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Research Article

The impact of SDGs triggering the geographical information system (GIS) innovation influencing urban and rural system mechanism and socio-economic growth

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ABSTRACT

The globe has seen major breakthroughs in a variety of disciplines in recent years. The implementation of the Sustainable Development Goals (SDGs) necessitates a multifaceted approach that incorporates innovative ideas and technology to track, monitor, and evaluate progress towards long-term development goals. Geographic Information System (GIS) innovation is one such disruptive technology that has gained traction in recent years. Geospatial data is used by GIS to give important insights, enhance decision-making, and enable effective resource allocation. This study aimed to investigate the impact of the implementation of SDGs and GIS innovation on the socio-economic boom and concrete and rural machine mechanisms, with a focal point on the mediating role of community engagement and the moderating function of technology infrastructure. A quantitative research method turned into followed, and data was gathered from 320 individuals. A structured questionnaire was administered electronically to measure the constructs of SDGs implementation, GIS innovation, community engagement, socio-economic growth, and urban and rural system mechanisms. Statistical Package for the Social Sciences (SPSS) was utilized for data analysis. The results indicated a significant and positive impact of both SDG implementation and GIS innovation on community engagement. Community engagement was found to have a significant and positive effect on socio-economic growth and urban and rural system mechanisms. Additionally, technology infrastructure was found to moderate the relationship between community engagement and urban and rural system mechanisms, as well as the relationship between community engagement and socio-economic growth. This study contributes to the existing literature by empirically examining the interplay between SDGs implementation, GIS innovation, community engagement, technology infrastructure, and their impacts on socio-economic growth and urban and rural system mechanisms. The findings highlight the importance of community engagement as a mediator and technology infrastructure as a moderator in achieving sustainable development goals and improving urban and rural systems.

Keywords: Sustainable Development Goals (SDGs), GIS Innovation, Community Engagement, Socio-Economic Growth, Technology Infrastructure.

INTRODUCTION

The Sustainable Development Goals (SDGs), which have been hooked up by the United Nations in 2015, are an bold and modern worldwide agenda aimed at addressing the sector's maximum pressing problems and achieving sustainable improvement for all. The SDGs, which encompass 17 interconnected desires and 169 objectives, cope with a lot of troubles, such as attaining zero starvation, eradicating poverty, promoting well-being and proper fitness, gender equality, first-rate training, respectable paintings, access to smooth energy and water, and financial growth, innovation, industry, and infrastructure, constructing sustainable cities and groups, lowering inequality, and taking movement against weather trade. The SDGs understand the inherent connections between the financial, social, and environmental components of improvement and the way achievements in a single vicinity are intrinsically linked to those in different areas. To cope with

complicated troubles including inequality, poverty, weather exchange, and environmental degradation, a complete approach to development is required. The Sustainable Development Goals (SDGs) function a framework for encouraging governments, groups, organizations, and other global companies to collaborate and take coordinated motion to attain sustainable development for present and destiny generations (Avotra & Nawaz, 2023).

GIS innovation has increased in significance across one-of-a-kind industries because of its ability to use geospatial facts for choice-making and evaluation (Chrisman, 2020). GIS technology enables the collection, preservation, evaluation, presentation, and interpretation of geographic data, providing valuable insights into spatial patterns and relationships. This analytical competence enables decision-makers to make educated decisions and plan focused interventions that are adapted to specific geographic places and their distinct characteristics. GIS innovation has a wide range of applications (Stranieri et al., 2023). GIS plays an important role in urban planning and infrastructure development in urban systems by examining population density, land use patterns, transportation networks, and environmental elements (Heiberg & Truffer, 2022). It assists city planners in optimizing resource allocation, improving service delivery, and improving overall city management. GIS is useful in rural systems for agricultural planning, natural resource management, and disaster preparedness, resulting in more sustainable land use and better agricultural output (Zhou & Li, 2021). Furthermore, GIS helps stakeholders comprehend the spatial dimensions of many development concerns, allowing them to identify vulnerable areas, evaluate the impact of interventions, and track progress over time. This technology-driven strategy improves the efficiency and efficacy of development activities by facilitating evidence-based decision-making.

The convergence of SDGs with GIS innovation offers a once-in-a-lifetime chance to accelerate progress toward sustainable development. Policymakers and development practitioners can harness the potential of geospatial data to uncover inequities, prioritize areas of need, and maximize resource allocation by using GIS technology into SDG implementation (Taloor et al., 2022). GIS enables extensive study of development indices such as poverty rates, access to education and healthcare, and environmental conditions, allowing for tailored actions to address unique difficulties encountered by various communities (Ukoba et al., 2023). Furthermore, the impact of the SDGs and GIS innovation extends beyond metropolitan regions to rural areas, which are as important for long-term development (Sajjad et al., 2022). GIS can help optimize agricultural methods, manage natural resources, and improve rural infrastructure in rural systems, thereby contributing to poverty reduction and economic growth. Understanding how the combination of SDG implementation and GIS innovation affects both urban and rural system dynamics is critical for achieving fair development and overcoming current regional imbalances (Allawi & Al-Jazaeri, 2023).

The successful pursuit of global sustainable development is dependent on the effective implementation of SDGs and the integration of Geographic Information System (GIS) innovation across several sectors. Despite their expanding importance, there is a crucial study gap on the specific processes by which their combined impact influences socioeconomic growth and urban and rural system dynamics (Adebayo & Ullah, 2023). While individual studies have looked at the effects of SDGs or GIS innovation on various areas of sustainable development, few have looked at how they interact (Al-Zahrani et al., 2020). As a result, a thorough grasp of how the intersection of SDGs and GIS innovation strengthens sustainable development efforts remains elusive. Addressing this research gap is critical for providing insights into the complex linkages between these elements and their combined impact on socioeconomic growth and the dynamics of urban and rural systems.

