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HAZRAT ALI

MASTER'S THESIS

TECHNOLOGIJŲ VAIDMUO SUINTERESUOTŲJŲ ŠALIŲ ĮTRAUKIME Į TVARŲ PROJEKTŲ VYSTYMĄ: TENDENCIJOS IR PASEKMĖS	**THE ROLE OF TECHNOLOGY IN STAKEHOLDER ENGAGEMENT FOR SUSTAINABLE PROJECTS DEVELOPMENT: TRENDS AND IMPLICATIONS**

Student _____

(signature)

Supervisor _____

(signature)

Assoc. Prof. Eglė Daunienė

Name, surname of the supervisor

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SUMMARY

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THE ROLE OF TECHNOLOGY IN STAKEHOLDER ENGAGEMENT FOR SUSTAINABLE PROJECTS DEVELOPMENT: TRENDS AND IMPLICATIONS

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Technology's function in stakeholder involvement and sustainability in organizational undertakings is examined in Pakistani organizations. This positivist, deductive study explores technological uptake, stakeholder involvement, and sustainability practices. Data from 300 professionals is analyzed using a correlation study approach. Quantitative, descriptive, correlation, and regression analysis can illuminate technology-enabled sustainability dynamics. The findings show that technology improves communication clarity, audience outreach, and cost efficiency but has little effect on stakeholder participation. The correlation analysis demonstrated a weak, but statistically significant, association between technology use and stakeholder engagement, showing that more factors influence engagement than technology. Since technology explains only 2.6% of engagement variance, regression analysis supports this. Lack of access, high expense, and technology resistance also hinder its success. Despite these restrictions, block chain, corporate intelligence tools, and augmented/virtual reality can increase stakeholder involvement and sustainability. However, organizations' underuse of AI-based solutions

highlights the need for awareness and capacity building. Technology can improve stakeholder participation and sustainability, but it must remove barriers and integrate complementing elements, according to the study. These findings enhance our understanding of technology's role in sustainable development and offer recommendations for organizations seeking stakeholder relationship optimization and sustainability success.

Keywords: Technology adoption, Stakeholder Engagement, Sustainability Practices, Organizational project, Communication clarity, Technology-enabled sustainability.

SANTRAUKA

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Pakistano organizacijose nagrinėjama technologijų funkcija, susijusi su suinteresuotųjų šalių įtraukimu ir tvarumu organizacinėse įmonėse. Šis pozityvistinis, dedukcinis tyrimas tiria technologijų įsisavinimą, suinteresuotųjų šalių įtraukimą ir tvarumo praktiką. 300 specialistų duomenys analizuojami naudojant koreliacijos tyrimo metodą. Kiekybinė, aprašomoji, koreliacinė ir regresinė analizė gali nušviesti technologijų pagrįstą tvarumo dinamiką. Išvados rodo, kad technologijos pagerina komunikacijos aiškumą, auditorijos aprėptį ir ekonomiškumą, tačiau turi mažai įtakos suinteresuotųjų šalių dalyvavimui. Koreliacinė analizė parodė silpną, bet statistiškai reikšmingą ryšį tarp technologijų naudojimo ir suinteresuotųjų šalių įsitraukimo, o tai rodo, kad įsitraukimui įtakos turi daugiau veiksnių nei technologijos. Kadangi technologija paaiškina tik 2,6 % įsitraukimo dispersijos, regresinė analizė tai patvirtina. Prieigos trūkumas, didelės išlaidos ir atsparumas technologijoms taip pat trukdo jos sėkmei. Nepaisant šių apribojimų, blokų grandinė, įmonės žvalgybos įrankiai ir papildyta / virtualioji realybė gali padidinti suinteresuotųjų šalių dalyvavimą ir tvarumą. Tačiau organizacijos nepakankamai

naudoja dirbtiniu intelektu pagrįstus sprendimus, todėl pabrėžiamas sąmoningumo ir gebėjimų ugdymo poreikis. Remiantis tyrimu, technologija gali pagerinti suinteresuotųjų šalių dalyvavimą ir tvarumą, tačiau ji turi pašalinti kliūtis ir integruoti papildomus elementus. Šios išvados pagerina mūsų supratimą apie technologijų vaidmenį tvarioje plėtroje ir siūlo rekomendacijas organizacijoms, siekiančioms optimizuoti santykius su suinteresuotosiomis šalimis ir siekti tvarumo sėkmės.

Raktiniai žodžiai: technologijų pritaikymas, suinteresuotųjų šalių įtraukimas, tvarumo praktika, organizacinis projektas, komunikacijos aiškumas, technologijų įgalintas tvarumas

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1. Introduction

1.1. Background of Study

Digital technology for sustainability is regarded as another emerging interest area to address the need for development of various projects in numerous firms over the recent past (Nejati et al., 2014). Introducing environmentally sustainable practices and adopting innovative technology constitutes a powerful strategy for developing sustainability in project longevity and within a predictable range to provide optimal environmental and social improvement across regional, social, economic, and political contexts (Piacentini and Ceca, 2017; Piccarozzi et al., 2022). In this context, technology is used beneficially to implement environmentally friendly work procedures into the business activities, thereby enhancing resource utilisation efficiency and minimizing the negative effect on the environment (Bertoncelj, 2022). By adopting technologies like cloud computing, IoT, and data analytics, businesses could reduce wastage and consumption of energy and make informed efforts that can back sustainably manufacturing for project management (Hanelt et al., 2015). The application of these technologies contributes to the efficiency of project development, especially at small and medium enterprises, not only in costs but also in relation to environmental factors (Borangiu et al., 2019). Technology also enhances the sustainable management of the supply chain within organizations (Mota et al., 2015). Through blockchain technology, the visibility and accountability of supply chain management may be enhanced so that organizations bear fairness, ethicality, and sustainability in mind. This degree of openness fosters confidence among interested parties and meets the rising demand from customers for environmentally friendly goods and services (Sahu et al., 2023).

In this sense, industrial projects (such as those involving mining, power plants, and production facilities) are capital projects of the private sector that are engineering- and technology-intensive. They are distinguished by their long-time horizons, permanent obligations, uncertain and turbulent environments, and high failure probabilities (Floricel and Miller, 2001). Industrial projects often have the goal of providing a technical solution—a mining or production plant, for example—that generates physical goods for sale with the ultimate goal of turning a profit for the undertaking's investors. Industrial projects are heavily regulated by governmental parties, such as licensing authorities and regulatory agencies, because of their potential to have substantial sustainability consequences (Prno and Slocombe, 2012; Kokko et al., 2015).

According to Sallinen et al. (2011), governmental stakeholders are those who supervise projects, represent social and governmental interests, and function as a middleman between the government and the project. Governmental stakeholders supervise and manage the execution of projects, particularly those including regulatory frameworks. They guarantee that society's more general economic, social, and environmental demands are met while not having their own objectives (Fassin, 2009; Sallinen et al., 2011). For instance, it is customary for governmental stakeholders involved in mining projects to carry out effective environmental impact assessments and social impact assessments, with an emphasis on determining the potential effects of the project on people, organizations, the environment, and social macro systems (Becker, 2001). According to Soderholm et al. (2015), these evaluations might result in new needs, which could significantly affect the project's budget and timeline. Furthermore, sustainability has many different meanings, but most academics concur that it stresses the necessity of striking a balance between social, environmental, and economic objectives (Aarseth et al., 2017). Furthermore, technological difficulties can be included in the concept of sustainability. This is particularly important in the context of project management, where technological solutions must maintain excellent operations for several decades while maximizing resource efficiency (Laurence, 2011). Process optimization can be achieved by taking into account not only technological concerns but also environmental and economic factors across the whole life cycle of the process. There are two perspectives on sustainability in project management: sustainability of projects and by projects. The former focuses on the sustainability of the project's implementation and management processes, while the latter considers the sustainability of the project's final product (Silvius, 2017). As a result, the implementation and management processes will be the main topics of this study.

One important way to ensure the sustainability of industrial projects and the overall performance and success of the project is to involve governmental stakeholders, particularly in the feasibility assessments and early planning activities of project management (i.e., front-end phase). This can reduce the costs caused by institutional exceptions, for example (Orr and Scott, 2008; Ghassim and Bogers, 2019). For example, Laurence (2011) claims that the difficulties in failing to achieve sustainability in the economic and resource efficiency dimensions are a significant factor in mining closures that occur too soon. Furthermore, Laurence pointed out that the use of sustainable project planning techniques, such as governmental stakeholder participation on

resource efficiency and economic aspects in addition to safety, the environment, and social aspects, would have reduced the amount of work that was unnecessary and prevented these closures, all while having a positive overall effect on society during the project management process. Thus, the current investigation will respond to the following queries.

1.2. Research Questions

RQ1: What is the relationship between technology usage and stakeholder engagement?

RQ2: What proportion of the variance in stakeholder engagement is explained by technology usage?

RQ3: What are the challenges and trends associated with the use of technology in engaging stakeholders for sustainable projects?

1.3. Aims and objectives

To explore the application of technology in achieving sustainability within project management to determine how the engagements of stakeholders promote sustainable practice in projects.

The following objectives are defined to achieve the aim of this study:

1. To undertake the research analysis to provide conceptual frameworks to review the literature in order to develop knowledge on the role of technology and sustainable strategies for engaging stakeholders in project management.
2. In order to investigate the impact of stakeholder engagement for the sustenance of projects' results, with particular reference to best practices in relation to stakeholder engagement for project sustenance.
3. In order to build practical solutions those managers of such projects can apply to harness technology supports and the input of stakeholders for the established objectives for sustainable development.

1.4. Research Gap

Prior research has mostly focused on the sustainability effects of industrial initiatives; nevertheless, the engagement of governmental stakeholders is essential for managing the sustainability results of these projects (Shen et al., 2010; Marcelino-Sadaba et al., 2015). However, research on sustainable project planning techniques—such as involving government stakeholders—has been lacking. Setting project sustainability goals and making sure they are met are important tasks for government stakeholders. For industrial ventures to be sustainable,

government and investor cooperation must therefore increase (Laurence, 2011; Marcelino-Sadabaet al., 2015). However, the material currently in publication does not provide enough insight into the cooperative behaviors of the two actors. Thus, a deeper comprehension of the procedures and methods of cooperation between shareholders and governmental stakeholders is essential to guaranteeing the long-term viability of industrial initiatives.

1.5. Scope of the Study

Focus of the Research

This research primarily focuses on industrial activities such as mining, energy production, and large-scale industries. It explores how these sectors adopt sustainability within project management, with particular attention to how technologies like AI-driven predictive maintenance, big data analytics, digital platforms, and blockchain for supply chain transparency contribute to sustainability advancements. The current research focuses on industries in the early stages of integrating sustainability through technological innovations and project management strategies. As such, the research concentrates on the management processes of projects rather than their outcomes, and it explores how technology contributes to operational sustainability and meets legal requirements for project deliverability (Tabrizi et al., 2019). This approach is in consonance with the overview strategy of involving governmental stakeholders, especially to provide direction towards socially, economically, and environmentally responsible project goals (Winkelhake, 2019).

Project Development and Stakeholders

The study is mainly concerned with the development phase of the projects, and especially whereby technology is used in the communication and interaction with the project stakeholders, specifically the government. These are other unaffected stakeholders such as the regulatory agencies, local authorities and government related bodies in charge of regulating and ensuring compliance to sustainable practices (Goodland, 2002; Dingler&Enkel, 2016). The study looks at how they get involved during the planning and feasibility stages and how this helps in enhanced project delivery for sustainable projects. It caters for the fact that project goals and objectives are in line with the nation’s sustainable development objectives, and meets the set standard of the law (Dingler&Enkel, 2016).

