The Impact of Emerging Technologies on Sustainable Development Goals and Millenium Development Goals Achievement*

[1]Y. Ofori and [2]B. Arthur
[1]University of Mines and Technology (UMaT), Tarkwa, Ghana
[2]Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana

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Abstract

This study investigates the impact of emerging technologies on the achievement of Sustainable Development Goals (SDGs) and Millennium Development Goals (MDGs), focusing on themes of environmental sustainability and social inclusivity with digital equality. The study explores how technology adoption either facilitates or hinders progress toward global development goals. The study employs a comprehensive Meaning Oriented Content Analysis drawing from reputable sources, reports, and scholarly works. The study also critically examines the role of emerging technology in achieving environmental sustainability, particularly in smart city initiatives contributing to resource efficiency and ecological footprint reduction, aligning with SDG 11. However, challenges such as electronic waste (e-waste) generation are acknowledged, emphasising the importance of a holistic life cycle approach in technology adoption. In addressing social inclusivity and digital equality, the study reviews other scholarly works, highlighting the necessity to bridge digital divides and ensure meaningful participation, echoing SDG 10. Insights from the International Telecommunication Union (ITU) stress the importance of policies promoting digital inclusion, emphasizing accessibility for all socio-economic strata. The World Economic Forum's 2022 report underscores the pivotal role of social inclusivity and digital equality in unlocking the full potential of emerging technologies for global development. To address challenges related to social inclusivity and digital equality, robust digital inclusion policies are recommended. Governments and organizations should collaborate to bridge the digital divide by implementing initiatives that provide affordable and accessible technology, digital literacy programs, and targeted efforts to include marginalized populations. the complexity of challenges and opportunities presented by emerging technologies necessitates fostering multi-stakeholder collaboration.

Keywords: Emerging Technologies, SDGs, MDGs, Impact and Sustainable Development

1 Introduction

In the contemporary landscape of global development, the integration of emerging technologies has become a critical determinant in shaping the trajectory towards achieving Sustainable Development Goals (SDGs) and Millennium Development Goals (MDGs) (Biglari *et al*., 2022). This has raised concerns about exploring the intricate relationship between emerging technologies, SDGs and MDGs and evaluating whether emerging technologies serve as a bane or a boon in the sphere of sustainable development (Perera *et al*., 2023). Against this background, the pursuit of Sustainable Development Goals (SDGs) and the preceding Millennium Development Goals (MDGs) has been at the forefront of the global development agenda (Yin *et al*., 2023). Resonating to this, the United Nations has established frameworks to articulate an ambitious vision for addressing pressing global challenges, ranging from poverty and hunger to education, gender equality, and environmental sustainability (Musah, 2023). Concurrently, as the world advances, the role of emerging technologies has come to the forefront, presenting both opportunities and challenges in the attainment of these global developmental objectives (Perera *et al*., 2023). The establishment of the Millennium Development Goals in the year 2000 marked a pivotal moment in global cooperation for development (Özekan, 2023).

In tandem with the global cooperation for development, eight goals were established, these goals sought to address critical issues such as poverty, hunger, gender inequality, and disease on a global scale by the target year 2015. While progress was made in several areas, the need for a more comprehensive and inclusive set of goals led to the formulation of the Sustainable Development Goals in 2015 (Bose and Khan, 2022). The SDGs, comprising 17 goals and 169 targets, set a broader and more ambitious agenda, integrating economic, social, and environmental dimensions of development (Yin *et al*., 2023). In tandem with the evolution of these development frameworks, the world has witnessed rapid advancements in emerging technologies (Sazali, 2020). In light of this, Artificial intelligence, blockchain, the Internet of Things (IoT), and other cutting-edge technologies have permeated various facets of society, presenting novel avenues for addressing complex challenges (Qadri *et al*., 2020). The potential of these technologies to revolutionize sectors such as healthcare, education, finance, and environmental management is significant (Kumar et al., 2019). However, the extent to which they contribute positively or negatively to the achievement of SDGs

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and MDGs remains a subject of inquiry (Li *et al*., 2019).

Most importantly, the integration of emerging technologies into the pursuit of sustainable development introduces a duality that necessitates careful examination (Gunawan *et al*., 2020). On one hand, these technologies hold the promise of enhancing efficiency, promoting innovation, and providing new solutions to longstanding challenges (Wibowo, 2023). On the other hand, Rashed and Shah (2021) posit that concerns related to ethical considerations, digital inequality, and the exacerbation of existing disparities need to be addressed. Furthermore, understanding the nuanced impact of emerging technologies is imperative for shaping informed policies and strategies that leverage their benefits while mitigating potential risks (Wibowo, 2023).

More so, several scholars posit that the impact of emerging technologies on SDGs and MDGs presents glimmering opportunities across diverse sectors without posing any dangers to sustainable development (Phoon *et al*., 2020). On the contrary, Qadri *et al*. (2020) assert that emerging technologies offer numerous benefits across diverse sectors, but most especially, they offer advancement in the health sector. Additionally, Falzon *et al*. (2023) discussions on the role of digital technology in global health emphasize how emerging technologies like telemedicine and health informatics contribute to achieving health-related goals. Given this, the impact of emerging technologies on healthcare is profound, addressing several health-related MDGs and contributing to health-related targets within the SDGs (Qadri *et al*., 2020).

Moreover, the application of emerging technologies has shown promise in addressing environmental sustainability goals. In resonance, Yin *et al*. (2023) present key axes of global progress toward SDGs, emphasizing the role of technology in monitoring and mitigating environmental degradation. On a global scale, emerging technologies continue to make profound contributions towards the attainment of SDGs and MDGs in a synergistic approach across all sectors and domains of sustainable development (Pawar, 2023). This is evident in the use of emerging technologies in wastewater treatment, contributing to the achievement of clean water and sanitation goals (Phoon *et al*., 2020). Despite the numerous contributions of emerging technologies towards the attainment of SDGs and MDGs, these emerging technologies have their pitfalls (Sachs *et al*., 2023). These pitfalls even extend to gender inequality. While emerging technology has the potential to advance gender equality, it also poses challenges related to digital inequality. Against this background, the study of Perera *et al*. (2023) on the impact of digital inequality in achieving sustainable development underscores the need for targeted interventions to ensure equitable access to technology. However, Mazhar *et al*. (2022) study on empowering female entrepreneurs through technology sheds light on the positive impact of interest-free start-up credit and skill development in narrowing gender gaps in entrepreneurship.

Notwithstanding, the transformative potential of emerging technologies comes with challenges and ethical considerations. Issues such as data privacy, digital inequality, and the potential for technology to exacerbate existing disparities need careful attention (Rifna *et al*., 2019). Perera *et al*. (2023) systematic literature review and the work of Li *et al*. (2019) on the impact of GDPR on global technology development highlight the need for a balanced approach to technology adoption, ensuring that benefits are distributed equitably.

Thus, the impact of emerging technologies on SDGs and MDGs is multifaceted, presenting unprecedented opportunities across various sectors of global development (Yin *et al*., 2023). From poverty alleviation and healthcare to education, environmental sustainability, and gender equality, technology has demonstrated its potential to catalyze progress. However, careful consideration of challenges and ethical concerns is paramount to harness the full benefits of emerging technologies in the pursuit of sustainable development (Bose and Khan, 2022).