Community involvement, which has been identified as a critical component of sustainable development, is critical in building ownership, inclusion, and active participation of local stakeholders in decision-making processes (Longoria et al., 2021). However, the specific mediation role of community engagement in the joint implementation of SDGs and GIS innovation needs to be investigated further. This research can provide insight on the factors driving positive development results at the grassroots level by investigating how community participation enables the translation of sustainable development policies into practical and context-specific actions. Aside from community engagement, technology infrastructure, particularly GIS capabilities, is crucial in facilitating sustainable development initiatives (Sun & Kim, 2021). However, the function of ICT infrastructure in mediating the relationship between SDGs, GIS innovation, and development results has received little attention. Understanding how the availability and accessibility of technology infrastructure enhances or limits the impact of SDGs and GIS integration can provide critical insights for policymakers and practitioners looking to use technological advances for sustainable development (Nawaz, Chen, Su, & Zahid Hassan, 2022; Nawaz,, Chen, & Su, 2023).

Therefore, the goal of this study is to thoroughly analyze the influence of SDG implementation and (GIS) innovation on socioeconomic growth and urban and rural system mechanisms. The study aims to investigate the interaction between SDGs and GIS innovation, as well as their combined impact on sustainable development outcomes. Furthermore, the study intends to investigate the mediating effect of community engagement in shaping the relationship between SDGs, GIS innovation, and development results. in addition to this, this study investigates the moderating role of technological infrastructure on the relationship between community engagement, socio economic growth and urban and rural system mechanism.

This research adds significantly to the existing body of information on sustainable development. To begin, the project intends to provide a complete knowledge of how the integration of SDGs and GIS innovation promotes sustainable development initiatives in a synergistic manner. The study provides vital insights into the ability of these two critical components to manage complex development difficulties and boost socioeconomic growth in both urban and rural settings by studying their combined influence. Second, the study contributes by pinpointing the precise processes by which the combination of SDG implementation and GIS innovation effects urban and rural system dynamics. This understanding of infrastructure development, environmental protection, and

community well-being allows policymakers and practitioners to devise focused methods that improve the effectiveness of sustainable development interventions. Third, research into community engagement's mediating role is shedding light on the importance of participatory decision-making and local ownership in sustainable development programs. Understanding the function of community involvement emphasizes the need of integrating communities in development project design and implementation to maintain project relevance and long-term viability.

LITERATURE REVIEW

The Implementation of the Sustainable Development Goals and Community Engagement

The implementation of the SDGs has underlined the need of community engagement in achieving long-term development goals. Boiral et al. (2019) have highlighted the importance of polycentric governance structures that involve multiple actors at various levels in increasing community participation. These frameworks promote community engagement, collaboration, and ownership, allowing local communities to actively contribute to the SDG implementation. In order to improve community engagement and ensure that diverse community needs and perspectives are incorporated into sustainable development projects, inclusive decision-making processes involving a wide range of stakeholders are required. Boyle et al. (2022) investigate the impact of social capital in driving community participation, which includes trust, networks, and cooperation within communities. Social capital can encourage collective action, information sharing, and collaboration, allowing communities to collaborate to achieve the SDGs. Building social capital allows communities to successfully organize resources, confront difficulties, and adopt sustainable development plans. Furthermore, the significance of community engagement in various locations and countries has been studied. Thurman et al. (2020) investigate the importance of community involvement in a rural region of Spain and discovered that active participation and contributions from local communities have a key influence in SDG implementation. Their participation raises awareness, encourages social innovation, and mobilizes resources, ultimately promoting local sustainable development. This emphasizes the importance of context-specific community engagement initiatives that include local realities, objectives, and resources.

H1: Implementation of SDGs has a significant and positive impact on community engagement.

GIS Innovation and Community Engagement

Kılıc et al. (2023) highlight how GIS tools enhance community group participation in urban ecosystem management. GIS enables community members to actively participate in decision-making processes by making geographical data and visualization capabilities available, allowing them to contribute their local knowledge and promote more inclusive and sustainable urban planning. Similarly, Rohe (2020) investigate the importance of geographic information systems (GIS) in involving communities in spatial planning for biodiversity and ecological services. They underline that GIS-based tools allow for the visualization of spatial data, which leads to improved community awareness and participation in conservation and land-use decisions. Furthermore, notion of "citizens as sensors" of Teodoro and Duarte (2022) emphasizes how GIS, when paired with crowdsourcing and citizen science methodologies, allows community members to collect and evaluate geographic data. This participatory strategy encourages community participation and uses local knowledge to inform decision-making processes. Banke-Thomas et al. (2023) examine how the technologies and collaborative mapping platforms has further democratized GIS and encouraged community engagement. Community members can contribute their local knowledge and change the portrayal of their settings through online mapping platforms and crowdsourcing efforts. Finally, Cairns et al. (2023) describe how GIS-based crowdsourcing efforts involve communities in data gathering procedures, empowering individuals to actively participate in urban planning, environmental monitoring, and decision-making. In summary, GIS innovation has transformed community interaction by making spatial data, visualization tools, collaboration platforms, and crowdsourcing opportunities more accessible. Community members can now actively participate in sustainable development activities, creating their environments and influencing decision-making processes as a result of these improvements.

H2: GIS innovation has a significant and positive impact on community engagement.

Community Engagement and Socio-economic Growth

The connection between community involvement and a number of socioeconomic growth indicators, such as economic development, educational attainment, and the production of social capital (Goodman & Dent, 2019). Research review by Kumar & Mehany (2022) backs up this claim by demonstrating how community participation improves economic conditions, increases access to resources, and improves social cohesiveness. Research by Hicken and Jamal (2019) examines the relationship between community engagement, political participation, and economic development, emphasizing the favorable impact of active community involvement on socio-economic growth. Luo and Song (2022) stress the significance of community engagement in collaborative governance, demonstrating its positive impact on economic development and social progress. The paradigm developed by Falanga & Nunes (2021) highlights the paths by which community participation promotes socioeconomic progress, such as entrepreneurship, innovation, workforce development, and social capital building.

H3: Community engagement has a significant and positive impact on socioeconomic growth.