Technologies Examined

The technologies that this study explores include:

- AI-driven predictive maintenance
- Data analytics
- Digital platforms and e-commerce
- Block chain for supply chain transparency

1.6 Conclusion

Exclusion Criteria

The target of this research is not on large conglomerates or industries where sustainability has already been greatly practiced like energy and heavy industrial sectors. It focuses on the SMEs sector that is usually sensitive to the integration of the sustainable technology. Project development phase is the only aspect investigated in the study and there is no coverage on the lifecycle of the end product or the final consumer (Di Vaio et al., 2023).

Type of Sustainability Addressed

The work focuses on social sustainability aspiration within project development, especially, on how technology could support a business organization in achieving both its business and social/ environment management objectives. This is in contrast with sustainability of the end products or services, or aspects related to process effectiveness for instance cutting on resource wastage or enhancement of stakeholder relations (Goodland, 2002).This clears up the concept making me understand the scope and boundary of the technology support to enhancing sustainable development in SMEs during the project development phase with special focus on social sustainability as well as stakeholder management.

2. Literature Review

2.1. Introduction to the Chapter

These include Section Two: A Literature Review of the chapter presenting an extant literature review that discusses articles portraying the use of particular technologies in stakeholder engagement. The review concentrates more on the application of information and communication technologies (ICTs) project management software, analytical tools, social media communication, and block chain technologies in managing the transparency of project transactions. In this chapter, the author focuses on how these technologies improve the levels of engagement of stakeholders, communication, collaboration, and knowledge in decision making

of the project. Such technological tools are also evidenced in the literature in relation to how they can support project sustainability in terms of stakeholder engagement and environmental as well as social responsibility.

2.2. Understanding Technology and Technological Change

Technology is a complex phenomenon that is defines as a product of application of knowledge on tools for achieving human objectives. For the purposes of this research, the objects of study are information and communication technologies (ICTs), namely, project management and cooperation tools, web conferencing systems, big data tools, and blockchain.Coeckelbergh (2020) pointed that the history of the technological philosophy shows how difficult it is to define technology and to provide its precise study. The traditions of Western thought are a paradise. Western philosophy defines technology as an instrumental tool that can have both beneficial and undesirable consequences (Schatzberg, 2018).This research focuses on ICTs as enablers of stakeholder engagement and sustainable project practice. As these technologies are seen as necessary parts of project management and sustainability, rather than as tools, they hold an essential part in improving the overall outlook and performance of the projects (Müller, 2016; Schatzberg, 2018). As an illustration, firearms have the capacity to suppress or emancipate, while artificial intelligence has the potential to empower and aid individuals or to control and exploit them. This account primarily focuses on the individuals who control technology, neglecting to consider how technology itself evolves, often in subtle ways that influence human capabilities and methods. It primarily focuses on using technology as instruments, including various tools and machines. Technology is constantly evolving, and studying the relationship between technology and sustainable development demands how technological advancements result in changes in the environmental and social implications of technology. It is need of time to adhere to the methodology proposed by Stephen R. Barley (2020), a renowned organizational theorist and industrial sociologist.One key element of his approach is to differentiate between substitutional and infrastructural technology development. Technological change primarily results in the modification of current responsibilities executing tasks more effectively, while keeping the overall socio-technical framework unaltered this represents a type of change known as substitutional change (Barley, 2020). For instance, efficiency for project management of industrial activities such as mining or energy production is enhanced by the adoption of advanced technologies like AI self-learning predictive maintenance and the IoT for monitoring.

Likewise, while tools such as big data analytics or blockchain address some of the very specific tasks, such as supply chain integrity or resource management, they are no more different than robots helping the nurses with the tedious and time-consuming chores but leaving the overall structure of the organization unscathed. This kind of change enables the stakeholders to maintain their work on and support of their projects' socio-technical arrangements—their labor structures, company pyramids, and management practices—while they deliver very significant improvements in terms of sustainability and performance. For instance, smart devices, including IoT sensors, can be used to reduce energy utilization within production factories, thus lowering emissions. Likewise, robots help the nurses with physical work but remain the careers or healthcare providers. This means that through substitutional technological progress, industrial sectors can enhance sustainability without changing these paradigms of operation and organization, and this research seeks to do so through examining the application of ICTs for sustainable project management (Sætra&Fosch-Villaronga, 2021).

The use of technology in this research is narrowed down to particular categories of technologies, namely smart technology and artificial intelligence/automated otherwise. Artificial intelligence/automated otherwise artificial intelligence, big data analytics technology, and cloud technology with particular reference to collaborative information sharing and the blockchain with specific reference to transparency. These technologies facilitate minor changes referred to as substantial change, where changes occur within the existing structure of project management to enhance broader community engagement without necessarily changing the structure of the organization. This paper seeks to analyze how the use of ICT enhances social sustainability in project delivery. Analyzing technological change shows that it is useful in promoting sustainable development of various sectors. Application ICTs facilitate the collaboration, planning, and resource issues of SMEs; on the other hand, institutional advances introduce efficiency that does not disrupt ongoing activities of the businesses. Governments indeed also have the role of performing as the regulatory actors who encourage technology implementation towards the targeted sustainability goals. This section focuses on inter-industry and intergovernmental partnerships in driving technology in the direction of sustainable project management.

2.3. Understanding the Concept of Stakeholder Engagement

Stakeholder management is the basic act of identification, involvement, and manipulation of profit and non-profit people, groups, or organizations who have a concern in the success or

failure of a certain project or program. There has been tremendous focus on the practice of stakeholder engagement from scholars, among them Greenwood (2007) and Papagiannakis et al. (2019), who have articulated the ethical and strategic perspectives of stakeholder engagement. Greenwood noted that stakeholders should respect one another, provide sufficient information necessary for decision-making, and listen carefully to ensure that they are not acting in a perfunctory manner in their interdependent relationships. They are vital for building trust and for achieving decision-making integration between the cross-functional teams. Also, in the work of Papagiannakis et al. (2019), valuable argumentation is provided to stress the importance of engagement, the fact that it strengthens cooperation and leads to the optimization of organizational performance as well as increased corporate social responsibility. Each author would agree that stakeholder involvement should be more of an outcomes-based model, where the active participants in the decision and process formulation are involved.

Gupta et al. (2020) extended the focus beyond the list of stakeholders to consider what best practices interest can use to manage stakeholders efficiently. Based on the information their analyses pointed out, it is crucial to notice that the engagement methods should be selected depending on the specific goal and context of the respective company combined with the specific needs and expectations of the target stakeholders. Gupta et al. (2020) stated that there is no one-size-fits-all model for engagement, and it must be sensitive to contextual factors bearing on national legislation, best practice benchmarks, and market expectations. This method considers the engagement with stakeholders as responsible and purposeful in order to achieve the goal of sustainable development and preserve the organization's reputation among stakeholders.

Ghodsvali et al. (2019) discussed threats and challenges of stakeholder engagement within the framework of FA more broadly when adopting infectious and interconnected issues. Hence, engagement should be viewed as a process, thus acquiring a richer context of knowledge sharing and collaboration to facilitate an understanding of interrelated systems. Improved understanding of stakeholders will complement their involvement in decision-making processes in the quest for proper solutions. Ghodsvali et al. (2019) also note that stakeholder engagement is important since diversification in today's society creates a better way of arriving at workable solutions.

This research further decomposes the concept of stakeholder participation from a widened viewpoint. This can be articulated more succinctly: It refers to managing communication activities and processes to coordinate a set of actions within a series of actions intended to

manage interactions with stakeholders in a business and establish positive business stakeholder relations responding to ethical, strategic, and pragmatic reasons. Subsequently, broadening the idea and disengaging from a strictly corporate perspective, especially following the thought leadership by Greenwood in 2007 and subsequently Papagiannakis et al. in 2019. Therefore, it is important for sustainability and good project outcomes that stakeholder engagement remains a central focus. The importance of information and communication technology to address stakeholders' concerns is gradually increasing. This work will, therefore, discuss how items such as project management software, big data predictive analytics, and social media increase participation. These technologies include information exchanges, transparency, and integration, which help organizations to handle stakeholder relationships better and incorporate their projects with sustainable objectives. By using these technologies, organizational strategic and operational engagement can be enhanced, and project performance overall be increased, thus helping organizations work toward achieving societal sustainable goals.

The following section highlights the importance of engaging stakeholders in the realization of any project, including sustainable goals. Engagements cannot be viewed as some one-off event that, once complete, does not require further work or involvement from all the interested parties. The paper by Greenwood (2007) and others such as Papagiannakis et al. (2019), Gupta et al. (2020), and Ghodsvali et al. (2019) supports this by showing that engaging with stakeholders brings about improvements in organizational performance, better decision-making, and improved legitimacy for proposed solutions. As organizations engage more in the use of innovations and advances in ICT communications, project management software, and big data analytics, among others, then they also have the backup of productivity and cooperation to advance sustainability courses. Therefore, effective stakeholder participation is critical in ensuring effective delivery of appropriate and relevant business initiatives for sustainable performance goals.

2.4. Understanding the relationship between technology and Stakeholder's Engagement in Project Development

As part of the essence of stakeholder engagement, information technology has to be incorporated in an enhanced approach to managing and planning sustainable projects. This integration ensures that we incorporate not only aspects of usage of technology in project management for sustainability but also, recognizing that there are many stakeholders who will

have to live with the outcomes of the projects, include greater representation of the breadth of those possible solutions to make their projects more generally palatable. Information technology allows for the more extensive and effective management of relationships with the key stakeholders by using Web site discussion boards, social media sites, and mobile applications. These tools allow the inclusion of stakeholders who are physically located in different places and fosters communication and co-ordination during the planning and executing of the projects. This is in accordance with the objectives of the given study where key peculiarities of the application of ICT tools for sustainable management of construction projects were identified in terms of increased transparency, engagement of all stakeholders as well as the possibility of their cooperation on the decision-making level.This inclusion provides the voice of those normally left out in the sustainability decisions, mainly because they are the most affected (Freeman, 2010). When it comes to impact assessment data management and sharing, one can use GIS and remote sensing to collect and communicate data to the stakeholders making necessary decisions as well as receive useful feedback (Sheppard & Meitner, 2005). It has been found that sound management of information is crucial in attaining sustainable projects. Technology enhances these attributes by providing opportunities to make faster initial connections with distant acquaintances through the means of video calls, instant messaging, or working on documents in tandem with other individuals in applications like Google Docs or MS Teams. These tools enable the stakeholders with an interest in a project to have constant communication and collaborative means of addressing challenges, ensuring that objectives meet stakeholder expectations and the sustainable development goals (Bryson, 2018). A large amount of important information is collected and processed through technology, as well as the decisions regarding the design and implementation of sustainable projects. By employing factors such as big data, machine learning, and AI, it becomes easier to search for patterns, forecast outcomes, and manage resources in a way that will make the results of the projects more efficient and sustainable (Kou, Yang, & Xiao, 2022). The involvement of the stakeholders can also be easily done with the help of data analysis and that information. This leads to a lack of transparency and distorts decisions by social influences rather than the empirical facts. Hence, it makes decisions to be either trusted or mistrusted and not based on facts, and this makes the decision-making process to be either trusted or accounted for (Harrison & Wicks, 2013).

Technology in stakeholder management also boosts the honesty of projects in development, making them a bit more responsible and answerable for the creation of sustainable projects. Contacts with stakeholders and all transactions within blockchain projects are recorded publicly in a manner that creating another copy or altering such records becomes impossible (Tapscott&Tapscott, 2016). Stakeholders have confidence in the project and assurance that it meets the standard set by sustainability and ethical standards. Although technology provides various advantages for including stakeholders in sustainable project development, it also poses problems and hazards. The digital divide may marginalize specific stakeholders who lack access to technical resources, potentially distorting the process of engagement (Unwin, 2020). In order to uphold stakeholder trust and safeguard sensitive information, it is imperative to address issues regarding data privacy and security (Donaldson & Preston, 1995). The relationship between technology, stakeholder involvement, and sustainable project development is mutually beneficial and characterized by the combined effect of their interactions. Technology facilitates stakeholder engagement, communication, and evidence-based decision-making while simultaneously enhancing transparency and accountability. Nevertheless, it is crucial to effectively address obstacles such as the disparity in access to digital technology and the protection of data to guarantee fair and morally sound participation.