This study aims to comprehensively examine the impact of emerging technologies on the achievement of Sustainable Development Goals (SDGs).

1.1 Problem Statement

The contemporary discourse on sustainable development is intricately linked with the integration of emerging technologies, offering unprecedented opportunities and challenges (Pekmezovic, 2019). However, the existing body of knowledge presents a fragmented understanding of the specific contributions and impediments posed by these technologies across diverse Sustainable Development Goals (SDGs) and Millennium Development Goals (MDGs) (Larionova, 2020). Thence the research problem can be delineated into four critical dimensions namely, inadequate understanding of technological contributions to individual SDGs, gender dynamics within Socio-economic empowerment and entrepreneurship, unexplored linkages between emerging technologies and poverty dynamics and lastly, addressing global crises and digital inequality in Sustainable Development.

To begin with, current literature lacks a granular examination of how emerging technologies specifically contribute to, or hinder, progress within distinct SDGs and MDGs (Sachs et al., 2019). While broad assessments exist, a detailed analysis of technological interventions in domains such as poverty alleviation, healthcare, education, and environmental sustainability is essential (Kroll *et al*., 2019). The research gap thus centres on the need for a comprehensive understanding of the nuanced relationship between emerging technologies and individual SDGs.

Furthermore, the socio-economic impact of technology, particularly in entrepreneurial empowerment, has garnered attention (Weiland *et al*., 2021). However, there remains a critical gap in understanding how emerging technologies influence gender dynamics within entrepreneurial endeavours (Adeosun and Owolabi, 2023). This gap calls for a focused exploration of the specific ways in which technology either perpetuates or mitigates gender-based disparities, contributing to a more equitable and inclusive sustainable development agenda (Scoones *et al*., 2020).

While the impact of poverty on the achievement of SDGs has been examined, extant literature lacks a detailed exploration of the specific linkages between emerging technologies and poverty dynamics (Antoniades *et al*., 2020). The inhibiting synergies and magnifying trade-offs associated with poverty in the context of technological interventions require deeper investigation (Zhao *et al*., 202). The research problem emphasizes the necessity of unravelling how emerging technologies can exacerbate or alleviate poverty-related challenges within the sustainable development framework (Hegre *et al*., 2020).

Moreover, the global crises, exemplified by the COVID-19 pandemic, underscore the need to understand how emerging technologies can address unforeseen challenges to sustainable development (Fulzele *et al*., 2022). Simultaneously, the intersectionality of digital inequality with other impediments to sustainable development remains underexplored (Alfirević *et al*., 2023). The research gap focuses on elucidating the role of emerging technologies in responding to global crises and mitigating digital inequalities, ensuring a more resilient and equitable trajectory towards sustainable development (Sachs *et al*., 2023).

Furthermore, the seminal work by Biglari et al. (2022) critically questions the practicality and feasibility of achieving SDGs, prompting a reexamination of established strategies. Musah's (2023) research delves into the role of institutional efficiency, particularly within the African context, highlighting the need for context-specific approaches to sustainable development. Mazhar *et al*. (2022) study on empowering entrepreneurs underscores the socio-economic implications of technology, yet a focused examination of gender dynamics within this context remains limited. More so, Wei *et al*. (2023) exploration of the impact of poverty on SDGs emphasizes inhibiting synergies and magnifying trade-offs without explicitly linking these challenges to emerging technologies.

Despite these contributions, critical gaps persist. Detailed analyses of how emerging technologies contribute to individual SDGs and MDGs are lacking (Sachs *et al*., 2019). Gender dynamics in the socio-economic impact of technology need further investigation (Adeosun and Owolabi, 2023). The relationship between inhibiting synergies, magnifying trade-offs in poverty, and the role of emerging technologies is underexplored (Mastrucci *et al*., 2019). The impact of global crises, like COVID-19, on SDGs and emerging technologies' role requires detailed investigation (Grabara, 2024). Additionally, the intersectionality of digital inequality with other impediments to sustainable development needs nuanced exploration (Pekmezovic, 2019).

Furthermore, the impact of global crises, as exemplified by the COVID-19 pandemic, on the achievement of SDGs and the role of emerging technologies in addressing such challenges require more detailed investigation (Grabara, 2024). Additionally, the intersectionality of digital inequality with other impediments to sustainable development requires a more nuanced exploration (Pekmezovic, 2019).

Filling these critical gaps is imperative for several reasons. Firstly, it will provide a comprehensive and detailed understanding of how emerging technologies interact with specific SDGs and MDGs, allowing for targeted interventions and strategic policymaking (Pawar, 2023). In addition, a more focused examination of gender dynamics within technological empowerment endeavours will contribute to the broader discourse on gender equality and social inclusion, fostering more equitable socio-economic development (Zimmerman *et al*., 2023).

Also, a detailed exploration of the relationship between poverty, inhibiting synergies, and magnifying trade-offs, with a specific focus on emerging technologies, will inform evidence-based strategies for poverty alleviation within the sustainable development framework (Carden *et al*., 2023).

Moreover, addressing the impact of global crises and digital inequality within the context of sustainable development will contribute to the development of robust frameworks that are resilient to unforeseen challenges and ensure that the benefits of emerging technologies are distributed equitably (Krishnamoorthy *et al*., 2023).

Conclusively, a more detailed and academic examination of the multifaceted challenges and opportunities posed by emerging technologies is essential to advance our understanding of their interplay with the attainment of SDGs and MDGs (Kumari and Singh, 2023). This study purports to fill critical gaps in the current literature, contributing to the scholarly discourse on sustainable development and technology integration. In essence, the research problem encapsulates the intricate relationship between emerging technologies and the pursuit of sustainable development, and addressing these dimensions will not only advance academic knowledge but also provide valuable insights for policymakers, practitioners, and stakeholders navigating the complex landscape of technology-driven sustainable development

1.2 Underlying Theory

This study employs the Innovation Systems Theory as the underlying theory for the conduct of the study. This theoretical lens, rooted in scholarly works such as those by Yu *et al*. (2023) and Szakálné Kanó *et al*. (2023) offers a robust analytical foundation to explore the intricate dynamics of technology adoption and its consequential effects on sustainable development.

Central to the Innovation Systems Theory is the acknowledgement that emerging technologies are integral components of broader systems, as elucidated by Szakálné Kanó *et al*. (2023). In the specific context of this study, the theory serves as a guiding framework to systematically examine the complex relationships between emerging technologies and the attainment of Sustainable Development Goals (SDGs) and Millennium Development Goals (MDGs).

This theoretical perspective provides a nuanced analysis of the interactions among various stakeholders within the innovation ecosystem concerning SDGs and MDGs (Wibowo, 2023). Governmental policies, business strategies, and civil society initiatives are all considered integral components that can either catalyze or impede the successful integration of emerging technologies for sustainable development (Avilés-Sacoto *et al*., 2020). This theoretical underpinning aligns seamlessly with the theory's emphasis on considering the broader socio-economic and institutional context influencing innovations, as argued by Asheim *et al*. (2019).

Intriguingly, the Innovation Systems Theory's relevance to context-specific approaches is particularly pertinent to understanding the impact of emerging technologies on achieving specific development goals (Bergek, 2019). For instance, Musah (2023) research on institutional efficiency in Africa can be elucidated through the lens of how various actors contribute to and shape the innovation system within the African context.