Community Engagement and Urban and Rural System Mechanisms

According to Umstattd Meyer et al. (2019), citizen science activities have the potential to improve community participation and sustainable development. Community involvement enhances the resilience and adaptive capability of urban and rural systems by incorporating community members in data gathering, knowledge exchange, and collaborative problem-solving. Cook (2020) highlight the importance of community participation in spatial planning, demonstrating that active participation leads to more inclusive and locally

responsive practices. Community participation ensures that resource allocation, land-use patterns, and infrastructure development are aligned with the community's needs and ambitions, thereby strengthening the mechanisms of urban and rural systems. Connolly et al. (2022) focus on community engagement in informal settlements, emphasizing its importance in sustainable urbanization planning. By incorporating local people in decision-making processes, urban development interventions become more effective and sustainable, resulting in improved urban system mechanisms and better living circumstances. Furthermore, as Goodman and Dent (2019) explain, community engagement in climate adaptation contributes to the resilience and transformative capacity of urban and rural systems. Transdisciplinary techniques that integrate scientific and local knowledge, paired with community engagement, promote adaptive capacity and knowledge co-production in the face of climate change issues. Finally, Hébert et al. (2022) underline the importance of community engagement in urban development and place-making processes in creating more inclusive and sustainable urban system mechanisms. A sense of ownership, social cohesiveness, and attachment to the built environment are promoted by integrating community members in decision-making, resulting in dynamic and livable urban settings. In conclusion, community participation has a significant impact on the processes of urban and rural systems, improving resilience, inclusivity, and sustainability (Masterson & Teljeur, 2023).

H4: Community engagement has a significant and positive impact on urban and rural system mechanisms.

Community Engagement as a Mediator

Ni et al. (2021) highlight the importance of community engagement in reducing health disparities and improving health outcomes. Community involvement improves trust, collaboration, and community-driven solutions by integrating members of the community in research and decision-making processes, resulting in better socioeconomic well-being. Silberberg and Martinez-Bianchi (2019) emphasize the relevance of community engagement in customizing development initiatives to local contexts, needs, and ambitions, hence increasing the effectiveness and sustainability of the programs. Linn et al. (2020) show how asset-based community development allows individuals and communities to discover and utilize their strengths, resulting in socioeconomic growth. According to Thurman et al. (2020), community engagement is critical in climate governance and fulfilling SDGs connected to climate change. Climate action becomes more inclusive, relevant, and responsive to local needs when communities are involved as essential stakeholders, ultimately boosting socioeconomic growth. Leknoi et al. (2022) highlight the potential of citizen science programs to improve community participation, knowledge exchange, and collaborative problem-solving, all of which contribute to long-term development outcomes and socioeconomic growth.

H5: Community engagement mediates the relationship between implementation of SDGs and socioeconomic growth.

Stewart et al. (2020) emphasize the relevance of community engagement in sustainable development, emphasizing the role of local knowledge and values in SDG implementation. Community involvement strengthens the mechanisms of urban and rural systems by integrating local people in decision-making and planning processes, ensuring that development approaches match with the specific needs and ambitions of the communities. Batidzirai et al. (2021) emphasize the transformative potential of community engagement in urban governance for SDG achievement. They underline that citizen participation improves urban system mechanisms by encouraging transparency, accountability, and participatory decision-making. Community participation enhances the effectiveness and long-term sustainability of urban systems by involving individuals in the planning, execution, and monitoring of sustainable development programs. In rural areas, community engagement also plays a significant mediating role in SDG implementation. Baba et al. (2021) emphasize that community engagement empowers rural communities, promotes social cohesion, and addresses the specific challenges and opportunities in rural contexts. Through community involvement, SDG implementation can be tailored to local needs, resources, and aspirations, leading to improved rural development outcomes and strengthened rural system mechanisms. In urban planning, Hazell (2019) highlights the mediating role of community engagement in enhancing urban system mechanisms. Community engagement fosters social capital, civic participation, and inclusive decision-making, resulting in urban planning practices that are responsive to local contexts and aligned with the SDGs. By involving communities in the planning process, urban development outcomes are more effective and sustainable, promoting the well-being of urban residents and strengthening urban system mechanisms (Connolly et al., 2022).

H6: Community engagement mediates the relationship between implementation of SDGs and urban and rural system mechanisms.

Connolly et al. (2022) highlight the concept of volunteered geographic information (VGI) and the transformative role of community engagement in GIS innovation. By involving individuals as active contributors, community engagement empowers citizens and fosters a sense of ownership in GIS projects. This engagement leads to increased data availability, improved decision-making processes, and the development of innovative applications and services, all of which contribute to socioeconomic growth. Connolly et al. (2022) emphasize the concept of citizens as sensors and their impact on GIS innovation. Engaging the community in GIS through the collection and sharing of geospatial data enhances socioeconomic growth. By involving citizens in data collection, analysis, and interpretation, GIS innovation facilitates the identification of local challenges and opportunities. This enables informed decision-making, targeted interventions, and effective resource allocation, all of which drive socioeconomic development. One prominent example of community engagement in GIS innovation is OpenStreetMap (OSM) discussed by Daniels et al. (2021). OSM relies on community contributions for mapping and spatial data creation. Through active community engagement, OSM provides accessible and up-to-date geospatial information that supports various applications, ranging from urban planning to emergency

response and transportation management. The availability of such geospatial information contributes to improved socioeconomic outcomes and promotes growth in communities. Gage et al. (2022) highlight the potential of crowdsourcing and community engagement in GIS innovation for urban geoinformatics. By involving citizens in mapping, data collection, and validation processes, community engagement supports the development of a citizen-contributed spatial data infrastructure. This active participation and collaboration lead to improved data quality, increased access to geospatial information, and enhanced decision-making processes, ultimately fostering socioeconomic growth in urban areas. Ure et al. (2021) underscore the relationship between citizen participation, volunteered geographic information, and socioeconomic growth. They emphasize that community engagement in GIS innovation empowers individuals and communities, promotes social inclusion, and drives local development initiatives. By involving citizens in the co-creation of geospatial data, GIS innovation enhances community capacity, supports evidence-based decision-making, and fosters collaborative problem-solving. These factors collectively contribute to socioeconomic growth and improved quality of life (Snow et al., 2020).