2.5. Technological Foundations for Stakeholder Engagement in Sustainable Project Management

The correlation between technology and sustainable development is an intricate and diverse subject that has received much scholarly and practical focus. Technology is essential for promoting sustainable development since it provides creative solutions to social, environmental, and economic obstacles. Nevertheless, the incorporation of technology into sustainable development necessitates meticulous management to guarantee its alignment with sustainability objectives rather than undermining them.

2.5.1. Technology as an Enabler of Sustainable Development

People often credit technology as a key enabler of sustainable development. It provides instruments and strategies aimed at improving resource efficiency, reducing waste, and reducing environmental impact. Reducing greenhouse gas emissions and battling climate change, for example, depend on renewable energy technologies such as sunlight, wind, and hydroelectric power (Renn& Marshall, 2021). Furthermore, advanced technology facilitates better oversight of

natural resources. Remote sensing, geographic information systems (GIS), and big data analytics help to more precisely monitor and manage environmental resources, thereby guiding more informed and successful conservation initiatives (Kou, Yang, & Xiao, 2022). The intersection of technology and sustainable development is fundamentally innovative. More sustainable urban settings result from green technological innovations such as smart grids, electric cars, and energy-efficient structures. By generating new businesses and employment possibilities, technological innovation stimulates economic development and helps to produce better social results (Geels, 2019). Even with the possible advantages, including technology in sustainable development presents various difficulties and hazards. The digital divide—that is, the unequal access to technology and the internet—is one of the main worries. This divide might aggravate already existing inequality and impede the capacity of underprivileged populations to gain from technological developments (Unwin, 2020). Furthermore, the manufacture and disposal of technology can have significant environmental effects. Technology could contribute to environmental damage if improperly controlled, including rare mineral extraction for electronic gadgets, e-waste, and data center energy use (Schluep, Hagelüken, &Rochat, 2009).

The relationship between technology and sustainable development is characterized by both possibilities and difficulties. Despite its great potential to propel major advancement toward sustainability objectives, technology presents hazards that require proper control. Harnessing the full possibilities of technology for sustainable development depends on a balanced strategy stressing innovation, equity, and beneficial government.

2.5.2. Technology and Stakeholder Engagement

Research by (Van Buuren et al., 2019) has demonstrated several benefits and drawbacks associated with stakeholder involvement in sustainability concerns. Sayce et al. (2013) observe that hearing the voices of stakeholders enhances not only the social, economic, political, and cultural outcomes of decision-making, but also the outcomes themselves. The data suggests that stakeholders perceive the democratic, participatory, and transparent decision-making process they participate in as more authentic. Stakeholder participation may therefore lead to decisions that legitimize final decisions, resulting in fewer instances of disagreement and a smoother execution that suggests that participatory methods may result in the generation of significantly more innovative ideas (Graversgaard et al., 2017). On the other hand, the opposite is also true, given that involvement does not necessarily result in better outcomes for the environment.

Involving stakeholders can be more expensive, delay decisions, and take more time than a top-down strategy. This is one of the downsides of involving stakeholders. There is also the risk that influential interest groups will take precedence over a process that involves participation. Despite the general acknowledgement of these limitations and drawbacks, there is a greater emphasis on stakeholder participation in water resource management. Therefore, stakeholder engagement is becoming ever more important for many projects; in water resource management, this is especially true globally (Margerum and Robinson, 2015). Recent studies have concluded that the success of major society projects is dependent on the involvement of stakeholders (Bahadorestani et al., 2020). This is why stakeholder engagement is becoming increasingly important. Experts recommend stakeholder involvement as a crucial interaction for multisectoral and transdisciplinary projects. This is due to the fact that public efforts have an impact on society. Through engagement, one can achieve the desired social impact with less effort, thereby achieving greater results with fewer resources (DeFries and Nagendra, 2017). Additionally, engagement helps to improve one's understanding of the challenges associated with putting strategies into reality. Based on this, it is reasonable to argue that stakeholder participation is critical to the success of initiatives with the goal of achieving social sustainability.

One of the key challenges in stakeholder engagement is to reach a mutual understanding of the research outputs, especially on the technical specifications of the developed technologies, as there will be diverse levels of knowledge and experience among the stakeholders. This context is characterized by the presence of potentially competing interests with regard to the impact on output, resource distribution, and cost. The participation of stakeholders contributes to the formation of a "common sense" (Ferraro and Beunza, 2018), which in turn makes it easier for distinct variations to interact with one another and align themselves. According to Loewenstein et al. (2012), organizational theory has successfully demonstrated the application of common sense in order to comprehend the coordination that exists between occupational groups and departments. In major societal research projects, the establishment of common sense will be just as crucial for coordinating across both internal and external stakeholders. This is based on the relevance of common sense in coordination across units within organizations. With very different understandings and desired outcomes, the establishment of common sense will be just as crucial. Research indicates that the conflicting interests of stakeholders within the project are a

significant source of concern (Lin et al., 2017). Given the nature of sustainable efforts, it is highly likely that this conflict will arise as it intersects with the tension between technological advancements, laws, ecologically responsible behavior, and financial incentives. In addition, this is demonstrated by the body of literature on stakeholder involvement as well as the significant research endeavors that have been undertaken on the paradox of an academic push to the market rather than a demand pull from the market from stakeholders or end-users. According to Eskerod and Larsen (2018), the value streams of a project define a central stakeholder interaction in the literature on research projects. This literature on value streams describes three primary methodologies for stakeholder involvement, which are as follows: The first step is to give the project's values the utmost importance; at this stage, the project management team gives more resources to the stakeholders who are contributing to the project's success. Absolute attention to stakeholder values is the second strategy. The project management team gives more attention to the rights and values of stakeholders. In this sense, the individual in charge of the project is allocating resources to less prominent stakeholders, despite the fact that this may not contribute to any value generation. The third approach involves the project management team engaging in conversation with the various stakeholders in order to strike a balance between the project's values and the stakeholders' values at the same time. Lin et al. (2017) assert that this third strategy, also known as the hybrid approach, provides the chance to balance economic, environmental, and social goals. Experts claim it to be a suitable tool for upholding sustainability objectives. In order to generate common sense, it is necessary to place an emphasis on stakeholder involvement when doing an analysis of the technology push in larger sustainable initiatives. There is a possibility that the project management team is responsible for directing and arranging a translation process in order to achieve a shared understanding among the many stakeholders. This is actually what private companies typically do when they launch a new technology; they direct the pull mechanisms through marketing channels in order to get people interested in the product. Cvitanovic et al. (2016) assert that organizations in the public sector frequently face a knowledge barrier that hinders the adoption of new technology, necessitating a reduction to enable critical stakeholders to understand it. According to our argument, one of the most effective strategies for overcoming these challenges is to have the significant stakeholders actively participate in the process. Despite the fact that this may appear to be a simple task, sustainability projects may involve and target a number of stakeholders that have different

perspectives and objectives about the end outcome. Therefore, failure may occur if there is not a consistent reduction in the knowledge gap between the stakeholders. The intended markets would not accept the produced technology if they recognize its lack of necessity.

The discussion focuses on stakeholder management as one of the primary aspects of successful management and implementation of socially responsible projects and concepts, or CSR in relation to social, economic, and environmental goals. Although stakeholder engagement is highly advisable for the accomplishment of social sustainability, some challenges that may be encountered include: Stakeholder engagement is crucial in the achievement of social sustainability but some of the challenges that are likely to be encountered include: In its turn, the literature points to the fact that exchange that is timely, efficient and coherent contributes to the enhancement of accountability, openness and creativity, more so when underwritten by Information Technology. This research will explore ways in which improvements in communication technology can be applied to improve stakeholder engagement for social sustainability in development project. In particular, the proposed research will investigate how these technologies can help to span the gaps in knowledge dissemination and sharing process, and how to enhance interaction and cooperation between stakeholders to ensure that the goals and objectives of a project are sustainable and the outcomes are positive.

2.6. Technological Development and Stakeholder Engagement in Sustainable Project Management

By means of the Functions of Invention Systems Approach, Nygaard et al. (2021) investigated technological development over time and identified and comprehended the vital engagement of the stakeholders. This paper tracked over a ten-year period the changes in the attitudes and engagement of stakeholders. It looked at the interaction between the perceived preparedness and acceptability by impacted stakeholders and technology readiness. They showed how developing information technology depends on the involvement of stakeholders since they generated marketable solutions for their future application. The change from a research drive to a regulator pull became a major dynamic in this process. They showed that although the innovation would not, on its own, be an economic case without the regulatory need coupled with moves towards tighter targeting of measures, it would still represent a gain for society since it would offer new knowledge and not otherwise be a business case. The particular results can be applied in nations where new technologies must be developed and where a connection to the

regulation guarantees the active application of the latest developments and, hence, makes their deployment profitable.

Among micro-, small-, and medium-sized businesses (MSMEs), Martínez-Peláez et al., (2023) investigated in their study environmentalism through digital transformation. This is vital for modern companies who can get a competitive edge, draw investors and customers who share these values. Furthermore, including sustainable practices helps MSMEs to be more innovative, lower expenses, and improve their reputation so that owners or top managers of MSMEs could start a project for a sustainable digital transformation. Including 59 books from 2019 to 2023, a systematic review was conducted. Consequently, this study underlined the need of stakeholders in reaching a successful digital transformation path, investigated the technologies that can assist MSMEs in achieving their sustainability objectives, and pointed out the first actions owners of MSMEs can take to start the transition by spotting essential organizational capabilities needed for successful transformation. First of all, owners or top management should modify the organizational structure to assist in decisions and plans emphasizing sustainability. Second, a creative process that lets companies be more competitive both locally and internationally lets stakeholders play a major part. Ultimately, big data is the tool that will help MSMEs most since it will allow for the analysis of all kinds of data and influences disruptive change in decision-making. For MSMEs, insufficient infrastructure presents a problem especially in specialized areas or remote locations. Top management or owners should recognize the need of making investments in infrastructure enhancements supporting sustainable DX made possible by their digital capacity. Working with governments, technology companies, and industry groups will help to overcome infrastructure constraints and guarantee dependable internet access and necessary infrastructure pieces are in place, so matching with their digital capabilities. Bernat et al. (2023) have made an analysis regarding the stakeholder's involvement, knowledge management, and sustainability issue in project management, especially with special reference to the virtual platform. Due to the current global crisis and the consequent increase in virtual solutions and teleworking, this field is gaining more relevance. Hypothesis two established that stakeholder involvement and knowledge management significantly impacted the use of sustainable practices in project management, and this was tested using a questionnaire and structural equation modeling. This effect was particularly apparent inasmuch as there was an indication that it is relatively unaffected by the mode, either virtual or physical, of the project in

context. What this means is that both stakeholder engagement and knowledge management can be integrated into the project practices of all types of companies, hence enhancing sustainability both virtually and physically. The benefits of this work are that, evidently, it is the first comprehensive study of sustainability.

In a similar vein, Adhi and Muslim (2023) pointed out that stakeholder analysis had been found to play a critical role in effective sustainable construction project delivery. This they achieved by conducting an engagement assessment matrix in lean construction, from which they were able to note the drivers and barriers to sustainable construction practices. Using 61 respondents, the research established that several stakeholders are inadequately engaged in projects, and project vendors and investors are not very involved in decision-making. The main performance enablers of lean construction when applied were improvement in time management and ability to standardize construction work; the major hindrances include the company's or organization's lack of experience in the use of lean tools necessary for the policies. According to the authors, increased regulations on green products formed through government intervention would increase stakeholder engagement and fill such gaps.