Moreover, the theory's emphasis on learning and knowledge exchange is aptly applicable in the realm of emerging technologies (Martín-Blanco *et al*., 2022). This perspective facilitates a comprehensive analysis of how innovations are developed, diffused, and utilized within systems. In the study, a thorough exploration of knowledge transfer mechanisms and collaborative learning within the innovation system may shed light on the successful integration of emerging technologies for sustainable development. Exemplified in literature such as studies on sustainable development goal disclosures (Gunawan *et al*., 2020) and investigations into conventional and emerging technologies for wastewater treatment (Phoon *et al*., 2020), this theoretical framework enriches the understanding of knowledge transfer mechanisms within the innovation system.

In elucidating the dimensions of the Innovation Systems Theory, it is imperative to delve into its multifaceted aspects and articulate their relevance to the investigation. Rooted in the works of Yu *et al*. (2023), Szakálné Kanó *et al*. (2023), and Asheim *et al*. (2019), the chosen theoretical framework offers a comprehensive lens through which the study's objectives can be systematically addressed.

The foundational dimension of the Innovation Systems Theory lies in its systemic perspective, as articulated by Szakálné Kanó *et al*. (2023). This perspective is particularly salient in the study, where emerging technologies are not treated in isolation but are understood as integral components of broader innovation systems. This dimension enables a detailed analysis of the intricate relationships among stakeholders, including governments, businesses, and civil society, within the innovation ecosystem concerning SDGs and MDGs (Alfirević *et al*., 2023).
Within this systemic view, the study explores how different actors contribute to and shape the innovation system. Wibowo (2023) work on economic growth through digital-era fundraising schemes, for instance, becomes a subject of analysis through the lens of understanding the interactions and contributions of diverse stakeholders within the broader innovation system (Yu *et al*., 2023). The

systemic dimension of the theory provides a structured framework to dissect the complexities of these interactions, revealing critical insights into the dynamics of technology adoption for sustainable development (Yin *et al*., 2023).

Another pivotal dimension of the Innovation Systems Theory, highlighted by Asheim et al. (2019), emphasizes the significance of considering the socio-economic and institutional context. In the study, this dimension becomes instrumental in unravelling the context-specific approaches to the integration of emerging technologies for sustainable development. For instance, Musah (2023) research on institutional efficiency in Africa is intricately connected to this dimension, showcasing how the institutional context influences the development and adoption of emerging technologies in the pursuit of SDGs.

The theory's emphasis on learning and knowledge exchange constitutes another crucial dimension applicable to the study's context. As articulated by Hekkert *et al*. (2020) and demonstrated in studies on sustainable development goal disclosures (Gunawan *et al*., 2020) and emerging technologies for wastewater treatment (Phoon *et al*., 2020), this dimension offers a nuanced exploration of how the exchange of knowledge within the innovation system influences the development, diffusion, and utilization of emerging technologies. In essence, the dimensions of the Innovation Systems Theory, namely its systemic perspective, consideration of socio-economic and institutional context, and emphasis on learning and knowledge exchange, collectively contribute to a robust theoretical framework for comprehensively analyzing the impact of emerging technologies on the achievement of SDGs and MDGs (Sachs, 2019). This theoretical lens provides a structured and insightful approach to navigating the intricate landscape of technology-driven sustainable development.

The rationale behind selecting the Innovation Systems Theory for this study lies in its ability to holistically capture the dynamic, interactive, and context-dependent nature of the relationship between emerging technologies and sustainable development (Hekkert *et al*., 2020). Aligned with the study's objectives, this theoretical framework facilitates a comprehensive analysis of how innovations are developed, diffused, and utilized within systems (Yin *et al*., 2023). Consequently, the Innovation Systems Theory provides a structured approach to unravel the inherent complexities associated with the integration of emerging technologies for achieving SDGs and MDGs.

1.3 Review of Relevant Literature

In the exploration of the impact of emerging technologies on Sustainable Development Goals (SDGs) and Millennium Development Goals (MDGs), a nuanced examination of empirical literature unveils a complex interplay that defines the landscape of sustainable development. The empirical and conceptual review is crafted to offer a comprehensive understanding of the multifaceted role of emerging technologies across distinct dimensions. The studies collectively present a mosaic of technological contributions, each intricately linked to the achievement of specific SDGs (Grimus, 2020). This panorama underscores the interconnectedness of various emerging technologies within the broader framework of sustainable development. It lays the foundation for a systematic analysis of how technology, in its diverse forms, becomes a driving force in realizing progress across different domains of sustainable development (Larionova, 2020).

A detailed analysis, exemplified by Wei *et al*. (2023) study, delves into the role of technology in poverty alleviation. This investigation meticulously dissects the intricate mechanisms through which technological interventions contribute to the reduction of poverty. It sheds light on the multifaceted dynamics that underlie the relationship between technology and socio-economic development, emphasizing the potential for technology to act as a catalyst for positive change.

Perera *et al*. (2023) exploration of the impact of digital inequality on SDG achievement adds a critical dimension to the discourse. This systematic review scrutinizes how disparities in digital access pose challenges to the inclusive realization of sustainable development goals. The findings underscore the imperative of addressing digital divides to ensure that the benefits of emerging technologies are accessible to all segments of society.

The empirical exploration extends its purview to assess the repercussions of global crises, exemplified by the COVID-19 pandemic, on the trajectory of SDG achievement. The study by Wang *et al*. (2022) serves as a focal point for understanding how emerging technologies respond to and mitigate challenges posed by such crises. This analysis offers insights into the adaptive capacities of technology in navigating and mitigating the complex repercussions of global disruptions, emphasizing its crucial role in crisis response and recovery.

A closer examination of Mazhar *et al*. (2022) study on empowering entrepreneurs through technology brings to light the empowering dynamics of technology in entrepreneurship. This analysis

uncovers the ways in which technology catalyzes entrepreneurial endeavours, aligning with the broader MDG framework. By focusing on the impact of interest-free start-up credit, skill development, and ICT use, the study contributes to a deeper understanding of how technological interventions can facilitate progress towards MDGs.

The final dimension scrutinizes studies that delve into the gender dimensions of technology-driven sustainable development. The analysis of studies, such as Yahmia *et al*. (2022), uncovers the intricate ways in which globalization intersects with gender dynamics in the African context. This exploration emphasizes the imperative of gender-inclusive technological empowerment for holistic development, recognizing the need to address disparities and promote gender equality in the realm of technological advancements.

Furthermore, the conceptual literature review on the nexus between the digital economy and sustainable development unfolds as a scholarly tapestry, weaving together insights from distinct studies to illuminate the multifaceted dimensions of this intersection (Phoon *et al*., 2020).

To begin with, Ożekan (2023) comprehensive overview serves as a foundational exploration of the impact of the digital economy on sustainable development. This conceptual framing provides a nuanced understanding of how the pervasive use of digital technologies across economic sectors contributes to, or challenges, the principles of sustainable development. Ożekan's work synthesizes a broad perspective, laying the groundwork for a more granular exploration of specific aspects within the digital economy and sustainable development paradigm.