H7: Community engagement mediates the relationship between GIS innovation and socioeconomic growth.

Community engagement serves as a mediator between GIS innovation and urban and rural system mechanisms, as highlighted in the literature. Esmaeilpoorarabi et al. (2020) emphasize the role of community engagement in urban planning processes facilitated by GIS innovation. By involving local communities in data collection, analysis, and decision-making, GIS innovation empowers community members and fosters collaboration, leading to improved urban system mechanisms. Community engagement helps align planning efforts with the needs and aspirations of the community, ensuring that urban development initiatives are more effective and sustainable. Cho and Park (2022) explore GIS-enabled planning methods that incorporate citizen participation, such as geo design, Geo Civic, and Geo web. They emphasize that community engagement plays a mediating role between GIS innovation and urban and rural system mechanisms. By involving citizens in participatory mapping, decision-making, and collaborative design processes, GIS-enabled planning methods integrate local knowledge, values, and aspirations, leading to more inclusive and responsive system mechanisms. Sharma et al. (2020) emphasize that community engagement acts as a mediator between GIS innovation and urban and rural system mechanisms. Through spatial enablement, GIS innovation facilitates community participation in data sharing, decision-making, and collaborative problem-solving processes. This engagement empowers communities, enhances communication, and promotes sustainable development, ultimately improving system mechanisms in urban and rural contexts (Banke-Thomas et al., 2023).

H8: Community engagement mediates the relationship between GIS innovation and urban and rural system mechanisms.

Technology Infrastructure as a Moderator

According to Aziz and Naima (2021), technology infrastructure, such as digital platforms, connectivity, and data management systems, facilitates effective community engagement and increases the impact of community involvement on urban system dynamics. Technology aids the gathering, analysis, and dissemination of data generated through community participation by providing the appropriate digital infrastructure, allowing for the incorporation of community insights into decision-making processes (Chung et al., 2022). This fusion results in more responsive, efficient, and long-term urban and rural system mechanisms. Wen et al. (2022) stress the need of technology infrastructure as a bridge between community participation and urban innovation. They emphasize that community interaction can yield useful insights and real-time feedback thanks to technology infrastructure that includes sensors, networks, and data analytics. When these inputs are incorporated into urban system mechanisms, they improve responsiveness, efficiency, and sustainability. Alsous et al. (2019) propose a vision of a smart city that emphasizes the relevance of technology infrastructure in supporting effective community interaction and altering urban system dynamics. Advanced telecommunications, data networks, and sensor networks enable the connectivity and data management required to incorporate community perspectives and input into decision-making processes, resulting in improved urban system mechanisms (Nelson et al., 2022).

Brozynski and Leibowicz (2022) evaluate European medium-sized cities based on smart city attributes, emphasizing the function of technology infrastructure as a moderator. By offering digital platforms, open data, and connectivity, effective technology infrastructure fosters community engagement by empowering community members to actively participate in creating urban system processes and promoting sustainable urban development. Tengilimoglu et al. (2023), for example, examine the move from intelligent to smart cities, emphasizing the importance of technology infrastructure in facilitating community engagement and improving urban system dynamics. Technology infrastructure allows the integration of community insights into urban system dynamics by providing the appropriate digital infrastructure for data collection, analysis, and distribution. This promotes more responsive, efficient, and sustainable cities.

H9: Technology Infrastructure moderates the relationship between community engagement and urban and rural system mechanisms.

Technology infrastructure plays an important moderating function between community participation and socioeconomic growth. According to Xiao and Goulias (2022), effective community participation requires a technological infrastructure that includes digital connectivity, data management tools, and information distribution platforms. Technology enables community people to actively engage in decision-making processes, share local knowledge, and contribute to socioeconomic growth by connecting urban development projects with community needs by providing the appropriate digital infrastructure. McManamay et al. (2021) underline the benefits of smart city technology infrastructure for community stakeholders. Technology infrastructure promotes community involvement by enabling stakeholders to co-create solutions, inspire innovation, and drive economic development through

digital platforms, open data, and connectivity. According to Sarabdeen and Alofaysan (2023), technology-enabled community participation can improve sustainable urban development and drive socioeconomic growth. Citizens are empowered by technology infrastructure to actively participate in decision-making processes, share ideas, and contribute to economic growth. Tengilimoglu et al. (2023) underline the importance of technological infrastructure in establishing sustainable communities and promoting socioeconomic growth. Technology infrastructure facilitates community engagement in civic acts that promote sustainable urban development by offering digital connectivity and information-sharing platforms. Through efforts such as social entrepreneurship and digital innovation, communities can collaborate, share resources, and create socioeconomic growth through technology-enabled community participation. Rice and Martin (2020) examine the concept of smart cities critically and emphasizes the moderating effect of technology infrastructure in the relationship between community participation and socioeconomic growth. Technology infrastructure supports community engagement, empowers residents, fosters entrepreneurship, and improves access to economic possibilities through providing digital connectivity, data management systems, and communication platforms.

H10: Technology Infrastructure moderates the relationship between community engagement and socioeconomic growth.

Based on the above literature review, we develop the following conceptual framework as shown in **Figure 1**.