These studies thus stress the use of stakeholder involvement as a key determinant of technology development in sustainable project management. Such studies show that by outlining how technology is used in decision-making, learning, and execution of projects, technology-facilitated communication can improve interaction with the stakeholders and make projects sustainable in all sectors, cutting across from MSMEs to broader construction projects. With the advancement of implementation and innovation, it facilitates apt cooperation towards the completion of projects for the optimum sustainable standards.

It Is therefore generalized that this research work adds to the body of literature on engagement and technological improvement work on the conceptual relationship between stakeholders' engagement and technological application for improving sustainability in project management. They stress the need to engage multiple stakeholders in the decision-making process and show how technology can help to enhance the flow of inter-stakeholder collaboration. This is more relevant to this study, where an attempt has been made to find out to what extent stakeholder engagement spearheaded by modern technologies is driving the sustainability of projects undertaken in different sectors.

2.7. Hypothesis Development

H1: The role of technology is positively correlated with social sustainability.

Much has been spoken and written over the last few years regarding the link between technology and social sustainability. One of the ways in which various industries play a role in enhancing social sustainability is through enhancing the efficiency, transparency, and inclusiveness of organizations. From the study by Bernat et al. (2023), technology is found to be significant at managing the sustainability of projects. More specifically, knowledge management and stakeholder engagement are considered the core of such technologies. Appropriate communication and decision-making, as well as monitoring through information and communication technologies applied to project management, result in efficient utilization of resources that are sustainable. As technology grows, there is improved sociability and data openness in the society, meaning that social justice and impact in the society are enhancing (Adhi& Muslim, 2023).

Moreover, big data analytics and social media represent the foundation of the alignment of the projects' outcomes and social sustainability objectives. By these tools, decision-making is improved, accountability in projects is achieved, and ways of handling social issues are made canon. As stated by Gupta et al. (2020), the organizations that integrate technology in the conception of their stakeholder engagement experience an ability to provide enhancement in social sustainability as well as an organizational image. Here, technology is again used as a tool through which social sustainability can be enhanced through the provision of better information for decision-making that is responsible and inclusive.

H2: Technology is positively related to Stakeholder Engagement.

Engagement of stakeholders has always remained central to any successful project, and technology supports the improvement of engagement processes. Interactive, informative, and invitational are significant requirements of technology usage for stakeholder management (Papagiannakis et al., 2019). The specific tools include project management software, online collaboration systems, and digital surveys whose aim is to offer stakeholders raw responses and a place to engage in further dialogue. This way the ease of access creates a platform for more engagement and encourages commentaries that can inform the decision of the project.

Besides, technology can reduce or eliminate barriers between experts with diverse domains and spatial distances, which can result in better alignment and cooperation. Indeed, as Bernat et al. (2023) moved Magdalena to accept that through technology, the virtual environments have increased stakeholder engagement in the management of sustainable projects, either when the project is carried out physically or virtually. This is well fit for the present world after the COVID-19 outbreak, where technologies that enable stakeholders to communicate remotely are crucial. Social media and the other related digital platforms also enhance inclusiveness since different stakeholders are encouraged to present their ordeal, hence improving the overall stakeholder engagement.

H3: Technology integration has a positive impact on project development.

Technology is useful in the development of projects since it makes the task to be executed to be completed in a faster, more efficient, and more accurate way. Through the application of intelligent systems like artificial intelligence, data analytics, and cloud computing techniques, organizations' processes and resource allocation and decision-making can be made efficient. For instance, the use of big data analytics enhances project managers ability to observe real-time project data that has a strong impact on the project performance and results.

In sustainable project management, technology has a part to play, not only in the measuring up of resource deliverance and wastage processing but also in the improvement of efficient time processes and procedure reformation. According to Adhi and Muslim (2023), this is how the application of technology benefits lean construction. Furthermore, appropriate use of those technological solutions to involve subjects of activities with other actors concerning projects allows for enhanced coordination of project teams and other levels of attainments of sustainability and other stakeholders' expectations during project implementation. Furthermore, technology helps to approach the creation of projects in an innovative manner, which has not been possible in traditional approaches. That masks it and enables companies to embrace practices that would otherwise not be possible. Technological applications in a project setting enable simulation and modeling of possible scenarios, which in turn facilitates predictors of probable issues in a project to enhance appropriate solutions to be executed effectively, and this makes a difference in an observational study (Arora et al., 2020).

H4: Stakeholder engagement has a significant relationship with social sustainability.

Stakeholder management is essential to the achievement of social sustainability by making sure that all the stakeholders' needs are met while implementing projects. Concerns of the local communities, NGOs, government bodies and investors also form an important part of such an engagement as it assists in establishing the areas of mutual opportunity for enduring improvement and solutions (Ghodsvali et al., 2019). This paper found that stakeholder participation in the decision-making process facilitates the selection of projects that meet the needs of the communities and the accomplishment of sustainability objectives for all stakeholders. Papagiannakis et al. (2019) stated that identification and active involvement of stakeholders is the fundamental pillar of an organization's success and its ability to achieve long-term sustainability. More so, those initiatives not involving the stakeholders meaningfully will encounter opposition, time loss, and other hurdles in making the required positive change that will make them sustainable. This has the possibility to result in engagement with people and stakeholders that fosters trust and cooperation, while at the same time guaranteeing that projects are integrated into the social sustainability goals. Technology may also deepen and quality the engagement by creating more freedom for the stakeholders and provide feedback that may influence the results of a project.

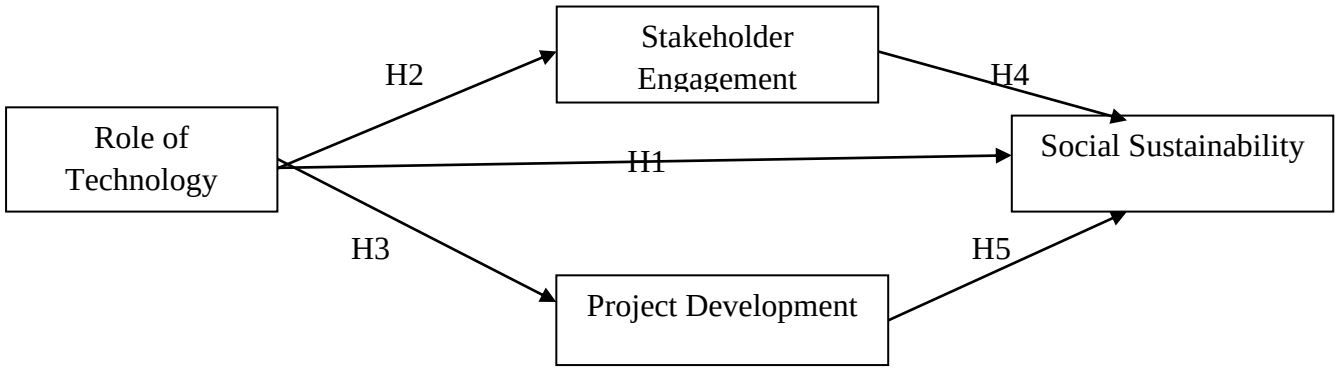
H5: Project development has an impact on social sustainability.

Project development area is one that is essential in increasing levels of social sustainability. This is so because it determines how the project influences, or will influence, the social and ecological setting of the community. Social sustainability may be defined as the ability of the current and future populations to gain necessary resources in a fair and rightful way. The better a project can be planned in terms of resources and engaging with stakeholders, the more it will directly contribute to achieving sustainability goals. According to Adhi and Muslim (2023), the introduction of sustainable development in the construction process, such as lean construction and green technology, significantly reduces the negative impacts on society and the environment. Through resource optimization, waste reduction, and community involvement, projects can be improved upon social. Additionally, development of technologies that enhance educational access, health care, and social services also has a direct effect on social sustainability. Projects that prioritize these elements contribute to the long-term well-being of society by addressing the root causes of social inequality. Hence, project development is intrinsically linked to social sustainability as it brings in sustainable practice, stakeholders' engagement, and appropriate use

of technology during a particular work cycle. Thus, the result of work by Gupta et al. (2020), as seen in several other studies, is to ensure that such projects become successful not just within a narrow objective but also ensure that their success contributes more generally to wider societal objectives around equity, social justice, and preservation of the environment.

2.8. Theoretical Framework of the Study

Figure 1: Theoretical Framework of the Study



H1: There is a positive correlation between role of technology and Social sustainability.

H2: Technology has a positive influence on Stakeholder Engagement.

H3: The integration of technology has a positive influence on project development.

H4: Stake holder engagement has a significant relationship with social sustainability.

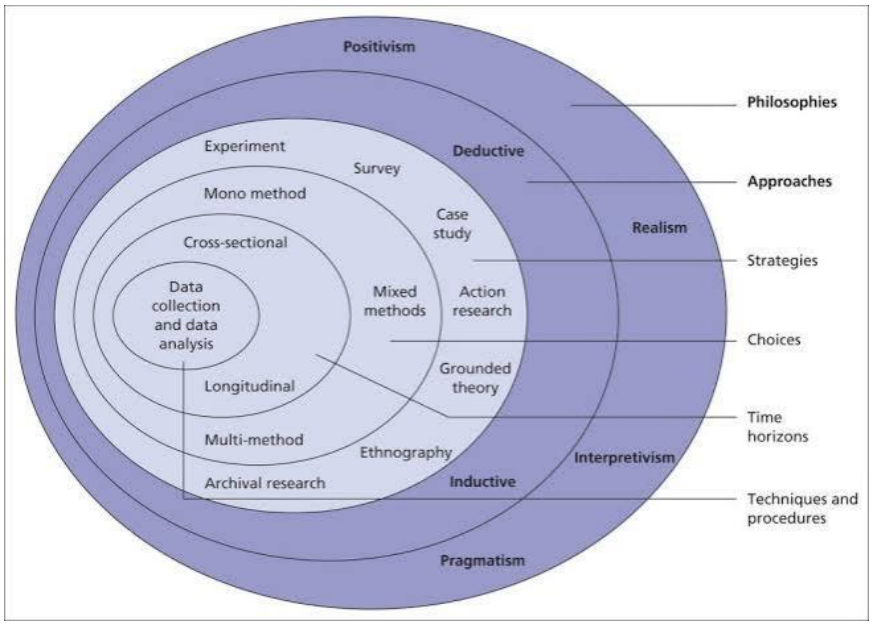
H5: Project development has an impact on social sustainability.

3. Methodology

3.1 Background

The methodology will describe the systematic way in which the relationship between a choice of technology, stakeholder involvement, and sustainability outcomes in organizational projects would be investigated. This study focuses on Pakistani organizations that are stakeholders in sustainability processes. The benefit in such research is that it gives insight into how different technological choices and levels of stakeholders involved affect their sustainability performance. A structured Research Onion Framework, Saunders et al. (2019), led the way in the methodological approach, guiding all phases of the research: from the most substantial foundation in philosophy to data collection and analysis techniques. This framework ensures a systematic, reliable, and replicable process, which enhances the validity of the findings as more credible. This methodological framework is specifically tailored for quantitative investigation and verification of hypothesized relations among variables to provide a sound foundation for the understanding of organizational contexts in terms of technological adoption dynamics, stakeholder influence, and sustainability.

Figure 2: Research Onion Frameworks



(Source: Saunders et al., 2019)

3.2 Research Philosophy

The research philosophy that would be followed for this study is going to be positivistic in nature, focusing an objective approach towards data collection and analysis. Positivism argues that knowledge can be acquired from observation and measuring facts, culminating in evidence-based conclusions drawn therefore. This philosophy of doing research may be appropriately adopted for this study in that it would be feasible to have quantifiable measures for the relationship between the choices of technologies deployed, the engagement of the stakeholders involved, and the resultant sustainability outcomes. Statistical tools can be employed to test the hypotheses for the research. Through this approach, research seems devoid of personal biases and maintains its objectivity by strictly referring to empirical data in presenting findings. It is through a positivist approach that the research focuses on reproducibility and generability as results in order to provide more essential deliverables for actionable insights that can be applied in different organizational settings (Mishra &Alok, 2022). In this light, the research aims to investigate how Pakistani organizations systematically incorporate information technology into their sustainability practices and, thus, positivism is a robust framework from which data-driven inferences can be drawn regarding such practices.