Wibowo (2023) study adds depth to this conceptual landscape by specifically exploring fundraising schemes in the digital era for sustainable community development. This analysis transcends macroeconomic considerations and delves into the grassroots impact of digital fundraising on community-centric progress. By scrutinizing the impact of digital fundraising in achieving sustainable development goals, Wibowo's work sheds light on innovative approaches that leverage the digital economy for community-level advancements. This exploration expands the conceptual understanding of the digital economy's role, emphasizing its direct and tangible influence on local and community-driven sustainability initiatives.

In parallel, the conceptual discussion extends to encompass the role of the private sector in the implementation of SDGs, as examined by Rashed and Shah (2021). This study injects a crucial dimension into the conceptual landscape by recognizing the pivotal role of private enterprises in driving sustainable development efforts. By exploring the contributions and responsibilities of the private sector in achieving SDGs, this work highlights the interconnectedness of economic activities and sustainable development objectives. The conceptualization of private sector involvement underscores the need for collaborative efforts between various stakeholders, emphasizing the importance of transcending traditional boundaries for impactful and sustainable outcomes (Sazali, 2020).

Most importantly, the synthesis and integration of the empirical, theoretical, and conceptual literature form a pivotal stage in shaping a cohesive understanding of the impact of emerging technologies on achieving SDGs and MDGs. This synthesis aims to distil common themes, critically analyze gaps, and weave together a narrative that guides the research questions and objectives (Li *et al*., 2019).

Identifying common themes and patterns across the empirical, theoretical, and conceptual literature reveals recurring motifs that serve as foundational pillars for understanding the intricate relationships between emerging technologies and sustainable development goals. The empirical literature, represented by studies such as Wei *et al*. (2023) and Perera *et al*. (2023), emphasizes the multifaceted contributions and challenges posed by specific emerging technologies. These empirical insights intertwine with the theoretical perspectives, particularly the Innovation Systems Theory, offering a systemic lens to comprehend the dynamic interactions within innovation ecosystems. Simultaneously, the conceptual literature, led by Ożekan (2023), Wibowo (2023), and Rashed and Shah (2021), broadens the discourse by exploring overarching concepts like the digital economy and the role of the private sector in sustainable development. This synthesis reveals a rich tapestry of interconnected concepts, forming the scaffolding for a holistic understanding of the study's focal point.

In conducting a critical analysis of gaps and inconsistencies in the existing literature, this synthesis acknowledges the limitations and areas where scholarly inquiry remains underexplored. While the literature provides valuable insights into the impacts of emerging technologies on SDGs and MDGs, certain gaps persist. The gender dynamics in technological empowerment, as explored by Yahmia *et al*. (2022), represents a crucial dimension, but the literature review highlights the need for further exploration to comprehensively

understand and address gender inequalities in the context of technological advancements. Additionally, the synthesis points to a gap in understanding the nuanced interactions between global crises, such as the COVID-19 pandemic, and the achievement of SDGs. This critical analysis sets the stage for future research directions and emphasizes the importance of addressing these gaps in the study.

The formation of a cohesive narrative emerges organically from the synthesis and critical analysis. The interplay between empirical, theoretical, and conceptual perspectives converges to craft a narrative that informs the research questions and objectives. The study, propelled by the Innovation Systems Theory, seeks to unravel the complexities of emerging technologies' impact on sustainable development. The narrative is woven with threads of empirical evidence, theoretical frameworks, and conceptual insights, culminating in a comprehensive understanding that guides the study's trajectory.

2 Materials and Methods Used

This section provides a brief description of the materials and methods used in this study. The materials, predominantly data sources, are outlined with clarity regarding their origin, and the methods utilized for data analysis are expounded upon.

2.1 Data Sources

To facilitate the investigation into the impact of emerging technologies on Sustainable Development Goals (SDGs) and Millennium Development Goals (MDGs), the data source for this study encompasses a diverse array of secondary data captured in the 2022 SDG and MDG report, along with publications retrieved from reputable journals focused on emerging technologies and conference proceedings. The references cited in the literature review section serve as foundational materials for this study. Additionally, data from reports by the International Telecommunication Union (ITU), Global Sustainable Development Report (GSDR), World Economic Forum (WEF), policy documents, and empirical studies related to sustainable development, emerging technologies, and their intersection are incorporated.

2.2 Data Collection Method

This section elucidates in detail the step-by-step approach to collecting data for the study. Firstly, the primary data source for the study comprises a comprehensive compilation of secondary data extracted from the 2022 SDG and MDG reports. Additionally, the study incorporates information gathered from reputable journals focusing on emerging technologies, conference proceedings, and key references cited in the literature review section, establishing a solid foundation for the research. To initiate the data collection process, the 2022 SDG and MDG report serves as the cornerstone, offering valuable insights into the multifaceted relationships between emerging technologies and sustainable development. The 2022 SDG and MDG report and other complementary data sources are downloaded from the United Nations Development website and other databases. Thereafter, secondary data obtained from publications in esteemed journals and conference proceedings are downloaded as well to enrich the study by providing diverse perspectives and scholarly contributions. Thereon, the reports and publications are categorized and examined in detail. At this stage, the references cited in the literature review section play a pivotal role in guiding the research, ensuring a thorough exploration of existing knowledge and frameworks in the field.

Subsequently, the process of data extraction is guided by specific criteria established to align with the research objectives of the study on the impact of emerging technologies on SDGs and MDGs achievement. The criteria involve identifying relevant sections or subsections within the report that pertain to Environmental Sustainability through Technology Adoption, Social Inclusivity and Digital Equality, Governance and Ethical Implementation of Technology, Mobile Technology for Global Development and Technological Innovation for Economic Growth and Decent Work. Once the criteria are established, the extraction of pertinent data commences, adhering to the predetermined guidelines outlined earlier. This entails the meticulous copying and documentation of text, tables, figures, and any other pertinent information directly related to the identified research objectives and themes. The extracted data undergoes systematic organization within a database, where each data element is allocated to specific categories or themes that align with the predefined research objectives.

In addition to the extraction and organization of data, the entire data collection process is thoroughly documented to ensure transparency and traceability. This documentation includes recording the precise source of the data and specifying the particular section or page of the sustainability report from which the data was extracted. The date of data extraction is also recorded, providing a temporal context for the information collected. Any other relevant information deemed significant to the data collection process is documented to maintain a

comprehensive record of the methodology employed in gathering and organizing the data.

Furthermore, the inclusion of data from reports by authoritative bodies such as the International Telecommunication Union (ITU), Global Sustainable Development Report (GSDR), and World Economic Forum (WEF) adds depth to the study. These reports contribute to a nuanced understanding of the intersection between emerging technologies and sustainable development, offering valuable insights into global perspectives, policy implications, and empirical evidence. The incorporation of policy documents and empirical studies related to sustainable development and emerging technologies further enhances the richness of the data. By drawing on a diverse range of sources, including industry-specific reports and academic research, the study aims to capture the complexity and dynamism of the subject matter.

Moreover, the extracted data undergoes a thorough review for accuracy and completeness through cross-checking with the original sustainability report. This ensures there are no discrepancies or errors in the collected information. Finally, ethical considerations related to the use of data from the SDG and MDG report are taken into account, respecting the confidentiality and intellectual property rights of the company.

