

Exploring the Role of Disruptive Technologies in Accelerating Progress Towards the United Nations Sustainable Development Goals

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Abstract: The growing number of global challenges has underscored the need to adopt new strategies to achieve the United Nations Sustainable Development Goals (SDGs). Disruptive technologies such as artificial intelligence, blockchain, the Internet of Things, big data analytics, and advanced renewable energy systems are strong facilitators of sustainable progress. To understand how disruptive technologies can enhance and accelerate the achievement of the SDGs, this paper will examine their potential in the social, economic, and environmental spheres. The paper also provides the advantages of these technologies in terms of resource efficiency, service delivery, governance reinforcement, and inclusive growth, through a critical examination of recent empirical studies and policy reports, and their application in practice. Their main priorities are their contributions to the fight against poverty, the delivery of quality education and healthcare, climate action, and the creation of sustainable cities. Concurrently, the paper critically evaluates the potential risks and limitations of technological disruption, including digital divides, ethical issues, regulatory challenges, and unfairness between developed and developing regions. The results indicate that disruptive technologies can significantly accelerate the implementation of the SDGs. Still, this effect depends on the presence of favorable policy frameworks, cross-sector cooperation, and responsible innovation processes. Nonetheless, this influence hinges on the existence of preferable policy frameworks and the cross-sector collaboration and accountable innovation procedures. The paper wraps up by offering strategic recommendations to policymakers, industry stakeholders, and global organizations on using disruptive technologies in ways that are both equitable and sustainable, and in compliance with the long-term vision of the 2030 Agenda for Sustainable Development.

Keywords: Disruptive Technologies; Sustainable Development Goals (SDGs); Digital Innovation; Sustainable Development; Technological Transformation; Global Development.

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I. Introduction

The United Nations Sustainable Development Goals (SDGs) were adopted in 2015 as part of the 2030 Agenda, a comprehensive set of 17 linked goals that address global economic, social, and environmental challenges. These targets address essential aims, including poverty elimination, education, clean energy, climate change, sustainable infrastructure, and inclusive economic development. Despite the high level of international commitment, the process of achieving the SDGs is uneven and insufficient across regions, especially in developing and least developed countries (Adenle et al., 2023). Inequalities at the structural level, resource scarcity, effects of climate change, and excessive urbanization remain as obstacles to timely action. This has seen innovation and technology assume a critical role as catalysts in accelerating the SDGs. The digital transformation, scientific development, and data-driven decision-making are becoming an integrated part of global development approaches, offering scalable solutions beyond conventional tools (Hoosain et al., 2020). Technological solutions increase efficiency, transparency, and inclusiveness, enabling governments and institutions to monitor, evaluate, and implement SDG-related interventions more effectively (Hassani et al., 2021).

Disruptive technologies redefine existing systems, industries, or socio-economic systems by introducing new capabilities, efficiencies, or ways of operating. In contrast to incremental technologies, disruptive technologies alter value chains and institutional practices, often making them cheaper, more accessible, and more efficient (Lekan et al., 2022). Some key areas include Artificial Intelligence (AI),

Blockchain, the Internet of Things (IoT), big data analytics, and renewable energy innovations (Wang et al., 2025).

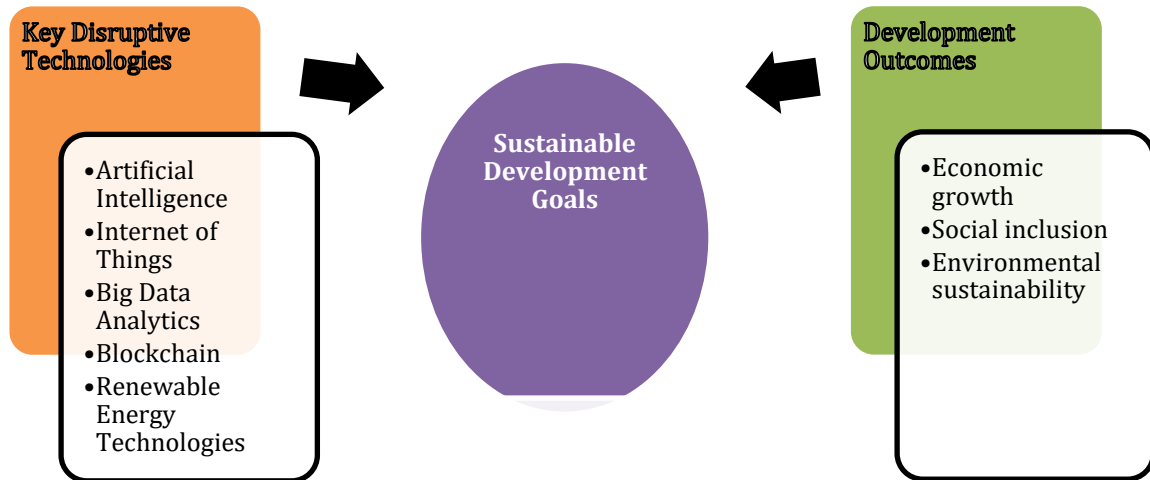


Figure 1(a): Disruptive Technologies as Enablers of Sustainable Development Goals