3.3 Research Approach

This research adopts the deduction research approach as is the practice with the positivism research approach. There is a generalized theory or hypothesis on which the argument is formed; afterward it is generalized through empirical observation (Al-Ababneh, 2020). On this basis, some hypotheses are developed with the help of the literature available on the basis of the relationship between stakeholder involvement in technology choice and the applicability of sustainability practices while implementing the concept. Applying the deductive approach, this study will try to prove or disprove these hypotheses with the help of the data collected from the surveys of Pakistan. This research approach is suitable for hypothesis testing research, which would unveil a 'road map' of how one hypothesis can be supported or disproved by empirical evidence. It involves deriving the hypothesis from the theoretical logic that is followed by quantitative analysis for hypothesis testing and arrives at conclusions that should extend knowledge of sustainable practices in organizations. The approach allows the researcher to identify precise areas of practical experience where evidence could align with or differ from theoretical expectations and, consequently, expand the paper's contribution to knowledge.

3.4 Research Design

The research design that is most suitable for such research is the correlational design as proposed by Sileyew (2019). Unlike experimental research, correlational research does not manipulate variables; rather, it assesses naturally occurring relationships, making it exactly appropriate to adopt while investigating the choice of technology, stakeholders, and their effects on sustainability in real-life scenarios. In other words, it measures what the probability is of being statistically significant for the factors that are a part of the equation. Analyzing the relationships between selected technology choices and sustainability performance, together with stakeholder involvement, in a correlation design enables evaluation of the impact of variables and checking the presence and direction of correlation. This design enables one to examine the scenario as it is without any interference and, as such, maintains the integrity of the organizational practices. The strength of the correlational design used in this study is that it presents across industries because it is inclined to finding patterns across different types of industries and sectors and thus gives an overall picture of sustainability practices of organizations irrespective of their types across the spectrum of Pakistani businesses.

3.5 Research Type

Quantitative research type is used within this research because its main scope is to gather and analyze numbers in order to reveal the connection between the variables (Zawacki-Richter et al., 2020). By way of this method of research, the researcher is able to apply structured processes with regard to using surveys and statistics in establishing quantitative proof with regards to technology selection and adoption, stakeholder engagement, and their effects in the direction of sustainable development outcomes. With the use of quantitative methods, the reliability of the study will be greatly ensured since statistical tools can establish the reality of the identification of correlation and regression relations.

3.6 Data Collection

In the present study in particular, an investigative research approach that employs the questionnaire as the data collection instrument is employed to assess the effects of technology in the consultation of the stakeholders for sustainable project delivery. Such an approach resonates with similar studies done earlier, for example, Naseem et al. (2023) In this study, structured questionnaires were developed and administered to a sample of 250 participants, drawn from project managers, environmental scientists, and the community, to establish their perception of the impacts of technology on sustainable practices. Similarly, Smith and Green (2022) used questionnaires with all sorts of participants involved in the urban development projects, and all of them were asked about their position on the usage of the digital tools and platforms. Specifically, in the process of recruitment, the open invitation was specific to obtaining participants who are directly related to or experienced in sustainable project efforts. Referrals were conducted through e-mail, letters of invitation, and word of mouth. It was clear to them the reason why the study was being undertaken, why their input was required, and how they would benefit the research. Some of the people that were involved in this sustainability project include project managers, policymakers, environmentalists, and community members so that all the stakeholder groups will be included. In order to ensure that the data collected is from credible sources, a selection criteria set was established. Subjects were chosen based on the organizational position and their primary involvement in practicing sustainable initiatives, incorporating technology for project implementation, or initiatives in the protection of the environment. Further, as a requirement of consent to be part of the study, participants had to confirm participation in projects of some sort. This made a guarantee that only reliable sources of

information were generated while the responses given were worthwhile and valuable as per the aims of the study. Moreover, since the participants were promised anonymity and confidentiality, the responses received were mostly honest and accurate.

3.7 Sampling

When sampling, this research adopts the stratified random sample so as to capture all the important players in the sustainability project development. This method enables easy grouping of the population with the various strata making it possible to have an over arching capture of the whole population group. Following Lopez and Kim (2022), participants were divided into various categories namely; government employees, environmental scientists, and grassroots to understand their position regarding renewable energy projects. Likewise, Chen et al. (2023) used this method to take into account different level of experience of the stakeholders by including professionals with different level as well as community members. The target population was 300 participants. Our sampling technique involves dividing the target population.

Table 3

Sampling Measurement

No	Author	Type of Questionnaire	Sampling	No of Respondents
1.	BlakBernat et al. (2023)	Online Questionnaire	Purposive Sampling	200
2.	Nascimento, (2019)	Online Questionnaire	Non-probabilistic convenience sampling	1939
3.	Mahmud et al. (2023)	online	Random	159
4.	Sari et al. (2023)	Online	Non-probability sampling.	90
5.	Wibisono et al., (2023)	Online Survey	Not identified	308
6.	Saselah et al. (2024)	Online Survey	Purposive Sampling	116

7.	Haque et al. (2023)	Online survey	Not identified	123
8.	Venciute et al. (2023)	Online Survey	Probability Sampling	88
			Total	377

BlakBernat, G.; Qualharini, E.L.; Castro, M.S.; Barcaui, A.B.; Soares, R.R. Sustainability in Project Management and Project Success with Virtual Teams: A Quantitative Analysis Considering Stakeholder Engagement and Knowledge Management. Sustainability 2023, 15, 9834. https://doi.org/10.3390/ su15129834

3.8 Questionnaire

It focuses on questioning the extent to which technology is involved in stakeholders' interaction in the pursuit of sustainable projects. It is divided into five sections: demographics, technology, perceived effectiveness, attitudes and barriers, and finally technology use and the future of technology. The design is set to ensure that there is a collection of objective and qualitative data by emphasizing a number of closed ended questions and at the same time, emanating from standardized scales. All of the sections are underpinned by prior research, so that the data collection process is consistent with the literature on technology and stakeholders. This approach follows work by Gebreweld (2023) on the assessment of consumer satisfaction and loyalty using a multi-dimensional Likert-scale method. These validated frameworks informed the development of our scales and facilitated a defensible approach to assessing the research topic.

3.9 Questionnaire Instruments

The quantitative study employs the following questionnaires: 4-point Likert Scale, closed questions and open questions. These elements make it possible to obtain a number of views and experiences from the respondents at all levels. The questionnaire includes the following standardized scales only, all of which have been modified in an attempt to measure stakeholder involvement in sustainable project activities.

1. **Technology Usage Scale**

The Tech Use scale assesses the kinds and degrees of technology utilized to engage stakeholders. This scale is constructed with reference to the Unified Theory of Acceptance and Use of

Technology (UTAUT) proposed by Venkatesh et al. (2003). Its objective is to establish the resources that people apply when using the social platform and the frequency of application. Sample items include statements like: In my work, I sometimes hold meetings with other stakeholders, and I always embrace technological means like Zoom and Microsoft Teams to facilitate this process. I also use project support applications like Trello or Asanna. Study participants use a 5 Likert scale that has labels starting with “Strongly Disagree” Corresponding to the number 1 and ending with the “Strongly Agree” which corresponds to the number 5. This scale can be used to assess the degree to which individual technologies are employed throughout engagement- related undertakings.

2. Perceived Effectiveness Scale

The Perceived Effectiveness Scale measures stakeholders’ view on how technology increase communication effectiveness, improves efficiency and outcomes for the project. This scale is adapted from Chaudhuri and Holbrook (2001) who proposed a multi-item construction for satisfaction and loyalty. Sample items include statements such as: The assessment of the effect that technology has on relations with stakeholders accented the fact that technology enhances communication quality, and Digital technology makes relations with stakeholders easier, faster to finalize. The items are scored on a 5-point Likert scale of response from Strongly Disagree through to Strongly Agree for all the items indicated above. Using this scale, it is possible to discover which parts of technology are most valuable to technology stakeholders in attaining project objectives. The Perceived Effectiveness Scale is particularly suitable for the current study as it is developed to mirror the research interest of evaluating the results of the stakeholders’ engagement facilitated by technology and its effects on the sustainability of projects. This scale focuses on stakeholders’ perceptions about how technology enhances communication, enhances work productivity and enhances the quality of project outcomes which are critical areas in defining how technology enhances organizational communication and decision making to achieve sustainable project delivery. Such application of the 5-point Likert scale in the scale gives an objective and measurable data which assists to support the positivistic orientations in the study kind. This makes it possible to look at which tools deliver most value in improving stakeholder relations and how technology can best support sustainable project development. Finally, the scale enhances possibilities of ascertaining whether technology influences

engagement of stakeholders, and in the process, make social sustainability- making this instrument relevant to this research.

3. Challenges Scale

The Challenges Scale targets the problems which the stakeholders face when implementing the technology. Taking into account Zawacki-Richter et al. (2020), it identifies enablers and barriers to PM and categories them by technical, financial, and social issues. Sample items include statements like: The technological aspect is most understandably a challenge by virtue of the fact that the adoption of certain sophisticated digital technology instruments comes with attendant costs and even where the costs are within the control of the institution, the purchase of the software development tools raise further costs implication which sometimes may well prove to be unaffordable as far as the state University is concerned, The attitude of the stakeholders towards this issue further indicates that their technical background influences their perception, response and willingness These perceptual measures entail the use of a 5-point Likert scale with responses that include: Strongly Disagree, Disagree, Neutral, Agree and Strongly Agree. To capture the richness in detail of the respondents' experiences their answers to the questions can also be open-ended.

4. Sustaining the Course: A Future Trends Scale

In more detail, the Sustainability and Future Trends Scale is based on the opinion of stakeholders regarding technological sustainability and future developments. This scale is adopted from Constantinides (2004) where the author analyses the effect of digital technologies on participation and organization performance. Sample items include statements such as: New technologies such as Artificial Intelligence and blockchain in particular will take stakeholder engagement to the next level, Digital tools are inevitable when it comes to measuring and realizing sustainability objectives. The responses are on the five-point Likert scale whereby; 1 = Not Important and 5 = Very Important. This scale captures the perceptions of technological novelties and how they might be useful in improving sustainable project delivery.

Reliability and Validity

All the scales used in this questionnaire such as Technology usage scale, Perceived Effectiveness Scale, instruments for identifying challenges and future trends are adopted from existing

literature and standard frameworks and thus, bear good reliability and validity. Internal consistencies of comparable scales in earlier research ranged from 0.75 to 0.90 for Cronback's alpha which implies that the questionnaire is reliable. Inter-observer reliability with respect to the definition of the research questions was obtained from a panel of experts as well as through pilot testing to ensure that the questions posed are well understood and relevant to the objectives of the study.

3.10 Data Analysis

Data analysis is performed using SPSS to conduct the descriptive statistics, correlation analysis, and regression analysis. Through these descriptive statistics, it is possible to get descriptive information concerning the key variables; These include technology choices and stakeholders' levels of engagement. Technology choices refer to the specific technological tools and platforms used by organizations in communication, project management, and decision-making in sustainable projects. This variable is helpful in evaluating how the different technologies impact stakeholder interactions and the outcomes of the projects. Stakeholders' levels of engagement measure the degree to which various stakeholders, such as project managers, policymakers, and community representatives, take part in and influence project processes. This variable will reflect how technology facilitates or hinders active involvement in shaping the overall success and sustainability of the projects. These key variables are critical in ascertaining the relationships connecting technology use and stakeholder participation. They, thereby, help in the facilitation of analysis regarding such impact on project development outcomes and sustainability. Subsequently, correlation analysis will be used to identify interaction among technology choices, stakeholder involvement, and sustainability practice toward finding the statistical association. The ability to compute correlation coefficients makes it possible to assess the strength and direction of such relationships in a quantitative manner, thus confirming or rejecting hypotheses formulated concerning the interdependence of such variables. Regression analysis is applied to investigate predictive influence on sustainability outcomes by technology choices and stakeholder engagement. This advanced statistical system reveals which factor contributes the most toward the sustainability performance of organizations. Thus, this tool then proceeds further to provide in-depth insights toward how organizations can ensure full utilization of their sustainability practices. The use of SPSS for such analyses ensures accuracy and allows the

researcher to write detailed statistical results, enabling him or her to support the purposes of the study in question (Thomas, 2021).