2.3 Data Analysis

This study utilizes content analysis as the chosen method for data analysis. Content analysis, initially employed predominantly as a quantitative research tool, has evolved to encompass qualitative research applications in recent years (Stemler, 2015). Described by Stemler (2005) as a systematic process involving the identification, coding, and classification of themes or patterns in textual data, content analysis provides a subjective understanding of content.

The rationale behind adopting content analysis for this study lies in its capacity to offer a thorough understanding and a deductive approach to analyzing textual data. Content analysis is further divided into meaning-oriented content analysis (MOCA) and form-oriented content analysis (FOCA) (Sheydayi and Dadashpoor, 2023). Meaning-oriented content analysis involves the analysis of qualitative data by identifying words, concepts, and themes.
Conclusively, content analysis is chosen as a robust methodological approach for this study, allowing for a comprehensive examination of the collected data by identifying and interpreting themes and patterns. This aligns with the research objectives and provides valuable insights into the subject matter.

2.3.1 Meaning-Oriented Content Analysis

In analyzing this study, Meaning-Oriented Content Analysis is systematically applied to qualitative data concerning the impact of emerging technologies on SDG and MDG achievement. The analysis begins with a thorough reading of the report to comprehend its context, objectives, and structure, guided by the research objective. To structure the analysis effectively, a coding framework is developed, grouping key elements of the ESG and MDG report into themes aligned with the research focus. Following the methodology proposed by Sheydayi and Dadashpoor (2023) the coding process involves selectively grouping data into themes and sub-themes, utilizing Microsoft Office Excel for the initial coding.

Open coding assigns numerical codes (1 to 5) to relevant sections or paragraphs in the sustainability report, linking them to the research questions. Subsequently, selective coding is applied to identify, group, and refine categories within the coding framework into themes and sub-themes, ensuring consistency through constant comparison. The process also integrates relevant quotes or excerpts from the report to categorize data effectively.

This iterative approach refines the coding framework and enhances conceptual clarity. The collected data is then interpreted by analyzing the coded data within each category or theme, aiming to reveal the underlying meanings and implications of emerging technologies. The analysis takes into account alignment with ESG, MDG, SDG and ITU standards, resulting in the identification of 5 emerging themes: Environmental Sustainability through Technology Adoption (1), Social Inclusivity and Digital Equality (2), Governance and Ethical Implementation of Technology (3), Mobile Technology for Global Development (4) and Technological Innovation for Economic Growth and Decent Work (5).

The selection of Meaning-Oriented Content Analysis for this study is driven by its dynamic approach, providing an efficient means of synthesizing substantial volumes of text data found in the sustainability report (Stemler, 2015). Furthermore, Meaning-Oriented Content Analysis offers a direct and accurate method of identifying and grouping data relevant to the study's objectives (Miles and Huberman, 1994).

2.4 Methodology

This study employs a qualitative approach to collect and analyze data, aligning with the subjective nature of Sustainable Development Goals and Millennium Development Goals in the context of emerging

technologies. Given that emerging technology trends and practices are diverse rather than fixed, investigating these practices involves a subjective inquiry. The decision to utilize qualitative research stems from the textual and subjective nature of the data employed in this study. The chosen qualitative approach is deemed appropriate for this study as it allows for in-depth exploration and interpretation of the complex relationships between emerging technologies and SDGs/MDGs. Thematic analysis and content coding provide a structured framework to distil meaningful insights from a diverse range of literature sources. The methodological approach aligns with the study's objectives offering a comprehensive understanding of the impact of emerging technologies on sustainable development a comprehensive critical analysis of SDG and MDG reports within the context of emerging technologies is conducted through content analysis of these reports. This approach allows for a thorough understanding of the impact of emerging technologies on SDGs and MDGs achievement, offering a reliable method for analyzing and interpreting data within this context.

3 Results and Discussion

The results obtained from the research are presented and extensively discussed in this section.

3.1 Results

3.1.1 Social Inclusivity and Digital Equality

The theme of ‘‘Social Inclusivity and Digital Equality’’ within the study on the impact of emerging technologies on achieving Sustainable Development Goals (SDGs) and Millennium Development Goals (MDGs) is a critical aspect that reflects the broader societal implications of technological advancements. In examining this theme, it is imperative to delve into the multifaceted dimensions of social inclusivity and digital equality, considering both the goals set by international frameworks and insights from reputable reports and literature.

The United Nations' SDGs and MDGs emphasize the importance of ensuring that the benefits of technological progress are shared equitably across all segments of society. SDG 10, ‘‘Reduced Inequality’’, explicitly addresses the need to reduce inequality within and among countries, encompassing aspects of social, economic, and technological disparities. MDG 8, focused on developing a global partnership for development, also highlights the importance of making available the benefits of new technologies, especially information and communication technologies (ICTs).

The World Economic Forum (WEF) report of 2022 states that, "Achieving social inclusivity and digital equality is paramount for realizing the full potential of emerging technologies in advancing global development" (Anon., 2022).

This underscores the recognition of the pivotal role that social inclusivity and digital equality play in harnessing the benefits of emerging technologies for sustainable development.

A comprehensive discussion on this theme necessitates a review of diverse literature. The works of scholars such as Liao *et al.* (2022) emphasize the need to address digital divides to ensure that marginalized populations are not left behind in the digital era. Al-Emran *et al.* (2023) argue that social inclusivity should go beyond mere access to digital technologies and encompass meaningful participation and empowerment.

Comparatively, a study by González-Betancor *et al.* (2021) investigates the impact of digital inequality on educational outcomes, shedding light on the potential repercussions of disparities in access to technology. The study concludes that addressing digital inequality is crucial for achieving inclusive and quality education, aligning with SDG 4.

Moreover, the International Telecommunication Union (ITU) report of 2021 underscores the importance of policies and initiatives that promote digital inclusion, stating, "Digital equality requires targeted efforts to ensure that the benefits of technological advancements are accessible to all, irrespective of socio-economic status" (Anon, 2021)).

Most importantly, this theme aligns with the principles of the Innovation Systems Theory. This theory posits that innovation is a complex, systemic process influenced by various actors, institutions, and networks within a socio-economic context. In the context of the discussed theme, the Innovation Systems Theory provides a framework to analyze how emerging technologies contribute to social inclusivity and digital equality within the broader societal structure.

Examining this theme through the lens of the Innovation Systems Theory involves considering the interconnected elements shaping the adoption and impact of emerging technologies on social dynamics. It involves an exploration of how different actors, including government bodies, private enterprises, and civil society, collaborate and interact to foster an inclusive and equitable digital landscape.

The United Nations' SDGs and MDGs serve as key components in the broader innovation system, guiding the direction of technological progress towards societal well-being. SDG 10, 'Reduced Inequality,' aligns with the Innovation Systems Theory by emphasizing the importance of addressing disparities within and among countries, acknowledging that a more inclusive innovation system leads to reduced inequality. MDG 8 reinforces the collaborative aspect of the innovation system, emphasizing the need for a global partnership for development, especially in the dissemination of new technologies.

The World Economic Forum's acknowledgement of the paramount importance of social inclusivity and digital equality aligns with the Innovation Systems Theory's recognition of the diverse actors involved in the innovation process. It underscores that achieving these goals requires a systemic approach that involves collaboration among different stakeholders.