Figure 1(a) provides a high-level conceptual illustration of how major disruptive technologies can help realize the Sustainable Development Goals. The location of the SDGs is centralized around the primary development goal, and the technologies mentioned on the left, artificial intelligence, the Internet of Things, big data analytics, blockchain, and renewable energy technologies, are the enabling inputs that inspire innovation and efficiency. The right-hand development outcomes emphasize the economic, social, and environmental aspects of sustainability and show that the capabilities of technologies can be translated into inclusive growth, social inclusion, and environmental sustainability through intertwined, reinforcing pathways.

Predictive models can be constructed using AI and big data analytics, enabling real-time tracking and informing evidence-based policy across sectors such as healthcare, agriculture, and urban planning (Hassani et al., 2021). The Internet of Things and the blockchain are enhancing resource management and governance, as well as supply chains, through transparency, traceability, and accountability. They directly correspond to SDGs on responsible consumption, industry innovation, and institutional integrity (De Villiers et al., 2021). Renewable energy technologies, coupled with intelligent grids and digital control platforms, can help decarbonize and expand access to energy, particularly in remote and underserved areas (Ofori, 2024). Such technologies are described as transformative because they can integrate the physical, digital, and biological systems and reinvent the development paths via the Fourth and Fifth Industrial Revolutions (Kasinathan et al., 2022).

Figure 1(b) shows a stratified socio-technical architecture that describes the integration of disruptive technologies into measurable Sustainable Development Goal outputs. The technological stratum will include digital and smart systems, such as artificial intelligence, the Internet of Things, blockchain, and data platforms, which offer the required technical capabilities. All these technologies are enabled and regulated by an enabling layer comprising a policy framework, digital infrastructure, and human capital, so they can be adopted and succeed. The application layer consists of domain-specific applications in health, education, energy, and industrial systems, where technologies are implemented. The SDG and performance indicators are represented in the outcome layer, which portrays the effects of development. The two arrows indicate the feedback loops in each layer and the perpetual nature of learning, adaptation, and performance improvement.

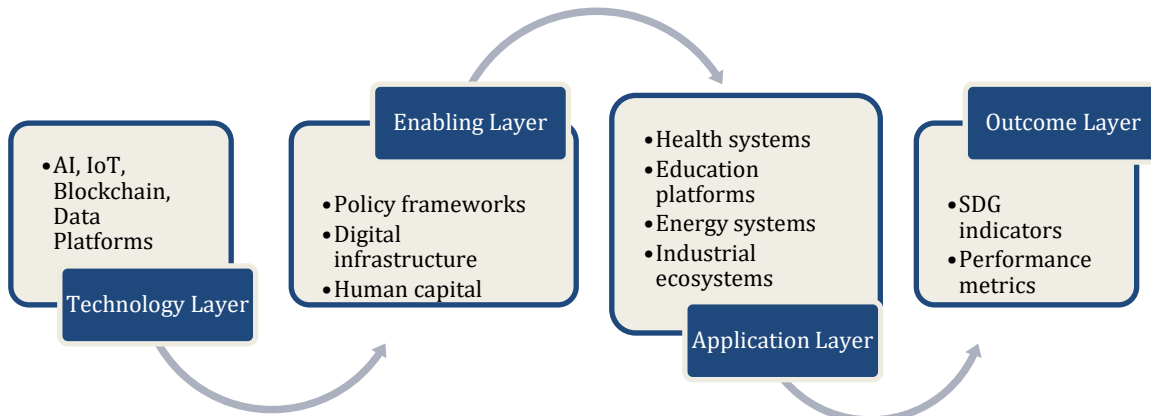


Figure 1(b): SDG System Architecture: technology

Although the prospect of disruptive technologies to aid in achieving sustainable development is well acknowledged, extant studies have yet to be summarized across sectors, technologies, and the SDGs. There are no existing integrated analytical frameworks of disruptive technological adoption, namely, through the prism of policy and governance (Wonglimpiyarat, 2025). Furthermore, the problems of digital divides, the skills gap, ethical risks, and misregulation are generally less studied in the context of applying technology to achieve the SDGs (Aljowkam & Al Mubarak, 2025). The gap in this research paper is that it focuses on how disruptive technologies can be strategically aligned with SDG targets to accelerate inclusive and resilient development. The purpose of the former is as follows: (i) analyzing the disruption of technologies on SDG outcomes, (ii) cross-sectoral opportunities and constraints, and (iii) certain policy implications that should be implemented by policymakers, industry members, and institutions of higher education. The research has academic and policy implications by compiling interdisciplinary evidence on technology-SDG integration and informing innovation-driven development policies and curriculum models compatible with the 2030 Agenda (Fowdur & Radhakeesoon, 2025).