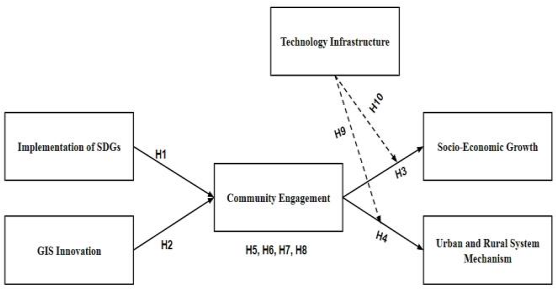

Figure 1. Conceptual Framework

METHODOLOGY

The current study used a quantitative research approach to explore the influence of SDG implementation and GIS innovation on socioeconomic growth and urban and rural system dynamics. Community engagement was investigated as a mediating variable, whereas technology infrastructure was investigated as a moderating variable. The study approach made it easier to collect empirical data in order to analyze the correlations between variables and evaluate the given hypotheses. This study's sample size was 320 individuals, chosen using a purposive sampling technique. This strategy guaranteed that persons with relevant knowledge and experience in SDG implementation, GIS innovation, community participation, and socioeconomic progress were included. A standardized questionnaire was used to collect data, which was administered electronically via an online survey platform. Validated scales were used to assess the constructs of SDG implementation, GIS innovation, community participation, socioeconomic growth, and urban and rural system dynamics. Prior to data collection, the questionnaire was pretested to ensure that the measurement scales were clear, valid, and reliable. The Statistical Package for the Social Sciences (SPSS) software was used to analyze the data. Descriptive analysis was used to summarize the study variables' and sample's characteristics, such as frequencies, percentages, means, and standard deviations.

Measures: Implementation of SDGs was measured by using 6 items scale adopted from Ando et al. (2019). GIS innovation was measured by using 4 items scale adopted from Ramaano (2021). Socio-economic growth was measured by using 6 items scale adopted from Ahmed et al. (2021). Urban and rural system mechanism was measured by using 6 items scale adopted from Yanbo et al. (2019). Community engagement was measured by using 4 items scale adopted from García-Carrión and Allotey (2023). Technology infrastructure was measured by using 3 items scale adopted from Lu et al. (2021).

RESULTS

Descriptive Statistics

Table 1 and **Figure 2** present statistical information for six variables: the implementation of sustainable development goals (ISDG), geographical information system innovation (GISI), urban and rural system mechanism (URSM), community engagement (CE), socioeconomic growth (SEG), and technology infrastructure (TI). Each variable has a total of 320 observations. The mean, which represents the average value, provides an indication of the typical level or performance for each variable. For example, the mean for the implementation of sustainable development goals (ISDG) is 4.125, suggesting a moderate level of progress towards achieving sustainable development objectives. Geographical information system innovation (GISI) has a higher mean of 4.640, indicating a relatively advanced state of innovation in using geographic information systems for various purposes. The mean for urban and rural system mechanism (URSM) is 4.00938, implying a reasonably effective mechanism in managing and coordinating urban and rural systems. Community engagement (CE) has a mean of 4.184, indicating a relatively high level of community involvement and participation in decision-making processes and activities. Socioeconomic growth (SEG) has a mean of 3.950, suggesting moderate economic and social progress in the analyzed context. Technology infrastructure (TI) has a mean of 3.984, indicating a relatively widespread use and availability of technology infrastructure. The standard deviation measures the variability or spread of the data around the mean. For instance, the standard deviation for the implementation of sustainable development goals (ISDG) is 0.749, indicating a relatively low variability in the progress levels reported. GISI has a lower standard deviation of 0.612, indicating a narrower range of innovation levels observed. Urban and rural system mechanism (URSM) has a standard deviation of 0.740, suggesting a moderate degree of variation in the effectiveness of the mechanism. Community engagement (CE) has a higher standard deviation of 0.796, indicating a wider range of community engagement levels reported. Socioeconomic growth

(SEG) has a standard deviation of 0.757, suggesting moderate variability in socioeconomic progress. Technology infrastructure (TI) also has a standard deviation of 0.757, indicating moderate variability in the use and availability of technology infrastructure. The minimum value observed for all variables is 1, representing the lowest level of performance reported. The maximum value for all variables is 5, indicating the highest level of performance recorded. These statistics provide an overview of the central tendency, spread, and range of values for each variable, offering insights into the characteristics and distribution of progress and performance related to the implementation of sustainable development goals, geographical information system innovation, urban and rural system mechanism, community engagement, socioeconomic growth, and technology infrastructure.

Table 1. Descriptive Statistics

	N Total	Mean	Standard Deviation	Minimum
ISDG	320	4.125	0.749	1
GISI	320	4.640	0.612	1
URSM	320	4.009	0.740	1
CE	320	4.184	0.796	1
SEG	320	3.950	0.757	1
TI	320	3.984	0.757	1

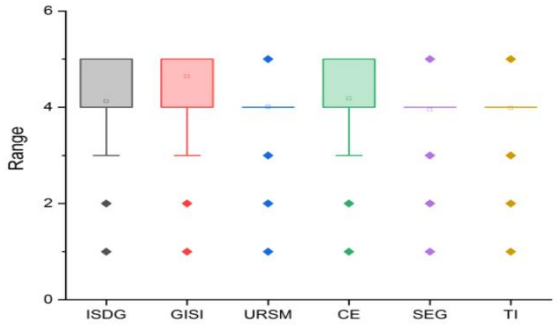

Figure 2. Descriptive Statistics

Normality Assessment

Table 2 and **Figure 3** show the results of a normality test for study variables. The table provides skewness and kurtosis data, as well as their standard errors. The table contains six variables, each with 320 observations: ISDG, GISI, URSM, CE, TI, and SEG. The skewness statistic quantifies the asymmetry of a variable's distribution. A negative skewness score shows that the distribution is skewed to the left (the left side's tail is longer). ISDG has a skewness value of -0.387 in this table, indicating a slightly left-skewed distribution. GISI, on the other hand, has a skewness of -1.825, indicating a more pronounced left-skewed distribution. The skewness of URSM is -0.561, indicating a moderately left-skewed distribution. CE has a skewness rating of -1.054, indicating that it has a significantly left-skewed distribution. The skewness of TI is -0.704, indicating a moderately left-skewed distribution. Finally, SEG has a skewness value of -0.823, indicating that the distribution is moderately left-skewed. When compared to a normal distribution, the kurtosis statistic quantifies the heaviness of the tails and the peakiness of the distribution. A positive kurtosis number indicates heavier tails and a flatter distribution, whereas a negative kurtosis value indicates lighter tails and a flatter distribution. ISDG has a kurtosis value of -0.462 in this table, indicating a reasonably flat distribution. The kurtosis value for GISI is 4.393, indicating a distribution with long tails and a high peak. URSM has a kurtosis score of 0.560, indicating a distribution that is more similar to a normal distribution. The kurtosis score for CE is 1.870, indicating a distribution with heavier tails and a greater peak. The kurtosis score for TI is 0.892, indicating a more normal distribution. Finally, SEG has a kurtosis value of 0.871, indicating a more normal distribution.