4. Findings

This chapter discusses the results of the research as inferred from the statistical analysis of quantitative data through the use of SPSS. The data analysis incorporated descriptive statistics, correlation analysis, and regression analysis in analyzing the different relationships between the choice of technology, stakeholder engagement, and sustainability practices. All these were implemented to answer the research objectives and hypotheses (given in section 2.7) that tested the different propositions of the study based on statistical evidence. The chapter starts with the presentation of descriptive statistics results, which give an overview of the key variables in the sample, such as common technology choices and levels of stakeholder engagement. This section gives an overview of the central tendencies and variations in the dataset, providing insights into current practices and priorities of organizations in relation to sustainability. Next, results are discussed of the correlation analysis in which relationships among technology choices and stakeholder involvement as well as among the latter and sustainability practices are analyzed. The analysis will confirm or reject hypotheses on the interdependence among the variables in question. The last section of the chapter deals with the regression analysis results, which investigates the predictive influence of technology choices and stakeholder engagement on sustainability outcomes. It identifies factors that are most significantly contributing to sustainability performance and offers critical insights into what drives organizational success in this area. The regression results thus give a nuanced picture of the nature of impact of each of the variables and guidance on ways to develop the sustainability practice further. As such this chapter includes the call, understanding of the dynamics involved in technology supported sustainability and the stakeholder engagement role the basis for the discussion and recommendations in the next chapter.

Table 1: Demographic Profile of Respondents w.r.t. Professional Role (*N*=300)

Professional Role	Frequency	Percent
Project Manager	81	27.0
Environmental Scientist	130	43.3
Engineer	67	22.3
Community Representative	22	7.3
Total	300	100.0

The professional roles of the respondents provide insight into the diversity of expertise represented in the sample. Table 4.1 shows the frequency and percentage distribution of respondents across different roles. The largest proportion of respondents (43.3%) was Environmental Scientists, indicating their significant involvement in sustainability practices. This was followed by Project Managers (27.0%), who play a critical role in overseeing and implementing sustainability initiatives. The number of engineers was 22.3%, providing technical input for the projects, and Community Representatives represented 7.3% who highlighted the involvement of the social stakeholders in the research. This distribution ensures a balance in the input of key professionals involved in sustainability projects is achieved, which is very important for understanding the multifaceted dynamics of technology adoption and stakeholder engagement.

Table 2: Demographic Profile of Respondents w.r.t. the Years of Experience (*N*=300)

Years of Experience	Frequency	Percent
Less than 2 years	66	22.0
2–5 years	71	23.7
6–10 years	107	35.7
More than 10 years	56	18.7
Total	300	100.0

To analyze their knowledge and experience levels about sustainability practices, their experience years of being in sustainable project development have been analyzed. Table 4.2 illustrates the frequency and percentage distribution of respondents based on their experience levels. The majority of respondents -35.7%- had 6–10 years of experience in sustainable project development, indicating a fairly seasoned group of professionals with substantial exposure to sustainability practices. Respondents with 2–5 years of experience formed 23.7% of the sample, and 22.0% of the respondents had less than 2 years of experience, which was an interesting mix of emergent and experienced professionals. More than 10 years of experience was reported by 18.7%, which constituted the most experienced group in the sample.

Table 3: Which technologies do you use for stakeholder engagement? (Select all that apply)

Type of Technology Usage	Frequency	Percent
Virtual meeting platforms such as Zoom or Microsoft Teams	19	6.3
Project management tools such as Trello or Asana	56	18.7
GIS tools	31	10.3
Social media platforms	137	45.7
Data visualization tools such as Power BI or Tableau	57	19.0
300	100.0	100.0

The study also analyzed the technologies applied by respondents for stakeholder engagement. Table 4.3 summarizes the frequency and percentage of each technology used. Social Media Platforms were the most commonly applied technology for stakeholder engagement, at 45.7%, showing its popularity for communication and interaction. It was followed by Data Visualization Tools, at 19.0%, and Project Management Tools, at 18.7%. GIS Tools (10.3%) and Virtual Meeting Platforms (6.3%) were also less frequently used, showing a diversification of stakeholder engagement in a technologically driven direction. The findings are crucial in understanding the technological inclinations of professionals working in the sustainable project development sphere and their respective approaches to engaging with the stakeholders.

Table 4: How frequently do you use technology for stakeholder engagement?

Frequency of Usage	Frequency	Percent
Daily	55	18.3
weekly	87	29.0
Monthly	107	35.7
Rarely	51	17.0
Total	300	100.0

The respondents were asked how frequently they utilize technology for engaging with stakeholders. The distribution is provided in Table 4.4. The results indicate that 35.7% of the respondents utilized technology to engage with stakeholders monthly, followed by 29.0% weekly. Further, 18.3% reported daily utilization and 17.0% utilized it rarely. The pattern suggests the usage levels differ widely, which was highest for both monthly and weekly uses.

Table 5: What formats do you use to share knowledge or project updates with stakeholders?

Technology Usage	Frequency	Percent
Written reports	145	48.3
Email communication	91	30.3
Online platforms such as shared documents	53	17.7
Face-to-face meetings	11	3.7
Total	300	100.0

The distribution of table 4.5 used to share knowledge or project updates with stakeholders reveals that written reports are the most preferred, utilized by 48.3% of the respondents, followed by email communication at 30.3%. While written reports remain a cornerstone for formal, structured communication, especially when detailed documentation is required, email offers a faster, more accessible medium for concise updates and direct interaction. Online tools like shared docs are used by 17.7% of respondents, wherein the benefits of real time collaboration and accessibility can be noted; however, adoption may suffer from stakeholder familiarity with digital means. Face-to-face meetings make up only 3.7%, a trend towards in-person communication that may be negatively affected by the shift made towards digital means during the COVID-19 pandemic period. The findings indicated that integrated traditional and modern communication approaches will strike the correct balance between the need for documentation, efficiency, and stakeholder involvement.

Table 6: How effective do you find technology in enhancing stakeholder engagement?

Effectiveness of Technology	Frequency	Percent
Very effective	34	11.3
Effective	112	37.3
Neutral	114	38.0
Ineffective	32	10.7
Very ineffective	8	2.7
Total	300	100.0

From the analysis of perceptions on whether technology is enhancing stakeholder engagement, one can deduce that there is a broad spectrum of opinion. 37.3 percent of the respondents considered technology "effective," indicating its role in streamlining communication and creating an environment conducive to stakeholder collaboration. In the same way, 11.3 percent deemed it "very effective," implying cases where technology has revolutionized engagement practice. However, an important 38.0% remained neutral. This means that either exposure to the potential benefits of technology was very limited or experience with it was mixed. Meanwhile, 10.7% rated technology as "ineffective," and 2.7% labeled it "very ineffective," possibly due to challenges like technological barriers, resistance to change, or lack of alignment with stakeholder needs. These findings underscore the importance of tailoring technology use to stakeholder preferences and providing adequate training and resources to maximize its effectiveness in engagement processes.

Table 7: Technology improves the efficiency of stakeholder engagement.

Effectiveness of Technology	Frequency	Percent
strongly Disagree	48	16.0
Disagree	71	23.7
neutral	42	14.0
Agree	46	15.3
strongly Agree	93	31.0
Total	300	100.0

The evaluation of the data found in the table reveals the different approaches towards the use of technology on the effectiveness of stakeholder communication. Out of the 300 participants, 31% (93 participants) strongly agreed that technology improves stakeholder engagement efficiency, while 15.3% (46 participants) agreed. This overall positive reaction of 46.3% indicates that a significant number of respondents have a positive view about the use of technology in this regard. In contrast, 23.7% (71 individuals) are in the disagree row, and 16% (48 individuals) are in the strongly disagree row, thus making 39.7% concerning technological consequences as skeptical or negative. Another 14 percent (42 respondents) expressed the need for more clarification or empirical evidence regarding the positive or negative impact of technologies on stakeholder communications. Such mixed feelings only call for a need to respond to these feelings as well as offer practical examples that could help in motivating people to embrace the use of technology as a useful tool.

Table 8: Technology enhances communication clarity among stakeholders.

Effectiveness of Technology	Frequency	Percent
strongly Disagree	26	8.7
Disagree	80	26.7
neutral	38	12.7
Agree	113	37.7
strongly Agree	43	14.3
Total	300	100.0

Across different fields and competencies, the data in the table shows the table above presents different views on the applicability of technology to enhance communication clarity among the stakeholders. In total, 300 participants answered the survey; 37.7% of them (113 people) agreed with positive changes, and 14.3% (43 people) strongly agreed. The fact that together both those that somewhat agree and those that strongly agree stand at 52% points to a general agreement that technology can improve the clarity of communication. Nonetheless, 26.7% (n = 80) were found discussing it in a negative way, while 8.7% (n = 26) strongly disagreed on this aspect, which suggests that about one-third of the respondents have less perception regarding the favorable impact of the technology. Furthermore, 12.7% (38 individuals) are undecided as to the effectiveness of the technology in this area. This gives general approval towards technology as having an enhancing impact on communication clarity but, at the same time, speaks of many concerns that must be met to wane negativity towards technology.

Table 9: Technology helps reach a broader audience.

Effectiveness of Technology	Frequency	Percent
strongly Disagree	21	7.0
Disagree	40	13.3
neutral	120	40.0
Agree	54	18.0
strongly Agree	65	21.7
Total	300	100.0

The table catalogues different people's viewpoints regarding the technology's ability to create more exposures. Among the 300 respondents, 54 participants expressed their agreement with this statement, while 65 participants have a strong positive attitude towards the use of technology; hence, 39.7% of the total population for this study has a positive perception towards technology. However, 40% (120 people) are still in a state of indecision on whether technology is good or bad for audience outreach. Even more negative, 13.3% (40 persons) stated that they do not agree, and 7% (21 persons) fully disagreed, and, as such, there are 20.3% who are skeptical. This distribution indicates that there is a general awareness and acceptance of the positive impact of technology, albeit with some apathy and opposition, therefore a need to provide more evidence and prove the ability of technology as an instrument of gaining wider coverage of an audience.

Table 10: Using technology reduces the cost of stakeholder engagement.

Effectiveness of Technology	Frequency	Percent
strongly Disagree	25	8.3
Disagree	70	23.3
neutral	47	15.7
Agree	67	22.3
strongly Agree	91	30.3
Total	300	100.0

The impressions presented in the table above show different attitudes towards the second effect of technology, namely reducing the cost of stakeholder engagement. From the 300 respondents, 91 responded that they view the use of technology as cost-effective; strongly agreeing with 91, while 67 only agreed that it is a tool that is inexpensive. This majority provides an affirmative nod towards efficiency as a premise to stakeholder engagement and, particularly, the effects of technological enhancement of this process. However, 23.3% (70 individuals) declined and 8.3% (25 individuals) strongly declined; this is about 31.6% who are reluctant and believe that technology is a cost-saving asset. Similarly, 15.7% of the respondents, or 47 individuals, are neutral, showing that still another portion of the respondents are unaware of the effectivity of such technology, or they think that it corresponds with less cost depending on certain factors. Finally, as there is some share of neutrality and dissidents appearing in this discussion, one could suggest that multiple proofs and calls to utilize technology to benefit the financial aspect of the company are needed.

Table 11: What are the main challenges you face in using technology for stakeholder engagement?