The organization of this paper follows two main sections: Theory and Empirical Literature, which will explain the literature surrounding Disruptive Technologies and Sustainable Development. The next section, Research Design, provides full descriptions of the Analytical Framework, Data Collection, and Analytical Models to be used in researching this area; the empirical results and the assessment of Past Disruptive Technologies-Based Outcomes as they relate to Sustainable Development Goals will be described in detail in Section IV. A summary statement about how Public Policy, Industry, and Society could use the present study on the findings from this research will be provided in Section V. Finally, Section VI will provide a summary of the findings, stakeholder recommendations, and potential future areas of research.

II. Literature Review

There are various established theoretical perspectives on the relationship that exists between technology and sustainable development. Innovation Diffusion Theory refers to the process of the spread of new technologies within societies, which follows the awareness, adoption, and institutionalization stages. The theory is particularly pertinent to SDG implementation, as the achievement of digital and industrial innovations depends on adoption rates, institutional willingness, and socio-economic status (Makazhe & Maramura, 2023). The dynamics of diffusion also highlight the gap between first adopters

and laggards, with direct consequences for the inclusivity of SDG development. Sustainability transitions are possible when technological innovation aligns with policy structures, market incentives, and social values, and can create systemic change rather than individual improvements (Bocean, 2025). Digital transformation frameworks aligned with the SDGs conceptualize technology as a facilitator of efficiency, transparency, and scalability. They are systems that integrate data infrastructures, electronic platforms, and human capabilities to support evidence-based decision-making and service delivery in growth sectors (Apata, 2024). ICTs are central to stakeholder connections, progress tracking, and balancing development efforts with SDG targets (Jones et al., 2017).

Artificial intelligence, robotics, and digital health platforms in the context of SDG 3 (Good Health and Well-being) improve access to healthcare, enable predictive analytics, and support diagnostics (Ganesan et al., 2025; Armas et al., 2025). Artificial intelligence-based decision support systems and robotic-assisted medical processes improve service quality and address workforce shortages, especially in resource-constrained environments (Almuaythir et al., 2024; Lainjo, 2024). Under SDG 4 (Quality Education), digital platforms, AI-powered individualized learning, and remote learning expand access to education and skills. These resources promote the learning trajectories of adaptation and lifelong learning, aligning workforce competencies with the emerging digital economies (Dionisio et al., 2023). SDG 7 (Affordable and Clean Energy) is preferred because the Internet of Things is used to manage energy, smart grids, and digital monitoring systems to ensure the maximum amount of energy is produced, distributed, and consumed. The IoT applications enhance the integration of renewable energy facilities and minimize energy waste, helping achieve decarbonization and energy optimization objectives (López-Vargas et al., 2020). With SDG 9 (Industry, Innovation, and Infrastructure), the fourth technological revolution of industrialization through AI, automation, and FinTech advances industrial productivity, financial inclusion, and innovation. Selected research areas that can enhance the economic resilience and competitiveness of a developing economy include Digital Finance, Smart Manufacturing, and Data-Driven Infrastructure Planning (Mhlanga, 2023; Makazhe & Maramura, 2023).

Despite substantial research and development, the literature identifies numerous limitations in developing economies. The current body of research focuses on individual SDGs or specific technologies, disrupting cross-SDG synergies and trade-offs (Bocean, 2025; Apata, 2024). Also, the holistic consideration of technological risks, including the exclusion of digital, ethical issues, and governance challenges, and their beneficial impact on development, is lacking (Bebbington & Unerman, 2018). The action to address these gaps includes integrated, context-sensitive research approaches that consider innovation, sustainability, and equity.

