeds unimaginable with classical computers. This technology holds the potential to revolutionise fields that require complex computations, such as cryptography, material science, pharmaceuticals, and optimisation problems, by solving problems currently intractable for classical computers (Nielsen & Chuang, 2010).

Big Data and Analytics: Big data refers to the massive volumes of data generated by digital interactions, which can be analysed to extract valuable insights. Advanced analytics and data mining techniques help organisations make data–driven decisions, optimise operations, and predict future trends. This technology is crucial in fields such as marketing, finance, healthcare, and logistics (Mayer-Schónberger & Cukier, 2013).

Biotechnology: Biotechnology involves using biological processes to develop products and technologies for various applications. This includes genetic engineering, bioinformatics, and synthetic biology, impacting sectors like healthcare (e.g., gene therapy), agriculture (e.g., GM crops), and environmental conservation (e.g., bioremediation) (Bains, 2017).

Networks provide faster speeds, lower latency, and greater connectivity compared to previous generations. It enables the enables efficient and effective operation of other 4IR technologies such as IoT devices, autonomous vehicles, and smart cities, by providing the necessary infrastructure for real-time communication and data exchange (Chen, Ma, & Zhang, 2020). These technologies collectively drive the Fourth Industrial Revolution, creating opportunities for solving challenges across various domains. They promise increased efficiency, innovation, and connectivity, while also necessitating new approaches to issues such as cyber security, data privacy, and workforce transformation.

Results and Discussion

Examples of successful implementations of 4IR technologies in underdeveloped communities are Ecocash in Zimbabwe, and Mpesa in Kenya Africa, where mobile money platforms are being used as banks, replacing the traditional brick and motor banks. These platforms have enabled people in underdeveloped communities to access banking facilities through their mobile phones. These banking platforms do not rely on brick and mortar. They are exclusively based on 4IR technologies.

The findings of the study suggest several key recommendations. To enable engineers to effectively contribute to SDG 9 in underdeveloped communities, policymakers should prioritize investments in backbone infrastructure projects that facilitate the deployment of Fourth Industrial Revolution (4IR) technologies in these areas. Engineers must also consider the specific needs and preferences of these communities when designing and implementing infrastructure projects, ensuring inclusive innovation. This may involve conducting needs assessments, engaging with local stakeholders, and incorporating suitable 4IR technologies to create equitable systems that distribute the benefits of these advancements fairly.

Additionally, engineers should continue to explore the potential of 4IR technologies in addressing infrastructure challenges in underdeveloped communities. Robust regulatory frameworks and standards for data privacy, cybersecurity, and ethical AI practices should be developed to build trust and ensure responsible technology deployment. Engineering education and professional development programs should integrate 4IR competencies, ethics training, and interdisciplinary collaboration to prepare future engineers for sustainable development challenges. Finally, investment in capacity-building initiatives is encouraged to equip engineers and local stakeholders with the skills and knowledge necessary to effectively leverage 4IR technologies.

Conclusion

Engineers' ought to play a pivotal role in advancing SDG 9 by leveraging 4IR technologies to foster industrialisation, innovation, and infrastructure development in underdeveloped communities. The implementation of 4IR technologies has the potential to significantly bridge the infrastructure gap in underdeveloped regions, enhancing productivity, job creation, and economic diversification. While the potential of these technologies is vast, engineers must also address

significant challenges such as limited access to technological infrastructure, skills gap, and financial constraints. Strategic partnerships, capacity building initiatives, and policy support are essential for overcoming these barriers, ensuring that underdeveloped communities fully benefit from 4IR driven industrialisation. Greater collaboration between government, private sectors, and educational institutions is crucial to develop the technical expertise required to maximise the benefits of 4IR technologies in underdeveloped communities.

Acknowledgements

May I extend my profound gratitude to all those contributed to the realisation of this paper, enabling this author to explore the intersection of engineering innovation and sustainable development in underdeveloped communities. Special mention go to New Era College and Dr Jerald Hondonga for the support. Thank you, INTI International University, for the opportunity.

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