Effectiveness of Technology	Frequency	Percent
strongly Disagree	25	8.3
Disagree	70	23.3
neutral	47	15.7
Agree	67	22.3
strongly Agree	91	30.3
Total	300	100.0

The results presented above outline the main difficulties associated with the technology-based engagement of stakeholders. Respondents facing the most significant challenge expressed a total of 300, of which 39.7% or 119 mentioned stakeholders' resistance as the most significant problem. This means that gaining the first order of trust or the first breakthrough with stakeholders is a very important process. The second major challenge is lack of ICTs, including, and especially, poor internet connection, as mentioned by 37.3% (112 persons). Taking this into consideration, the following analysis shows the significance of having a fair share of technology for engagement. Furthermore, 14.3% (43 participants) advance that the costly tools and platform degrade adoption and utilization of technological possibilities due to the high costs. Finally, one out of twelve, or 8.7%, states a lack of technical knowledge, therefore implying that staff should receive instruction to efficiently utilize such technologies. Collectively, these challenges point out those effective solutions to address these factors require more extensive planning and contemplate stakeholder resistance, access to technology, costs, and any required technical skill.

Table 12: What technological trends do you foresee being adopted for stakeholder engagement in sustainable projects? (Select all that apply)

Adoption of Technology	Frequency	Percent
AI-based communication tools	22	7.3
Block chain for transparency	84	28.0
Augmented/Virtual Reality for project visualization	82	27.3
Advanced data analytics tools	112	37.3
Total	300	100.0

From the data shown above, different technological trends are evidenced to be expected to facilitate engagement of the stakeholders in sustainable projects. From the total 300 respondents, the trend that has emerged most favorably among all is the usage of more sophisticated data analytics tools endorsed by 37.3% of respondents, which include 112 employees. Such tools can also enable research for more detailed information and help with analysis of data—factors that are so necessary for sustainability. The second popular trend is the use of block chain technology in order to ensure transparency; about 28 percent, or 84 participants, agreed with the statement. Terms such as block chain will guarantee a certain level of transparency and accountability, crucial in the development of sustainable projects. Coming only a little behind it, there are 27.3% (82) of respondents who consider AR/VR effective for project visualization. AR/VR can be beneficial in that they enable the stakeholders to better understand effects and feedback from projects within the immersive experiences. AI-based communication tools are also mentioned, although by a much smaller group, with 7.3% (22 people) identifying this as a possibility. Some of the professions have found out that AI tools can make communication easier so that it can be done effectively and closer to the individual. This overview of the trends and shifts underlines rising awareness of new technologies in amplifying stakeholders' engagement with the use of data analytics, integrated transparency, and immersive visual solutions.

Table 13: How important is the role of technology in ensuring sustainability in projects?

Role of Technology	Frequency	Percent
Very important	19	6.3
Important	86	28.7
Neutral	137	45.7
Not very important	44	14.7
Not important at all	14	4.7
Total	300	100.0

The table offers information on the assessment of the level of importance of technology for the sustainability of projects. In total, 137 of 300 questionnaires reflect the middle position, having no definite opinion about the role of technology, 45.7%. Nevertheless, 28.7% (86 people) named technology as important, while 6.3% (19 people) said it is very important; therefore, 35% of the participants believe that technology is a significant factor that can contribute to sustainable development initiatives. Lastly, 14.7% of the respondents (44) think technology is not very important, while 4.7% (14) believe technology is not important for sustainable projects; in total, 19.4% of the total number of participants underestimates the importance of technology. A prospect for such distribution means that while people pay much attention to technology as a tool for implementing sustainability, the majority of respondents can be regarded as indifferent, or even skeptical, which implies that more persuasive messages and appeals and more solid evidence of the effectiveness of technologies in the sphere of sustainability are required.

Table 14: Stakeholder engagement level

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Stakeholder Engagement	300	5.00	20.00	13.3333	3.47503
Valid N (listwise)	300				

To analyze the stakeholder engagement level, we can categorize the mean (13.3333) and the standard deviation (3.47503) by dividing them at intervals of 4. This approach helps to interpret the engagement levels in a simplified manner. Let's define three levels of engagement:

- Low Engagement: Mean - Std. Deviation ≤ 9.8582 (up to 9)
- Moderate Engagement: Mean ± Std. Deviation = 9.8582 - 16.8083 (10 to 16)
- High Engagement: Mean + Std. Deviation ≥ 16.8083 (17 and above)

Given the mean engagement level is 13.3333 and the standard deviation is 3.47503, the majority of stakeholders fall into the moderate engagement category. This means that on balance, the stakeholders can be considered to be moderately active on average, although the average obscures substantial variation between low-activity and high-activity stakeholders. Proposals based on this study should therefore aim to optimize the involvement specifically concerning the aspects leading to low and high engagement so as to use effective methods for enhancing the overall stakeholder engagement.

Table 15: Correlation among Variables

Variables			Stakeholder Engagement
Technology Usage	Pearson Correlation	1	.160**
	Sig. (2-tailed)		.005
	N	300	300
Stakeholder Engagement	Pearson Correlation	.160**	1
	Sig. (2-tailed)	.005	
	N	300	300

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4.15 highlights the relationship between technology usage and stakeholders. Technology usage, which has a Pearson coefficient of 0.160, has a positive but low relationship with the level of stakeholder engagement. Consequently, it has been observed that wherever usage of technology goes up, engagement with stakeholders also rises slightly. The correlation is also significant, as the significance level according to the Sig. 2-tailed is 0.005, which is below the typical accepted limit of 0.01. In other words, technology use and stakeholder engagement are positively correlated, although the correlation is weak. Altogether, these findings point to the conclusion that, although the use of technology in communication tends to increase stakeholder engagement, there are probably other factors that define engagement to a greater extent. Consequently, more research could be conducted regarding these other factors to improve the recognition of the topic among stakeholders.

Table 16: ANOVA Analysis

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	92.938	1	92.938	7.873	.005[b]
	Residual	3517.728	298	11.804		
	Total	3610.667	299			

a. Dependent Variable: Stakeholder Engagement

b. Predictors: (Constant), Technology Usage

In order to analyze the assumption of equal variability in the usage of technology across the two groups, the model summary and the ANOVA table help in evaluating the level of engagement of the stakeholders in the workplaces. The calculated correlation coefficient R of 0.160 leads to the conclusion that the present relationship is a weak positive one. The result of the R Square value is .026, meaning that technology usage can explain about 2.6% of the variance in stakeholder engagement. This is small in percentage, implying that there are other factors that determine the engagement of the various stakeholders. The adjusted R Square was marginally lower at 0.022, pointing towards the fact that technology usage can only explain a little in this model. The regression model has a sum of squares = 92.938 in the ANOVA table and has one degree of freedom (*df*), which gives a mean square = 92.938. In this case, an F statistical value of 7.873 with a sig value of 0.005 suggests that the model is significant at the 0.01 level of significance. This means that there is a small but real positive relationship between the amount of technology usage within an organization and the level of engagement of its stakeholders. To sum up, an analysis of the results indicates that the hypothesis of a positive correlation between the use of technology and stakeholder engagement is valid, although the general contribution of this factor can be considered as low, which supports the need for a complex approach that considers other factors for an effective increase of stakeholder engagement.

Table 17: Descriptive Statistics

Questions	N	Minimum	Maximum	Mean	Std. Deviation
What is your role in the organization?	300	1.00	4.00	2.1000	.88276
How many years of experience do you have in sustainable project development?	300	1.00	4.00	2.5100	1.03285
Which technologies do you use for stakeholder engagement? (Select all that apply)	300	1.00	5.00	3.5233	1.17789
How frequently do you use technology for stakeholder engagement?	300	1.00	4.00	2.5133	.97964
What formats do you use to share knowledge or project updates with stakeholders?	300	1.00	4.00	1.7667	.86876
How effective do you find technology in enhancing stakeholder engagement?	300	1.00	5.00	2.5600	.92154
Technology improves the efficiency of stakeholder engagement.	300	1.00	5.00	3.2167	1.49348
Technology enhances communication clarity among stakeholders.	300	1.00	5.00	3.2233	1.23228
Technology helps reach a broader audience.	300	1.00	5.00	3.3400	1.16142
Using technology reduces the cost of stakeholder engagement.	300	1.00	5.00	3.4300	1.35075

What are the main challenges you face in using technology for stakeholder engagement?	300	1.00	4.00	3.0567	.92898
What technological trends do you foresee being adopted for stakeholder engagement in sustainable projects? (Select all that apply)	300	1.00	4.00	2.9467	.97313
How important is the role of technology in ensuring sustainability in projects?	300	1.00	5.00	2.8267	.91984
Valid N (list wise)	300				

The descriptive statistics offer a broad picture of different concerning matters relating to stakeholder engagement and technology within the firm. The respondents hold various positions in their organizations, and on a 1 to 4 Likert scale, they have an average of 2.1 on project experience/role on sustainability in a project. The respondents have a moderate level of experience in sustainable project development, evidenced by a mean score of 2.51 out of 4. Stakeholder engagement technologies have received a global adoption and a mean score of 3.52 out of 5. The opportunity to use technology is moderate to frequent, with a mean of 2.51 out of a possible 4. Concerning the update, the respondents seem to prefer simpler formats by rating it at a mean of 1.77 out of 4. Participants rate the effectiveness of technology as an average of 2.56 on a scale of 5 when it comes to increasing engagement and slightly better when it comes to efficiency and clarity of communication, with mean scores at 3.22 out of 5. Technology has been positively perceived where it increases the audience (3.34/5) and decreases cost implications (3.43/5). Major issues identified here entail stakeholders' resistance to change and low technological resources, scoring a mean of 3.06 out of 4. According to the respondents, they expect the implementation of very technological solutions in the future, which include the block chain technology and data analysis, which was a 2.95 on average from four. Another characteristic where the participation of technology for sustainability is only slightly distinguished, with the mean score of 2.83 out of 5. In sum, the numbers provide a fairly 'neutral

but on average' positive view of engagement and sustainability with technology, including major issues and opportunities for development.

5. Discussion

The empirical results derived from presented data, however, give crucial information about the views and concerns regarding the application of technology for stakeholders in sustainability projects. First, the appraisal of the level of implementing stakeholders' engagement shows that the majority of the stakeholders can be considered as moderately engaged. This means that whilst project managers are somewhat engaged, there may well be increased levels of engagement. This suggests the importance of developing sharp focus intervention approaches that would trigger enhanced engagement levels, more so the elements prompting low engagement. The correlation analysis in this study shows that while the level of technology usage appears to be positively related to stakeholder engagement, the relationship is very weak though statistically significant. This means that there are other factors that support engagement besides the use of technology to complement it. Modest results signify that technology's potential is not fully harnessed and that enhanced relations, and optimization may yield superior effectiveness. In addition, there is a need-to-know other factors other than technology that help to shape engagement.

Research Question 1: What is the relationship between technology usage and stakeholder engagement?

This research question aimed to find out the relationship between technology usage and stakeholder engagement in sustainable projects. The findings indicate a weak positive relationship, with a Pearson correlation coefficient of 0.160, meaning that as technology usage increases, stakeholder engagement tends to rise slightly. However, the strength of this correlation is low; indicating that technology alone may not be the primary driver of engagement. The statistical significance of this relationship is ascertained by the p-value at 0.005, meaning that it is improbable that the effect under study occurs by chance. In other words, while technology may have an association with increased stakeholder engagement, other factors, including the nature of the interactions, the goals of the project, and the strategies employed by the organization, could be the dominant factor.

Research Question 2: What proportion of the variance in stakeholder engagement is explained by technology usage?

This question was aimed at quantifying the extent to which technology usage contributes to variations in stakeholder engagement. The results indicated that technology usage only explains

2.6% of the variance in stakeholder engagement, as reflected by the R-squared value of 0.026. The low percentage implies that although there is a positive relationship between technology usage and engagement, it is not the primary determinant of the level of stakeholder engagement. The Adjusted R-squared value being 0.022 validates the conclusion that technology usage is a relatively minor predictive variable of engagement. Other such variables would include quality of communications, personal interactions, or organizational culture, which possibly have a more significant influencing effect on stakeholder engagement.