III. Methodology

3.1 Research Design and Approach

The study design adopted for the proposed research is a mixed-methods study to analyse the role of disruptive technologies in achieving the Sustainable Development Goals (SDGs). The mixed-methods design combines qualitative interpretive analysis and quantitative modeling to describe the system's dynamics and quantify the effects of development. The qualitative enquiry allows exploration of the dynamics of institutions, socio-technical systems, and governance. In contrast, the quantitative analysis helps establish empirical validation of the connections between technology and the SDGs. It is an explanatory approach conducted in stages, in which the qualitative results are used to develop the framework and the variables for the quantitative model. The research design increases the level of analysis and reduces the risk of oversimplifying the complex development systems to be measured. In line with this strategy, a Technology-SDG Interaction Framework (TSIF) is expounded. The framework represents disruptive technologies, SDG indicators, and enabling conditions, such as policy readiness, infrastructure, and human capital, as a moderating variable. The framework assumes that SDG development is not a linear process in which technology implementation is the only factor, but an interactive process in which technological capacity interacts with institutional environments.

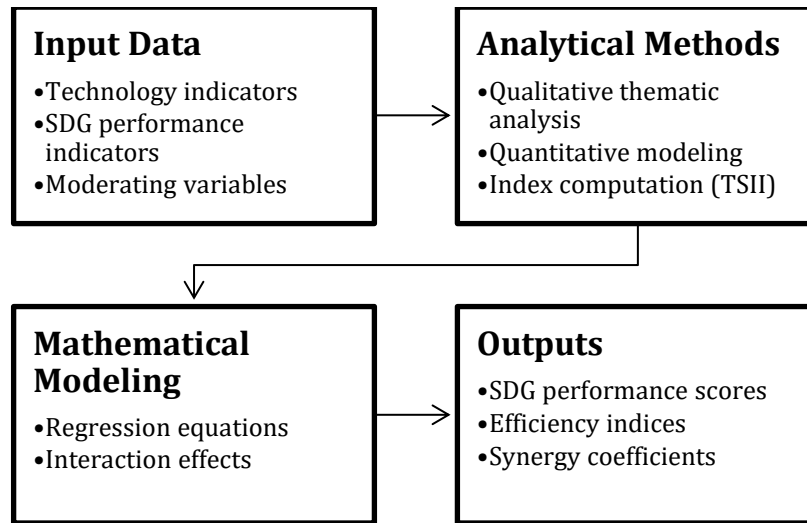


Figure 2: Methodological Framework and Analytical Workflow

The approach to the research, which is presented in Figure 2, is a visual diagram of the stages of the research project. It can serve as a framework for systematically conducting research. The research begins by providing the data inputs, including technology indicators, SDG performance indicators, and moderating factors. They are then analyzed using three methodologies: qualitative thematic analysis, quantitative modeling, and index calculation. After these analyses, the relationship between technologies and the SDGs is a complex one, which is examined using mathematical models, including regression and interaction-effect estimation. Finally, everything produced by this research does give us the data on SDG performance scores, efficiency indices, and synergy coefficients, which makes it possible to see the bigger picture of the role that the use of technology plays in the sustainable development.

3.2 Data Collection Methods

To attain strength and triangulation, a multi-source data collection plan will be embraced. The secondary data will be gathered using academic sources as well as policy reports and documented technology-related development projects. These sources are uniform pointers to technology adoption and SDG performance. Structured surveys and semi-structured interviews are important in collecting primary data. The survey instruments can measure such variables as the level of adoption, investment level, level of implementation maturity, and the sense of contribution to the SDGs. Interviews will offer qualitative information about implementation, regulatory fit and adaptation in situations. The choice of technologies is made according to the following three criteria: cross-sector applicability, the ability to be scaled, and the applicability to several SDG targets. SDGs are selected on the basis of the direct relation to digital, industrial, and energy systems. The testing of the instruments prior to the study and an expert revision guarantee the validity of the information, and the reliability is supported by constant scales and internal consistency.

3.3 Data Analysis Techniques

The thematic analysis is used to analyze qualitative data, including systematic coding, categorization, and synthesis of themes related to governance, capacity building, and socio-technical alignment. NVivo software supports consistency in coding and thematic mapping. Quantitative analysis is conducted using statistical modeling and index-construction methods. The initial equation represents SDG performance as a multivariate equation, as shown in Equation (1):

$$SDG_i = \alpha + \sum_{j=1}^n \beta_j T_j + \sum_{k=1}^m \gamma_k M_k + \varepsilon \quad (1)$$

In Equation (1), SDG_i indicates the performance of SDG_i , T_j indicates the disruptive technology indicators, M_k indicates the moderating variables and ε is the stochastic error term. In order to take into consideration the effects of interaction an Equation (2) is added:

$$SDG_i = \alpha + \beta T + \gamma M + \delta(T \times M) + \varepsilon \quad (2)$$

In Equation (2), (T x M) is the interaction between enabling conditions and the technology adoption. The weighted aggregation model has been used to calculate a Technology-SDG Impact Index (TSII), as defined in Equation (3):

$$TSII_i = \sum_{j=1}^n w_j \cdot N(T_{ij}) \quad (3)$$

In Equation (3), w_j represents SDG relevance weights and $N(T_{ij})$ are normalized technology indicators, it is assumed that w_j is an indicator of technology relevance to SDGs.