Table 2. Normality Assessment

	N	Skewness		Kurtosis	
	Statistic	Statistic	Std. Error	Statistic	Std. Error
ISDG	320	-.387	.136	-.462	.272
GISI	320	-1.825	.136	4.393	.272
URSM	320	-.561	.136	.560	.272
CE	320	-1.054	.136	1.870	.272
TI	320	-.704	.136	.892	.272
SEG	320	-.823	.136	.871	.272

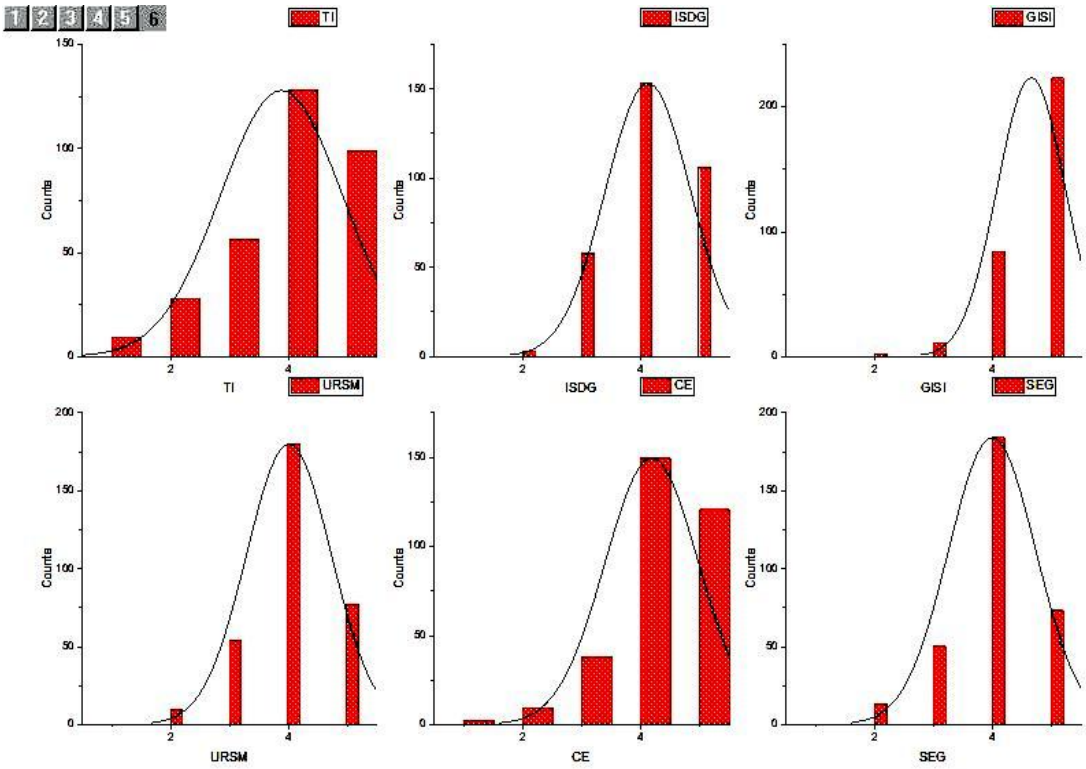

Figure 3. Normality Assessment of Variables

Reliability and Validity

Table 3 provides information about the reliability and validity of the variables measured in a study. Each variable has a specific number of items, and the table presents their outer loadings and Cronbach's alpha values, which indicate the internal consistency of the items within each variable. The ISDG variable consists of six items (ISDG1, ISDG2, ISDG3, ISDG4, ISDG5, and ISDG6). The outer loadings, which represent the strength of the relationship between each item and the underlying construct, range from 0.599 to 0.875. The high outer loadings suggest that most items have a substantial association with the ISDG construct. The Cronbach's alpha value of 0.915 indicates a high level of internal consistency, suggesting that the items within the ISDG variable measure the same underlying construct reliably.

Similarly, the GISI variable includes four items (GISI1, GISI2, GISI3, and GISI4). The outer loadings range from 0.678 to 0.762, indicating a moderate to strong relationship between the items and the GISI construct. The Cronbach's alpha value of 0.728 suggests an acceptable level of internal consistency for the GISI variable. The URSM variable comprises six items (URSM1, URSM2, URSM3, URSM4, URSM5, and URSM6). The outer loadings range from 0.537 to 0.822, indicating varying degrees of association between the items and the URSM construct. The Cronbach's alpha value of 0.828 suggests a high level of internal consistency for the URSM variable. The CE variable consists of four items (CE1, CE2, CE3, and CE4). The outer loadings range from 0.681 to 0.768, suggesting a moderate to strong relationship between the items and the CE construct. The Cronbach's alpha value of 0.828 indicates a high level of internal consistency for the CE variable. The TI variable includes three items (TI1, TI2, and TI3). The outer loadings range from 0.621 to 0.672, indicating a moderate relationship between the items and the TI construct. The Cronbach's alpha value of 0.726 suggests an acceptable level of internal consistency for the TI variable. Lastly, the SEG variable comprises four items (SEG1, SEG2, SEG3, and SEG4). The outer loadings range from 0.716 to 0.828, indicating a moderate to strong relationship between the items and the SEG construct. The Cronbach's alpha value of 0.752 suggests an acceptable level of internal consistency for the SEG variable.