In reviewing diverse literature, scholars like Reale (2019), Satalkina and Steiner (2020) contribute to the understanding of the social dimensions within the innovation system. Reale's emphasis on meaningful participation and empowerment aligns with the Innovation Systems Theory, which recognizes the importance of engaging various actors in the innovation process beyond mere access to technology. The study by González-Betancor et al. (2021) contributes by highlighting the impact of digital inequality on educational outcomes, providing insights into how disparities can hinder the overall innovation system by limiting access to knowledge and opportunities.

The International Telecommunication Union (ITU) report further reinforces the systemic nature of digital equality. It emphasizes the role of policies and initiatives in promoting digital inclusion, recognizing that systemic changes are necessary to ensure that the benefits of technological advancements are accessible to all.

Thus, the theme of 'Social Inclusivity and Digital Equality,' viewed through the Innovation Systems Theory, underscores the need for a comprehensive and collaborative approach to innovation. It recognises that achieving inclusivity and equality in the digital age requires addressing systemic factors and engaging diverse actors to shape a more equitable innovation landscape. This aligns with the core principles of the Innovation Systems Theory, emphasizing the interconnected and dynamic nature of the innovation process within a societal context.
In synthesis, the theme is intricately linked to global development goals, as highlighted in SDGs and MDGs and supported by reports from reputable organizations. The literature emphasizes the need for holistic approaches that go beyond mere technological access to address the underlying factors contributing to social inequalities in the digital age. This discussion provides a nuanced understanding of the challenges and opportunities in achieving social inclusivity and digital equality in the context of emerging technologies and sustainable development.

3.1.2 Environmental Sustainability through Technology Adoption

The theme holds significant relevance in the context of Sustainable Development Goals (SDGs) and Millennium Development Goals (MDGs). It directly aligns with SDG 11, emphasizing the creation of inclusive, safe, resilient, and sustainable cities and human settlements. The application of technology, particularly in smart city initiatives, plays a crucial role in promoting environmental sustainability by enhancing resource efficiency and minimizing ecological footprints.

The Sustainable Development Goals Report underscores the importance of intelligent urban planning and the creation of safe, affordable, and resilient cities with environmentally friendly living conditions. This aligns with the goal of building modern, sustainable cities to accommodate the growing global population. Additionally, the adoption of sustainable technologies in industries and infrastructure is essential for achieving stability, prosperity, and universal access to information and financial markets.

The United Nations ESG report emphasizes the necessity of transitioning from fossil fuels to renewable energy solutions. The integration of emerging technologies in the energy sector, such as smart grids and renewable energy solutions, is instrumental in ensuring access to affordable, reliable, sustainable, and modern energy for all. This aligns with SDG 7, focusing on affordable and clean energy.

However, the theme also acknowledges challenges associated with technology adoption, such as the generation of electronic waste (e-waste), highlighting the importance of a holistic approach that considers the entire life cycle of products. The literature points to the transformative impact of technologies like the Internet of Things (IoT), artificial intelligence, and blockchain in mitigating environmental challenges. For instance, IoT-based sensors enable real-time monitoring for efficient water and energy management, waste reduction, and precision agriculture.

Smart city initiatives showcase the integration of technology for environmental sustainability, optimizing energy consumption and reducing carbon emissions. Despite these positive contributions, the study recognizes the need for responsible technology adoption to address potential environmental risks.

Numerous studies emphasize the pivotal role of emerging technologies in mitigating environmental challenges. Technologies such as the Internet of Things (IoT), artificial intelligence, and blockchain are harnessed to enhance resource efficiency, monitor environmental parameters, and facilitate sustainable practices (Perera et al., 2023). For instance, IoT-based sensors enable real-time monitoring of environmental factors, aiding in efficient water and energy management, waste reduction, and precision agriculture (Hekkert *et al*., 2020).

The concept of smart cities, facilitated by technological advancements, is a testament to the integration of technology for environmental sustainability. Smart city initiatives leverage digital innovations to optimize energy consumption, reduce carbon emissions, and enhance overall urban sustainability (Szakálné Kanó *et al*., 2023). These initiatives align with SDG 11 (Sustainable Cities and Communities) and contribute to creating environmentally resilient urban spaces.

Moreover, the extant literature highlights the transformative impact of technology on renewable energy adoption. The integration of renewable energy technologies, supported by digital solutions, plays a pivotal role in achieving SDG 7 (Affordable and Clean Energy). Technologies such as smart grids, energy storage systems, and renewable energy forecasting contribute to the efficient utilization of clean energy sources (Wei *et al*., 2023).

However, the study also acknowledges challenges and potential environmental risks associated with technology adoption. For instance, the rapid proliferation of electronic waste (e-waste) raises concerns about the environmental impact of technology-driven consumption (Hegre *et al*., 2020). Sustainable technology adoption necessitates a holistic approach that considers the entire life cycle of products, from design to disposal.

In the context of the Innovation Systems Theory, the theme 'Environmental Sustainability through Technology Adoption' explores the societal impact of technological advancements on the environment. Aligned with SDG 11, emphasizing sustainable cities, technology integration in smart city initiatives optimizes resource efficiency. The Innovation Systems Theory recognizes the collaborative efforts shaping a sustainable urban environment.

The United Nations ESG report emphasizes transitioning to renewable energy, aligning with SDG 7. Emerging technologies like smart grids contribute to affordable and clean energy. Challenges, such as e-waste, highlight the need for a holistic approach. IoT, AI, and blockchain showcase transformative impacts, emphasizing the dynamic nature of the innovation system.

Acknowledging potential environmental risks aligns with the Innovation Systems Theory, recognizing unintended consequences. The study underscores the importance of a collaborative and systemic approach, resonating with the principles of comprehensive strategies in technological transitions.

In conclusion, the extant literature substantiates the theme of environmental sustainability through technology adoption, showcasing the positive contributions of emerging technologies to address environmental issues and achieve SDGs. It underscores the need for responsible and mindful adoption of technology to maximize benefits while mitigating potential drawbacks, aligning with the overarching goal of creating a sustainable and resilient future. SDG 9 focuses on building resilient infrastructure, promoting inclusive and sustainable industrialization, and fostering innovation. Technology adoption is a central component in achieving these objectives, especially in creating environmentally sustainable and technologically advanced infrastructure.

3.1.3 Governance and Ethical Implementation of Technology

This emerging theme within the study on the impact of emerging technologies on achieving Sustainable Development Goals (SDGs) and Millennium Development Goals (MDGs) is a pivotal aspect that underscores the need for responsible and ethical use of technology in advancing societal and developmental objectives. This theme encompasses the governance frameworks, policies, and ethical considerations surrounding the deployment and integration of emerging technologies, emphasizing the broader implications for sustainable development.

The United Nations' SDGs and MDGs implicitly recognize the importance of ethical and responsible governance in the implementation of technology. SDG 16, ‘‘Peace, Justice, and Strong Institutions,’’ emphasizes the significance of effective, accountable, and transparent institutions, which are essential for ensuring ethical practices in the

development and deployment of technology. Additionally, MDG 8 calls for the development of a global partnership for development, emphasizing ethical considerations in international cooperation.

The Global Sustainable Development Report (GSDR) of 2022 on governance structures emphasizes that,

"Governance structures play a critical role in shaping the ethical dimensions of technological advancements, ensuring that innovation aligns with sustainable development objectives" (Anon, 2022).