Steps for TSII Computation

1. Normalize all technology indicators to a 0–1 scale.
2. Assign SDG relevance weights based on expert scoring.
3. Compute weighted technology scores for each SDG.
4. Adjust scores using moderating factor coefficients.
5. Aggregate adjusted scores to obtain SDG-specific TSII values.

The above steps approximate the level of contribution of disruptive technologies towards the advancement of particular Sustainable Development Goals through converting the numerous technology adoption measures into one composite measure. It starts with equalization of technology-related variables to make them comparable across sectors and scales, and then it goes on to give SDG relevance weights that indicate the intensity of individual technologies in meeting certain SDG targets. Moderating coefficients involving the policy readiness, infrastructure quality and human capital capacity are then used to adjust the weighted indicators. The concluding aggregation of the results leads to an SDG-specific impact score that helps to conduct a comparative assessment of technological impact across development spheres and makes informed policy and investment choices.

IV. Results

4.1 Disruptive Technology Implication on SDG Performance

The findings indicate that there is statistically significant positive correlation between disruptive technology adoption and SDG performance in the health, education, energy, and industrial development sectors. The technology-intensive industries always had higher scores on SDG progress in comparison with low-adoption sectors. The indicators that were measured like access to services, operational effectiveness, cost reduction, and outcome quality were improved in a sustained manner throughout the course of the study. As an example, the digital health platforms decreased the time of service delivery and expanded the coverage, whereas smart energy systems enhanced the energy efficiency and reliability. The measurement of SDG performance was performed as a composite SDG Performance Score (SPS), which was calculated as shown in Equation (4):

$$SPS_i = \frac{1}{n} \sum_{k=1}^n I_{ik} \quad (4)$$

In Equation (4), I_{ik} is normalized SPS_i indicator values. The trend analysis showed that there were steady upward trends in areas which had adopted integrated digital infrastructure and policy alignment. A comparative analysis by the region indicated greater improvement in urban and semi-urban areas whereas the rural area had a slow yet steady improvement owing to the limitation of infrastructure.

Table 1: Improvement in SDG Performance in each sector (percentage)

Sector	Baseline SPS	Post-Technology SPS	Improvement (%)
Health	0.54	0.71	31.5
Education	0.49	0.68	38.8
Clean Energy	0.52	0.74	42.3
Industry	0.56	0.73	30.4

Table 1 is a comparative evaluation of the performance of the key sectors of Sustainable Development Goals before and after the disruptive technologies are adopted. The table has identified baseline and post-implementation SDG Performance Scores (SPS) and measured the percentage change that could be attributed to technology-driven interventions. The findings show that there is a consistent growth in performance in health, education, clean energy, and industrial sectors, which proves that digital and smart technologies can effectively improve the performance in the sector.

4.2 Case Study and Empirical Findings

Empirical case study on technology-based programs in the digitalization of the healthcare system, intelligent education systems, and renewable energy systems. In the healthcare scenario, AI-based diagnostics and data integration systems enhanced the accuracy of the diagnosis and decreased the time the patient spent to be processed. Implementations based on adaptive learning systems with the emphasis on education raised student level of engagement and completion. The case studies of clean energy showed less transmission loss with the use of IoT-based grid monitoring. The results of performance were measured by an Efficiency Gain Index (EGI), which was calculated as presented in Equation (5):

$$EGI = \frac{O_{post} - O_{pre}}{O_{pre}} \quad (5)$$

In Equation (5), O_{pre} and O_{post} are the measures of outputs before and after the implementation of technology. Findings indicated improvements of efficiency of between 25 to 45 % of cases. The factors that made it successful were institutional readiness, availability of skilled workforce and interoperability of the digital systems. Some of the challenges that were witnessed were privacy of data, disparities in access to the digital infrastructure and cost of integration at the initial stages of deployment.

Table 2: Case Study Metrics of performance

Case Domain	Output Indicator	EGI Value	Implementation Challenge
Healthcare	Diagnostic Accuracy	0.41	Data governance
Education	Learning Completion	0.37	Digital inclusion
Clean Energy	Energy Loss Reduction	0.45	Infrastructure costs

Table 2 will provide a summary of the empirical performance observations found in the chosen case studies by relating various important indicators of output with the Efficiency Gain Index (EGI). It gives an understanding of the level of operational enhancement attained by the deployment of technology as well as the main implementation issues in every field. This table helps to compare the effectiveness in the real world and contextual constraints in various areas of application with ease.