Table 3. Reliability Analysis

Variable	No. of Items	Items	Outer Loading	Cronbach's Alpha
ISDG	6	ISDG1	0.875	0.915
		ISDG2	0.599	
		ISDG3	0.828	
		ISDG4	0.780	
		ISDG5	0.712	
		ISDG6	0.761	
GISI	4	GISI1	0.762	0.728
		GISI2	0.678	

Variable	No. of Items	Items	Outer Loading	Cronbach's Alpha
		GISI3	0.747	
		GISI4	0.734	
URSM	6	URSM1	0.822	0.828
		URSM2	0.537	
		URSM3	0.822	
		URSM4	0.608	
		URSM5	0.658	
		URSM6	0.764	
CE	4	CE1	0.702	0.828
		CE2	0.768	
		CE3	0.729	
		CE4	0.681	
TI	3	TI1	0.621	0.726
		TI2	0.672	
		TI3	0.632	
SEG	4	SEG1	0.716	0.752
		SEG2	0.749	
		SEG3	0.810	
		SEG4	0.828	

Correlation Analysis

Table 4 and **Figure 4** display the correlation matrix, which illustrates the interrelationships among the variables ISDG, GISI, URSM, CE, SEG, and TI. The study revealed statistically significant positive correlations between all pairs of variables, with a p-value less than 0.01. The findings indicate robust correlations among the variables, implying their interconnectedness.

Table 4. Correlation Analysis

		ISDG	GISI	URSM	CE	SEG	TI
ISDG	Pearson Corr.	1.00	0.38	0.56	0.58	0.33	0.59
	P-value	--	0.00	0.00	0.00	0.00	0.00
GISI	Pearson Corr.	0.38	1.00	0.44	0.44	0.23	0.47
	P-value	0.00	--	0.00	0.00	0.00	0.00
URSM	Pearson Corr.	0.56	0.44	1.00	0.72	0.31	0.56
	P-value	0.00	0.00	--	0.00	0.00	0.00
CE	Pearson Corr.	0.58	0.44	0.72	1.00	0.42	0.74
	P-value	0.00	0.00	0.00	--	0.00	0.00
SEG	Pearson Corr.	0.33	0.23	0.31	0.42	1.00	0.43
	P-value	0.00	0.00	0.00	0.00	--	0.00
TI	Pearson Corr.	0.59	0.47	0.56	0.74	0.43	1.00
	P-value	0.00	0.00	0.00	0.00	0.00	--
2-tailed test of significance is used.							

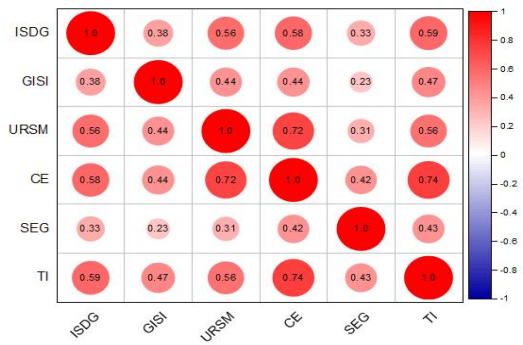

Figure 4. Correlation Matrix

Hypotheses Testing

Table 5 and **Figure 5** present the results of the regression analysis, which examines the relationships between the variables and tests specific hypotheses. The table includes information on the regression coefficients (BETA), t-values, p-values, and the decision regarding the acceptance or rejection of each hypothesis. Hypothesis 1 (H1) states a relationship between the implementation of sustainable development goals (ISDG) and community engagement (CE). The regression analysis shows a significant positive relationship with a beta coefficient (BETA) of 0.572. The t-value of 13.487 and a p-value of 0.000 indicate a highly significant relationship. Therefore, H1 is accepted, suggesting that the implementation of sustainable development goals has a strong positive impact on community engagement. Hypothesis 2 (H2) examines the relationship between geographical information system innovation (GISI) and community engagement (CE). The regression analysis reveals a positive relationship with a BETA coefficient of 0.290. The t-value of 6.846 and a p-value

of 0.000 indicate a significant relationship. Thus, H2 is accepted, indicating that GISI has a positive impact on community engagement. Hypothesis 3 (H3) tests the relationship between community engagement (CE) and socioeconomic growth (SEG). The regression analysis demonstrates a strong positive relationship, as evidenced by a BETA coefficient of 0.842. The t-value of 27.804 and a p-value of 0.000 indicate a highly significant relationship. Consequently, H3 is accepted, indicating that community engagement has a substantial positive impact on socioeconomic growth. Hypothesis 4 (H4) investigates the relationship between community engagement (CE) and the urban and rural system mechanism (URSM). The regression analysis shows a positive relationship with a BETA coefficient of 0.479. The t-value of 9.739 and a p-value of 0.000 indicate a significant relationship. Hence, H4 is accepted, suggesting that community engagement has a positive impact on the urban and rural system mechanism.

Table 5. Regression Analysis

Hypothesis	Relation	BETA	T-value	P-value	Decision
H1	ISDG -> CE	0.572	13.487	0.000	Accepted
H2	GISI -> CE	0.290	6.846	0.000	Accepted
H3	CE -> SEG	0.842	27.804	0.000	Accepted
H4	CE -> URSM	0.479	9.739	0.000	Accepted