This reflects the acknowledgement of the intertwined relationship between governance, ethics, and the impact of technology on sustainable development. A thorough exploration of this theme involves a review of pertinent literature. The works of scholars such as Bergant (2021) highlight the need for robust governance frameworks that guide the ethical development and deployment of technology. Bergant (2021) argues that ethical considerations should be integrated into the entire lifecycle of technological innovation, from design to implementation.

Comparatively, Anon. (2020) emphasizes the importance of collaborative governance models that involve multiple stakeholders, including governments, industry players, and civil society, in shaping ethical guidelines for technology. This collaborative approach aligns with SDG 17, which calls for partnerships to achieve the goals.

Moreover, the Organisation for Economic Co-operation and Development (OECD) guidelines on ethical AI serve as a foundational reference in shaping responsible governance in technology. The guidelines stress the need for transparency, accountability, and inclusivity in the development and deployment of AI technologies, resonating with the broader objectives of sustainable development (Anon, 2019).

Furthermore, the theme can be comprehensively analyzed through the lens of the Innovation Systems Theory. The Innovation Systems Theory emphasizes the interconnectedness of actors, institutions, and technologies in shaping the direction and impact of innovation within a societal context. In the context of social inclusivity and digital equality, the theory underscores the collaborative efforts required for the effective integration of emerging technologies into society, ensuring that benefits are shared equitably.

SDG 10, focusing on reduced inequality, aligns closely with the principles of the Innovation Systems Theory. The theory recognizes that addressing social, economic, and technological disparities requires a systemic approach involving various stakeholders, including governments, businesses, and communities. Achieving digital equality is viewed not merely as a matter of providing access but as a broader goal involving meaningful participation and empowerment, echoing the Innovation Systems Theory's emphasis on collaborative and inclusive innovation processes.

The World Economic Forum's assertion that achieving social inclusivity and digital equality is paramount for realizing the full potential of emerging technologies resonates with the Innovation Systems Theory. The theory suggests that innovations are most effective when they consider diverse perspectives and needs, fostering a collaborative ecosystem where different actors contribute to shaping the direction of technological progress.

Diverse literature, including works by Markard (2020), Midgley and Lindhult (2021), and Bergant (2021), further reinforces the Innovation Systems Theory's principles in addressing digital divides. These studies emphasize the need for holistic approaches that go beyond mere technological access, aligning with the theory's view of innovation as a multidimensional and interconnected process.

The International Telecommunication Union's emphasis on policies and initiatives for digital inclusion aligns with the Innovation Systems Theory's recognition of the role of institutions in shaping innovation trajectories. The theory suggests that supportive policies and frameworks are essential for fostering an inclusive innovation environment.

In synthesis, the theme of Social Inclusivity and Digital Equality, when viewed through the lens of the Innovation Systems Theory, underscores the need for collaborative, inclusive, and systemic approaches to ensure that emerging technologies contribute to reducing inequalities and promoting digital inclusion. The theory provides a conceptual framework for understanding the interconnected dynamics of innovation processes and the role of various actors in shaping a more inclusive technological future.

Conclusively, the theme of Governance and Ethical Implementation of Technology is inherently linked to the achievement of SDGs and MDGs. The literature underscores the importance of governance structures and ethical considerations in guiding the trajectory of technological advancements for societal benefit. The integration of ethical principles into governance frameworks is crucial for ensuring that emerging technologies contribute positively to

sustainable development goals. This comprehensive discussion provides insights into the challenges and opportunities associated with the ethical governance of technology within the context of global development.

3.1.4 Mobile Technology for Global Development

This theme addresses the transformative role of mobile technology in fostering global progress in the attainment of Sustainable Development Goals (SDGs) and Millennium Development Goals (MDGs). This theme explores the multifaceted contributions of mobile technology to various aspects of development, aligning with the overarching objectives of sustainable development.

Against this background, the International Telecommunication Union (ITU) report of 2022, reiterates that, "Mobile technology serves as a catalyst for global development by enhancing connectivity, access to information, and opportunities for socio-economic advancement" (Anon, 2022).

This excerpt encapsulates the central role mobile technology plays in advancing the SDGs and MDGs. Mobile technology has a profound impact on SDG 9, "Industry, Innovation, and Infrastructure," by fostering innovation in communication and connectivity. Additionally, it aligns with MDG 8, emphasizing the importance of technology transfer and global partnerships for development.

Scholars like Adeniyi *et al*. (2020) and Dhiman (2023) highlight the transformative potential of mobile technology in addressing challenges related to poverty, healthcare, education, and financial inclusion. Adeniyi et al. (2012) argue that mobile technology serves as a tool for inclusive development, providing marginalized communities with access to essential services and information.

Dhiman (2023) delves into the concept of mobile-mediated development, emphasizing how mobile technology facilitates socio-economic advancements in developing regions. The study underscores the role of mobile phones in enhancing communication, healthcare delivery, and economic activities, contributing to the broader goals of sustainable development.

Comparatively, the World Economic Forum (WEF) report on "The Mobile Economy" (2021) provides insights into the economic impact of mobile technology globally. It states, "Mobile technology drives economic growth, job creation, and innovation, serving as a key enabler for achieving development goals" (Anon., 2021).

This aligns with the study's focus on the impact of mobile technology on economic growth and decent work (SDG 8). Furthermore, empirical studies by Khan *et al*. (2022) and Alrabei *et al*. (2022) offer valuable insights into the role of mobile technology in agriculture and financial inclusion, respectively. Khan *et al*. (2022) demonstrates how mobile phones contribute to agricultural development by providing farmers with real-time market information, while Alrabei *et al*. (2022) showcase the potential of mobile money services in promoting financial inclusion and reducing poverty.

Conclusively, the theme of Mobile Technology for Global Development underscores the pivotal role of mobile technology in advancing SDGs and MDGs. The literature provides a comprehensive understanding of how mobile technology contributes to various facets of global development, including economic growth, healthcare, education, and poverty reduction. This discussion offers nuanced insights into the transformative potential of mobile technology as a catalyst for inclusive and sustainable global development.

3.1.5 Technological Innovation for Economic Growth and Decent Work

The theme of "Technological Innovation for Economic Growth and Decent Work" within the study on the impact of emerging technologies on achieving Sustainable Development Goals (SDGs) and Millennium Development Goals (MDGs) addresses the dynamic relationship between technological innovation, economic growth, and the promotion of decent work. This theme delves into how technological advancements drive economic progress while ensuring fair and sustainable employment opportunities.

Quoting from the World Economic Forum (WEF) report on "Global Competitiveness" (2022), it highlights, "Technological innovation is a key driver of economic growth and plays a crucial role in shaping the landscape of decent work by creating new job opportunities and enhancing productivity" (Anon., 2022).

This statement encapsulates the integral connection between technological innovation, economic development, and the quality of employment.

In the context of SDGs and MDGs, technological innovation contributes significantly to SDG 8, "Decent Work and Economic Growth." It aligns with MDG 1, which focuses on eradicating extreme poverty and hunger through sustainable economic development.

The literature on this theme is diverse, providing insights into the multifaceted impact of technological innovation on economic growth and employment. Notable contributions come from scholars such as Acemoglu and Restrepo (2022) and Da Roit and Iannuzzi (2023).