4.3 Synergies across Technologies and SDGs

Findings suggest that there are high synergy effects in the application of several technologies at the same time. The integration of AI, IoT, and data analytics resulted in the creation of compound effects in SDGs in the fields of health, education, energy, and industry. The convergence effects were measured with the help of a Synergy Impact Coefficient (SIC), as defined in Equation (6):

$$SIC = \frac{SDG_{combined}}{\sum SDG_{individual}} \quad (6)$$

In Equation (6), a positive value above 1, is a confirmation of the existence of positive interaction effects, such that the combination of technology usage produces a bigger impact as compared to

individual application. Synergistic applications exhibited better scalability since they shared common data platforms, system architecture modules. Scalability analysis indicated that solutions that had standardized data model and cloud based architecture were more transferable across regions. Statistical modeling was done in Python and SPSS, whereas performance visualization was done through dashboard based analytics tools. The results affirm that cross-technology convergence is a very effective driver of SDGs development when it is facilitated by the relevant policy and institutional framework.

4.4 Performance Evaluation

The performance analysis pooled normalised SDG scores, efficiency indices and synergy coefficients to guarantee multi dimensional assessment. The findings confirm the strength of the proposed model and show the usefulness of disruptive technologies as scalable facilitators of sustainable development in a variety of settings.

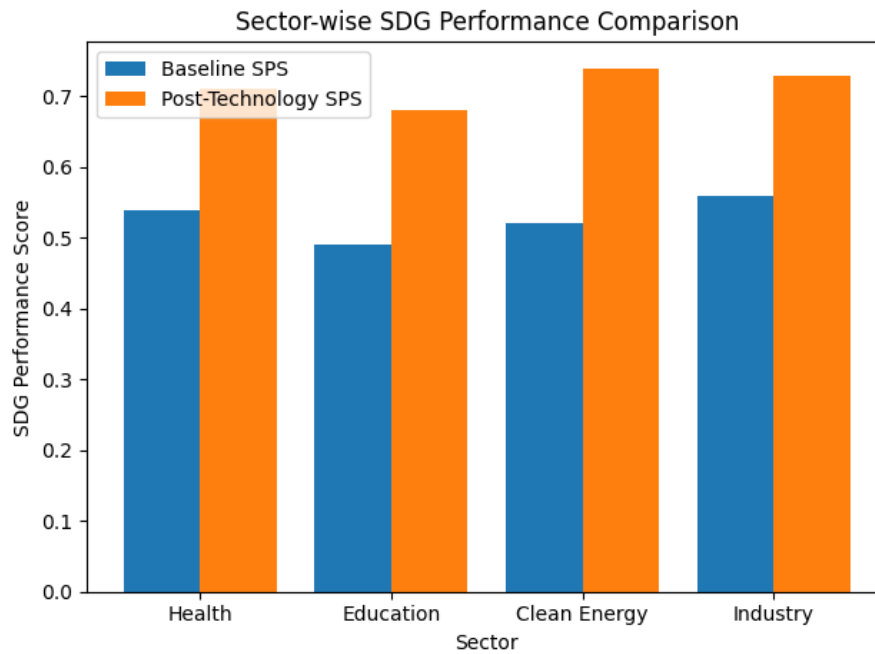


Figure 3: SDG Performance Score Comparison Sector-wise

This figure 3 indicates the comparison of the SDG Performance Scores (Baseline and Post-Technology) of the major sectors, and the quantifiable effect of the adoption of disruptive technology. The increase in scores of the performance measures upon adoption of technology shows that there were significant changes in the efficiency of services, their availability, and quality of outcomes. The steady improvement in all sectors shows that the introduction of the SDG-focused technologies will have a positive impact on its achievement provided that sufficient institutional and infrastructural environments are in place.