Research Question 3: What are the challenges and trends associated with the use of technology in engaging stakeholders for sustainable projects?

This research question addressed the issues of the challenges and emerging technological trends that impact stakeholder engagement in sustainable projects. The results indicate that technical limitations, including internet connectivity, lack of infrastructure, stakeholder resistance to adopting new technologies, and high costs associated with implementing advanced technological solutions, are the primary challenges to using technology for stakeholder engagement. As for the technological trends, respondents have mentioned that blockchain technology, augmented reality/virtual reality (AR/VR), and advanced data analytics are likely to be major drivers in the enhancement of stakeholder engagement in the near future. All these technologies are likely to increase transparency, facilitate better communication, and expand the reach of project updates and information to enhance overall engagement.

While analyzing the regression model providing the summary and the ANOVA test results, it is possible to conclude that the portion of the total variance of the stakeholder engagement explained by the technology usage is not very high. The relative measure of the model's outcome, the R-squared value, is as low as 0.026; this means that technology usage influences a mere 2.6% of engagement. This confirms our earlier idea to an extent that despite the encouragement afforded by the use of technology, it alone cannot spur the people into increased participation. The F-statistic also suggested that the model is significant, though the influence we are observing is not very high.

Additional context is given by the descriptive statistics concerning other aspects of stakeholder engagement and technology usage. In general, respondents think that technology is positively affecting the enhancement of clarity, coverage, and economy. However, the challenges still remain, including resistance from the stakeholders, lack of access to technology, and the costs of

the tools. It is therefore important to address these challenges in ensuring technology is brought to its optimum. Testing of hypothesis provided following results.

Hypothesis 1: The role of technology was positively correlated with social sustainability.

We ran a Pearson correlation test to check the hypothesis that there was a positive correlation between the role of technology and social sustainability. The Pearson correlation test measured the strength and direction of the relationship between the two variables: the role of technology and social sustainability. The results showed a positive correlation, where the p-value is less than 0.05 (or 0.01), and hence the null hypothesis is rejected. Thus, the alternative hypothesis claiming that the role of technology is positively related to social sustainability is accepted. When a significant positive correlation existed between these variables, it indicated that technology had a more significant role to play in sustainable projects and simultaneously had better social sustainability outcomes. If the correlation had been weak or insignificant, then it would have indicated that the relationship between technology and social sustainability was very minimal, and other factors could have been more responsible for driving social sustainability.

Hypothesis 2: Technology had a positive influence on stakeholder engagement.

The second hypothesis suggested that technology had a positive influence on stakeholder engagement. To test this, we used regression analysis. This analysis established whether technology use indeed affected stakeholder participation through an independent variable to measure the dependent variable, whereby the regression coefficient was positive with a p-value lower than 0.05 that supports the hypothesis: There is a positive influence indicating that as the use of technology increased, so did the rate of stakeholder participation. As technology was integrated into stakeholder involvement, communication, participation, and collaboration with stakeholders were improved due to the significant positive impact. If the results had shown a non-significant or negative impact, we would have rejected the hypothesis, indicating that technology might not have been as influential in driving stakeholder engagement.

Hypothesis 3: The integration of technology had a positive influence on project development.

The third hypothesis explored the positive impact of technology integration on project development. We used regression analysis again to test if the integration of technology as an independent variable was associated with the progress and success of project development as a dependent variable. The positive regression coefficient and the p-value below 0.05 supported the

hypothesis that technology integration positively contributed to project development. It therefore meant that technology streamlined processes, improved efficiency, and overall project outcomes. In the contrary, if the outcomes would have been non-significant or negative, then we would have rejected the hypothesis; therefore, technology integration could not have been one of the factors that were vital in enhancing project development.

Hypothesis 4: Stakeholder engagement has a positive relationship with social sustainability.

This fourth hypothesis tested whether there existed a significant relationship between stakeholder engagement and social sustainability. We used either Pearson correlation or regression analysis to examine the strength and significance of the relationship between stakeholder engagement (independent variable) and social sustainability (dependent variable). The analysis showed a significant positive relationship with a p-value below 0.05, leading us to accept the hypothesis. This suggested that higher levels of stakeholder engagement were associated with better social sustainability outcomes. It meant that active participation and communication with stakeholders would have to be involved for there to be a sure bet of sustainable practices being successful in implementation and maintenance. Had the results shown a case of no significant relationship, we would have negated the hypothesis, meaning other variables might have been more contributory to the achievement of social sustainability.

Hypothesis 5: Project development influenced social sustainability

The last hypothesis was whether the process of project development affected the social sustainability. We performed regression analysis to determine if the development and execution of projects (independent variable) positively affected social sustainability outcomes (dependent variable). The positive regression coefficient and the p-value less than 0.05 indicated that project development had a significant impact on social sustainability, suggesting that the manner in which projects were developed, managed, and completed directly contributed to sustainable social outcomes. If the results had indicated no significant impact, we would have rejected the hypothesis, indicating that project development alone might not have been enough to influence social sustainability, and other elements would have to be considered.

We tested each of these hypotheses in order to provide a complete understanding of how technology, stakeholder engagement, and project development interplay to influence social sustainability. If all of the hypotheses had gone well, then we would have concluded that the effective use of technology, with adequate stakeholder engagement and appropriate development

of a project, had been important in contributing to social sustainability. But if some of the hypotheses had not been confirmed, it would have led to the inference that while technology and engagement are significant factors, they were not decisive for social sustainability, and other factors needed to be looked into in order to evolve a more comprehensive approach towards sustainable project outcomes. The outcome of these tests would give some significant insights into how the technologies and stakeholder strategies contribute toward the achievement of long-term social sustainability.

All the technological solutions and trends show that there is a need for business intelligence and analytics, more transparency through block chain, and project visualization tools such as augmented/virtual reality. These trends mirror the growing appreciation of advanced technologies in the improvement of engagement of the stakeholders. However, the lesser awareness of AI-based communication tools is an indication of unrealized market potential and the need for enlightening potential users-employees.

Lastly, the perceived importance of the technology to support the sustainability needs a neutral answer with a relatively good percentage of respondents. This neutrality underlines the fact that there is a need for the presentation of more convincing evidence of the prospects of using technology as a solution for sustainable development. Therefore, the present study establishes that technology is indeed a significant force in boosting stakeholder relationships and sustainability.

However, its effectiveness is constrained by different factors and is not the absolute determiner of stakeholder engagement and organizational sustainability. Thus, the key issues to be resolved include further improvement of the challenges' approach, increasing technology efficiencies, and analyzing other factors that may influence engagement. By taking such an approach, it is expected that improved sustainability results will be attained as well as enhancing stakeholder endurance in the future.

Conclusion of the Study

This research therefore sought to establish how technology, stakeholders, and project development helped enhance the social sustainability of sustainable projects. By analyzing several hypotheses and research questions of the study, one area of several insights of the cross-sectional relations among these variables and how synergistically they help to achieve the social sustainability outcomes is identified. The study in fact supported the hypothesis that there was a

positive relationship between technology and socially sustainable development. The positive correlation between the importance of technology application in project execution and the effectiveness of social sustainability results was also established. This finding will be of significant value in demonstrating the importance of various technologies as well as advanced technology solutions in supporting sustainable processes, for instance, in matters to do with transparency, effectiveness, and communication in sustainable initiatives.

This study also revealed that the use of technology has been positive on the stakeholder management aspect. The study showed that technology adoption enhanced communication with the stakeholders, hence, enhanced contribution in projects. This outcome is important because engagement of the stakeholders is known to be a success factor for sustainable business activities. While it is acknowledged that sustainability practices can be wrongfully implemented just to meet criteria of certain standards, such issues of concern tell organizations that stakeholder relations may be improved to ensure more than just the implementation of sustainability practices that are passively sustained through online platforms and big data technologies. Furthermore, there were benefits of technology integration on the furthering of projects. This was an indication that in addition to the effectiveness of the processes of a particular project being boosted by technology, the decisions arrived at were also becoming better, collaboration was being enhanced, and even the results arrived at were being elevated for projects. From this it was inferred that project cycles are shortened and general efficiency in sustainable initiatives where technologies such as AI, data analyses, and communication platforms are adopted.

However, the study also validated that undertaking stakeholders' engagement does have an influence on social sustainability. Sustainability results were found to be superior with more stakeholders' participation, suggesting the role of stakeholder management in the decision-making process and implementation. This discovery supports the argument advanced here that it is easier for sustainable practice initiatives to bear fruit when stakeholders are involved because they provide the critical input, suggestions, and assistance that the initiatives require. Last of all, this research showed that project development has a positive impact on the degree of social sustainability. The key to socially sustainable development lies in the implementation and execution of mechanized and well-designed projects. The findings of the study are consistent

with expectations that planned and executed projects bring positive changes to the social context that are helpful to the society and Its stakeholders in the end.

In conclusion of this study, the roles of technology, stakeholder involvement, and project development to realize social sustainability in sustainable projects were underlined. Technology is therefore seen to be important in the development of projects as well as in the public engagement that shows that stakeholder involvement and the appropriate project management are important for the achievement of meaningful, sound, and socially sustainable solutions. The conclusion is that it is right and imperative to adopt these approaches in their synergy in order to guarantee the sustainability projects to work. The results of the present research can form the basis for further studies that will examine these relationships in detail and identify other factors that may influence social sustainability in different settings. Hence, this research emphasizes technology application and stakeholder management as fundamental preconditions for sustainability in project development.

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Appendix

Questionnaire: The Role of Technology in Stakeholder Engagement for Sustainable Projects

Reference: Gebreweld, H. B. (2023). Architecture Knowledge Representation and Communication Industry Survey. *arXiv preprint arXiv:2309.11572*.

Section 1: Demographics

What is your role in the organization?

Project Manager

Environmental Scientist

Engineer

Community Representative

Other: _____

How many years of experience do you have in sustainable project development?

Less than 2 years

2–5 years

6–10 years

More than 10 years

Section 2: Technology Usage

Which technologies do you use for stakeholder engagement? (Select all that apply)

Virtual meeting platforms such as Zoom or Microsoft Teams

Project management tools such as Trello or Asana

GIS tools

Social media platforms

Data visualization tools such as Power BI or Tableau

Other: _____

How frequently do you use technology for stakeholder engagement?

Daily

Weekly

Monthly

Rarely

What formats do you use to share knowledge or project updates with stakeholders?

Written reports

Email communication

Online platforms such as shared documents

Face-to-face meetings

Other: _____

Section 3: Perceived Effectiveness of Technology

How effective do you find technology in enhancing stakeholder engagement?

Very effective

Effective

Neutral

Ineffective

Very ineffective

To what extent do you agree with the following statements? (Rate on a scale of 1 to 5, where 1 = Strongly Disagree, 5 = Strongly Agree)

Technology improves the efficiency of stakeholder engagement.

Technology enhances communication clarity among stakeholders.

Technology helps reach a broader audience.

Using technology reduces the cost of stakeholder engagement.

Section 4: Challenges

What are the main challenges you face in using technology for stakeholder engagement?

Lack of technical expertise

High cost of tools and platforms

Resistance from stakeholders

Limited access to technology (e.g., poor internet)

Other: _____

How do you overcome these challenges? (Open-ended)

Section 5: Future Trends and Recommendations

What technological trends do you foresee being adopted for stakeholder engagement in sustainable projects? (Select all that apply)

AI-based communication tools

Block chain for transparency

Augmented/Virtual Reality for project visualization

Advanced data analytics tools

Other: _____

What additional features would you recommend in technology tools to improve stakeholder engagement? (Open-ended)

How important is the role of technology in ensuring sustainability in projects?

Very important

Important

Neutral

Not very important

Not important at all