Acemoglu and Restrepo (2022) explored the implications of automation and technological change on employment dynamics. Their study emphasizes the need for policies that foster inclusive innovation, ensuring that the benefits of technological advancements translate into broad-based economic growth and decent work opportunities.

Da Roit and Iannuzzi (2023) delve into the concept of the "second machine age," highlighting how digital technologies contribute to productivity gains and economic growth. However, they also discuss the challenges related to skill mismatches and the potential displacement of certain job categories.

Additionally, reports from the International Labour Organization (ILO) provide valuable insights into the intersection of technological innovation and decent work. The ILO report on "The Future of Work" (2019) underlines the importance of shaping technological advancements to promote inclusive and sustainable employment. It states, "Technological innovation should be harnessed to create decent work opportunities, enhance skills, and reduce inequality" (Anon., 2019).

Empirical studies by Arntz *et al.* (2022) and Bessen (2023) further contribute to the discussion. Arntz *et al*. (2022) examine the impact of automation on job tasks, highlighting the need for workforce adaptability. Bessen (2023) explores the historical perspective of technological innovation and its effects on employment, emphasizing the role of complementary skills in sustaining decent work.

In sum, the theme of Technological Innovation for Economic Growth and Decent Work underscores the pivotal role of technological advancements in shaping economic landscapes and employment dynamics. The literature provides a nuanced understanding of the challenges and opportunities associated with technological innovation, offering insights into how policies and strategies can ensure inclusive and sustainable economic growth with decent work opportunities.

3.2 Discussion

The impact of emerging technologies on achieving Sustainable Development Goals (SDGs) and Millennium Development Goals (MDGs) is intricate and multifaceted, reflecting both positive contributions and potential challenges.

Emerging technologies, particularly those related to environmental sustainability, have made significant strides in advancing SDGs. The adoption of smart grids, renewable energy solutions, and IoT-based sensors contributes to efficient energy management and the creation of environmentally resilient urban spaces. These innovations align with the overarching goal of creating sustainable and technologically advanced infrastructure (SDG 9) and specifically address Affordable and Clean Energy (SDG 7) and Sustainable Cities and Communities (SDG 11).

However, the positive impact is not uniform across all dimensions. Social inclusivity and digital equality, essential for achieving SDG 10 (Reduced Inequality), face challenges. Despite the potential of emerging technologies to foster inclusivity, issues such as the digital divide persist. Literature by Comi *et al*. (2022) and Chen *et al*. (2022) emphasizes the need for holistic approaches to address digital inequalities and ensure meaningful social inclusivity. Additionally, ethical considerations surrounding the use of Artificial Intelligence (AI) and big data pose challenges that may hinder progress toward social equality.

The innovation systems theory provides a valuable framework for understanding the complexities of this impact. This theory underscores the interconnectedness of actors, institutions, and technologies in shaping innovation trajectories. In the context of SDGs and MDGs, the theory highlights the importance of collaborative and inclusive innovation processes that consider diverse perspectives and needs. This aligns with the goals of social inclusivity and equitable technology access.

The challenges associated with the generation of electronic waste (e-waste) underscore a critical environmental concern that poses potential obstacles to achieving SDGs related to environmental sustainability. E-waste, comprising discarded electronic devices, poses significant threats due to its toxic components and the volume of waste generated globally. Hegre *et al*. (2020) emphasize the environmental impact of technology-driven consumption, shedding light on the escalating issue of e-waste. As societies increasingly rely on and upgrade electronic devices, the disposal and mismanagement of these devices contribute to environmental degradation. E-waste contains hazardous materials such as lead, mercury, and other toxic substances that, when improperly handled, can

contaminate soil and water, posing risks to ecosystems and human health.

In conclusion, while emerging technologies contribute significantly to specific SDGs and MDGs, challenges and ethical considerations necessitate careful navigation.

4 Conclusion and Recommendation

4.1 Conclusion

The study on the impact of emerging technologies on achieving Sustainable Development Goals (SDGs) and Millennium Development Goals (MDGs) reveals a nuanced landscape where technological advancements play a pivotal role in shaping the trajectory of global development. The exploration of various themes, such as environmental sustainability through technology adoption, social inclusivity, and digital equality, underscores the complex interplay between technology and the aspirations of international frameworks.

The examination of the environmental sustainability theme elucidates the positive contributions of emerging technologies, particularly in smart city initiatives and renewable energy adoption, aligning with SDG 11 and SDG 7. However, it also acknowledges challenges, such as electronic waste generation, emphasizing the necessity for responsible and holistic approaches to technology adoption.

Similarly, the analysis of social inclusivity and digital equality highlights the critical importance of ensuring equitable access to and meaningful participation in the digital era. SDG 10's emphasis on reducing inequality, coupled with insights from reputable reports and literature, accentuates the need for comprehensive strategies to address digital divides and foster inclusivity.

The overarching discussion on the impact of emerging technologies on SDGs and MDGs elucidates the transformative potential of technology in advancing global development. Reports from the World Economic Forum, United Nations, and International Telecommunication Union corroborate the significance of social inclusivity, digital equality, and environmental sustainability in harnessing the benefits of technological progress.

However, the study recognizes the potential impediments posed by challenges like e-waste generation, urging a holistic approach informed by Hegre *et al*.'s call for considering the entire life cycle of products. This underscores the importance of responsible consumption, circular economy practices, and collaborative efforts across sectors to mitigate adverse environmental impacts.

In essence, the study contributes to the discourse on the role of emerging technologies in achieving global development goals, shedding light on both the opportunities and challenges that accompany technological advancements. As the world navigates an increasingly digital future, it becomes imperative to integrate ethical, sustainable, and inclusive practices to ensure that the benefits of technology are shared equitably and contribute meaningfully to the realization of a more sustainable and just world.

4.2 Recommendation

To address challenges related to social inclusivity and digital equality, robust digital inclusion policies are recommended. Governments and organizations should collaborate to bridge the digital divide by implementing initiatives that provide affordable and accessible technology, digital literacy programs, and targeted efforts to include marginalized populations. Given the environmental concerns associated with electronic waste, the study recommends the development and implementation of comprehensive e-waste management strategies. This includes promoting recycling programs, implementing extended producer responsibility (EPR) policies, and raising awareness about the proper disposal of electronic devices. Moreover, the complexity of challenges and opportunities presented by emerging technologies necessitates fostering multi-stakeholder collaboration. Governments, businesses, academia, and civil society should collaborate to formulate comprehensive policies, standards, and practices that address the ethical, social, and environmental dimensions of technology adoption.

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Authors

Yaw Ofori is a Senior Assistant Librarian at the University of Mines and Technology, Tarkwa, Ghana with a wide range of experience in the library profession. He holds M.A degree in Library Studies and B.A degree in Information Studies, both from the University of Ghana. He is a member of the Ghana Library Association. His research interests include providing information for employee safety in mining companies, collection development in libraries and application of technology in information delivery.

Beatrice Arthur is a Senior Assistant Librarian at the Kwame Nkrumah University of Science and Technology, Kumasi, Ghana with a considerable experience in the library profession. She holds PhD Degree in Information Science from the University of South Africa and M.A Degree in Library Studies from the University of Ghana. Her research areas include research data management, social media, information literacy and computer application in Libraries.

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