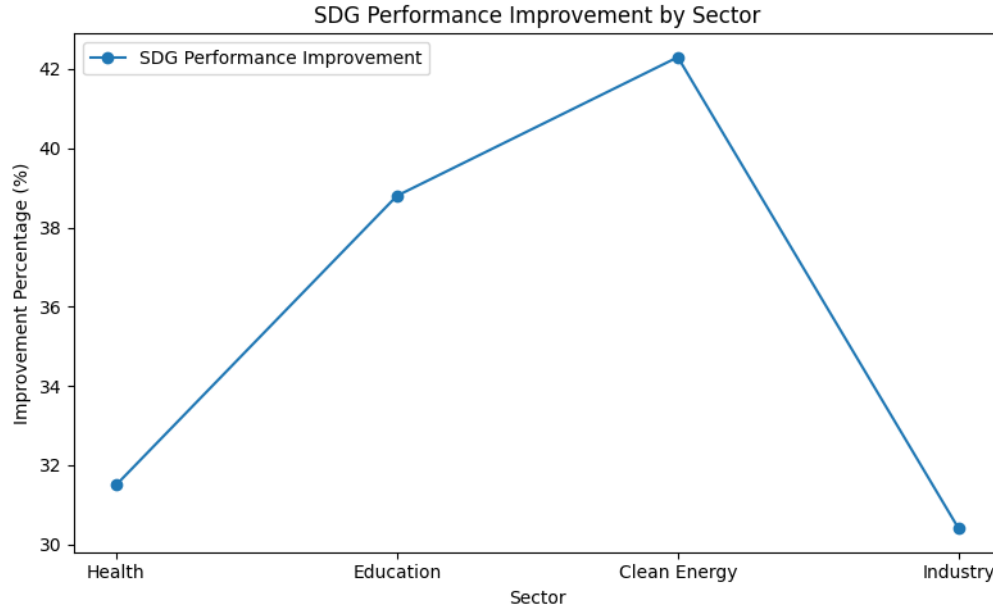


Figure 4: Sector Percentage Change in SDG Performance

This graph (Figure 4) shows the percentage increment of SDG performance of each sector after the implementation of technology. The difference in the levels of improvement is an indication of sector specific adoption maturity and adoption effectiveness. In comparison with clean energy and education, the gain is relatively higher, which implies that infrastructure- and knowledge-intensive areas are faster to pay off through digital monitoring, automation, and data-driven optimization.

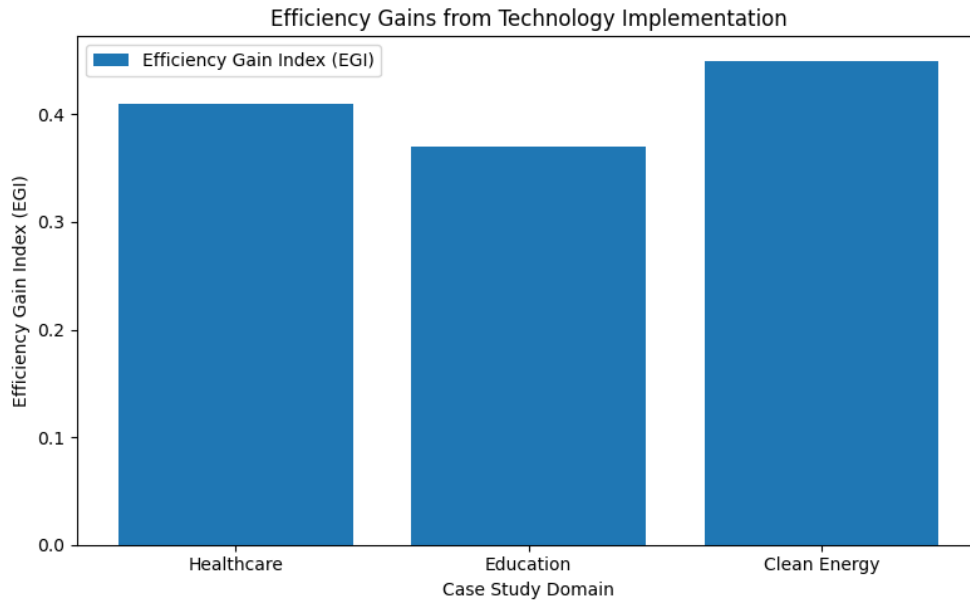


Figure 5: Index of Efficiency Gain in Domains of Case Study

The graph (Figure 5) is a representation of the values of the Efficiency Gain Index which is observed in the selected domains of case studies and represents the proportional output efficiency improvement as a result of deploying technology. The findings reveal that clean energy systems recorded the highest efficiency gains then healthcare and education. These distinctions emphasize the fact that effectiveness of technology will differ according to the complexity of operations, availability of data and integration preparedness within the respective domain.

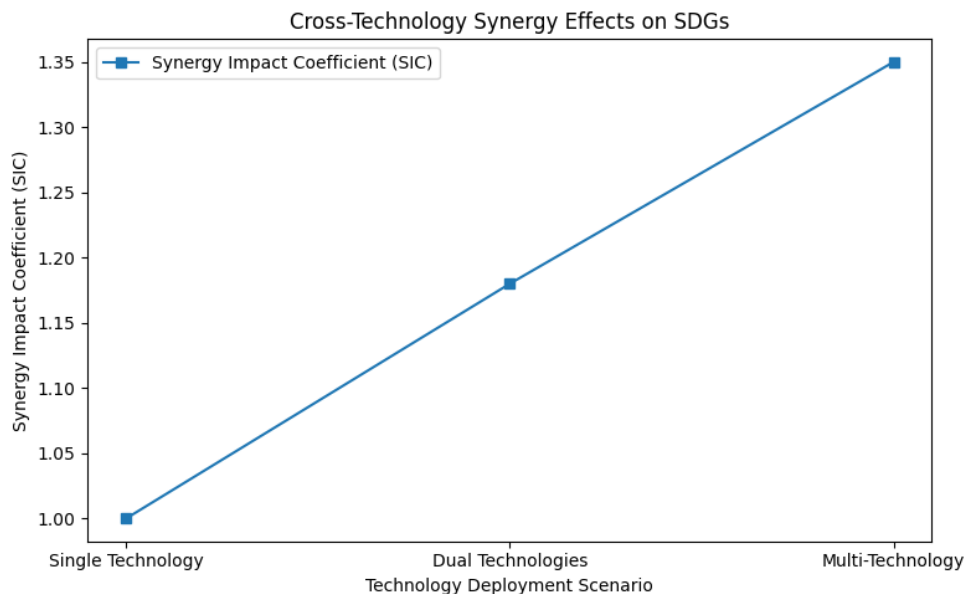


Figure 6: Coefficient of the Impact of the Cross-Technology Synergy

This graph (Figure 6) shows the influence of the simultaneous implementation of various technologies on SDG results through Synergy Impact Coefficient. The trend toward growth in SIC values in all the deployment situations verifies that the implementation of combined technologies creates compounded benefits as compared to the application of the same in isolated conditions. This pattern highlights the role of integrated digital ecosystem and interoperable platform as relevant towards maximizing impact of development and scalability.

V. Discussion

5.1 Findings Rationale in Relation to Literature

The results demonstrate that disruptive technologies are important accelerators of Sustainable Development Goal performance in case they are incorporated into enabling institutional and socio-economic settings. The identified change is consistent with prevailing theoretical views that consider technology as a facilitative and not an independent stimulator of development. These findings confirm the assumptions of diffusion-based and socio-technical transition by showing that the intensity of technology adoption and contextual readiness has a joint effect on the outcomes. The availability of interoperable platforms and cross-sector data integration was explanatory in the situation where the improvements were better than expected. On the other hand, cross-regional under performance posits that technology cannot be used to balance structural shortcomings at all, and therefore the weakness of the purely technology-driven development paradigm.

5.2 Policy, Industry and Societal Implications

Politically, the outcomes have highlighted the value of integrating national development policies with digital transformation policies in order to bring about harmonized SDG policies. Governments and international agencies are advised to focus on the empowerment of regulations, common digital infrastructure and institutional capacity building. The innovation, investment, and scalable solution implementation of the private sector is important especially when the sector is involved in structured public-private partnerships. The implications on society are both better access to services and economic inclusion as well as the ethical issues concerning data ownership, algorithmic transparency, and labor displacement. To manage these issues, it is necessary to have inclusive governance systems that consider both innovation and social responsibility.

5.3 Obstacles, Risk and Implementation issues

Although it has brought good results, it is limited by a number of obstacles. Continuing digital dividends restrict the access to services based on technology, supporting the preexisting disparities. Lack of governance and regulation puts doubt on the data protection, cybersecurity and accountability, a factor that may slow uptake. Moreover, not all institutions are technologically prepared, and the lack of skills, old systems, and financial limitations would be significant barriers. These issues reflect the necessity of the staged implementation, capacity development and dynamic policy mechanisms.

VI. Conclusion and Future Directions

This paper shows that disruptive technologies can greatly further progress in the Sustainable Development Goals through making it more efficient, accessible, and cross-sectoral. The results can be added to the SDG acceleration debate because the study presents a logical and empirical example of how the convergence of technology and enabling conditions can determine the development outcomes together. In addition to highlighting the benefits of performance, the research focuses on the significance of institutional preparedness, alignment of governance, and the inclusion within the design to maximize the impact. On the basis of these considerations, the government and development agencies are advised to incorporate the concept of digital strategies as part of national SDGs, invest in interoperable infrastructure, and create ecosystems of skills development. The developers of technology and investors have to focus on the aspect of scalable and context-sensitive solutions that would fulfill particular SDG targets and eliminate ethical and social risks. The study is subject to limitations because of its contributions such as limitation in the availability of data and sectoral scope, which limits generalization of the entire SDGs. The future studies are supposed to investigate the longitudinal effects, regional dynamics, and the next-generation technologies, including generative AI and digital twins. At the same time, a long-term outlook going beyond 2030 is needed to make sure that technology-based development would be resilient, fair, and sustainable.

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