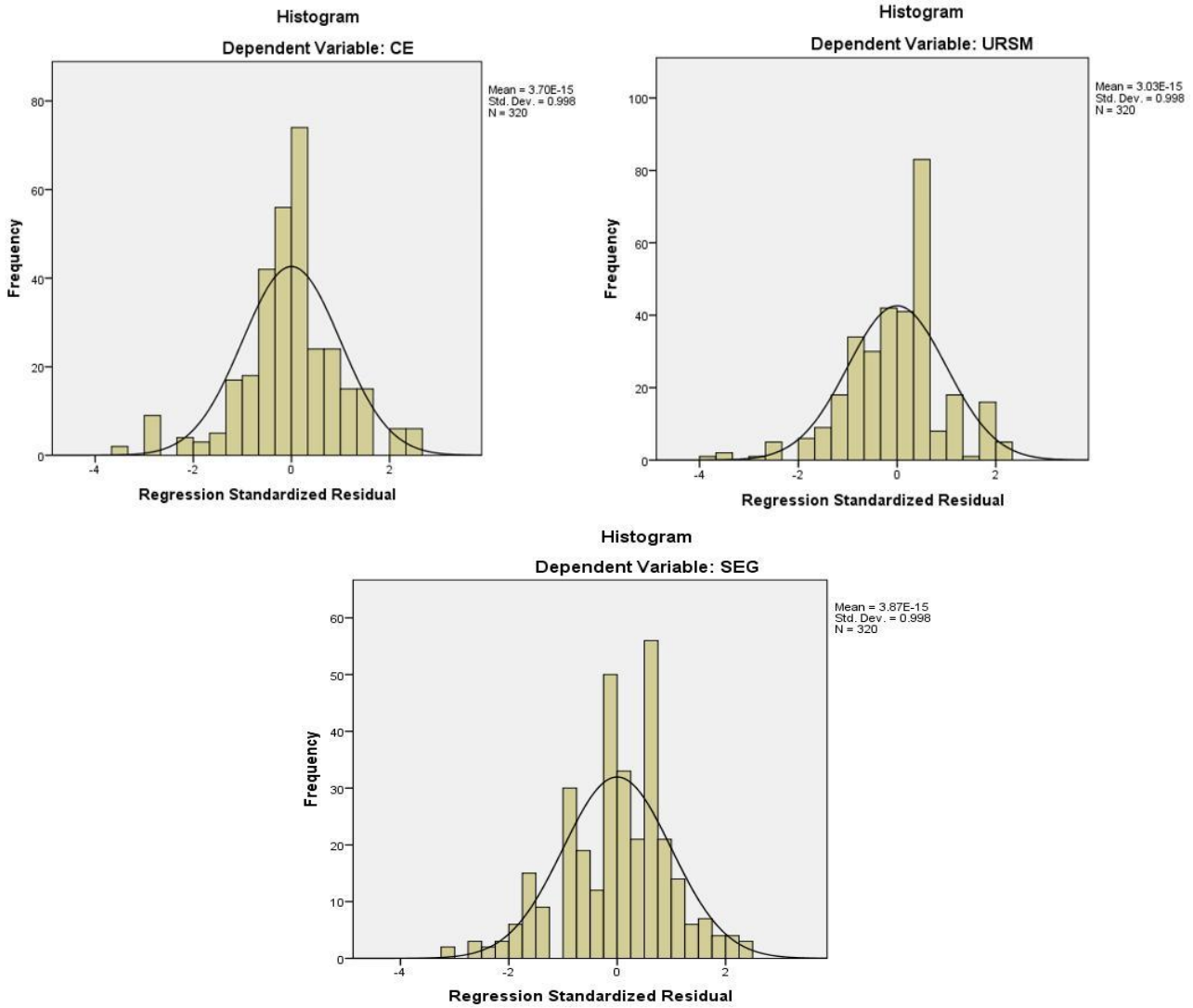

Figure 5. Regression Charts

Meditation Analysis

Table 6 presents the results of the mediation analysis, which investigates the indirect effects of variables through a mediating variable. The table includes information on the regression coefficients (BETA), t-values, p-values, and the decision regarding the acceptance or rejection of each hypothesis. Hypothesis 5 (H5) examines the mediation effect

of community engagement (CE) on the relationship between the implementation of sustainable development goals (ISDG) and socioeconomic growth (SEG). The mediation analysis shows a positive indirect effect with a BETA coefficient of 0.374. The t-value of 5.686 and a p-value of 0.001 indicate a significant indirect effect. Thus, H5 is accepted, suggesting that community engagement partially mediates the relationship between the implementation of sustainable development goals and socioeconomic growth. Hypothesis 6 (H6) investigates the mediation effect of community engagement (CE) on the relationship between the implementation of sustainable development goals (ISDG) and the urban and rural system mechanism (URSM). The mediation analysis reveals a positive indirect effect with a BETA coefficient of 0.640. The t-value of 16.377 and a p-value of 0.001 indicate a significant indirect effect. Therefore, H6 is accepted, indicating that community engagement partially mediates the relationship between the implementation of sustainable development goals and the urban and rural system mechanism. Hypothesis 7 (H7) tests the mediation effect of community engagement (CE) on the relationship between geographical information system innovation (GISI) and socioeconomic growth (SEG). The mediation analysis demonstrates a positive indirect effect with a BETA coefficient of 0.130. The t-value of 2.639 and a p-value of 0.008 indicate a significant indirect effect. Hence, H7 is accepted, suggesting that community engagement partially mediates the relationship between geographical information system innovation and socioeconomic growth. Hypothesis 8 (H8) examines the mediation effect of community engagement (CE) on the relationship between geographical information system innovation (GISI) and the urban and rural system mechanism (URSM). The mediation analysis shows a positive indirect effect with a BETA coefficient of 0.420. The t-value of 7.455 and a p-value of 0.001 indicate a significant indirect effect. Thus, H8 is accepted, indicating that community engagement partially mediates the relationship between geographical information system innovation and the urban and rural system mechanism.

Table 6. Meditation Analysis

Hypothesis	Relation	BETA	T-value	P-value	Decision
H5	ISDG-> CE -> SEG	0.374	5.686	0.001	Accepted
H6	ISDG -> CE -> URSM	0.640	16.377	0.001	Accepted
H7	GISI -> CE -> SEG	0.130	2.639	0.008	Accepted
H8	GISI -> CE -> URSM	0.420	7.455	0.001	Accepted

Moderation Analysis

Table 7, **Figure 6**, and **Figure 7** show the result of moderation analysis. Hypothesis 9 (H9) states that technology infrastructure moderates the relationship between community engagement and the urban and rural system mechanisms. The analysis reveals a significant positive interaction effect with a BETA coefficient of 0.214. A t-value of 3.145 and a p-value of 0.001 indicate a highly significant interaction effect. Therefore, H9 is accepted. Hypothesis 10 (H10) examines the moderation effect of technology infrastructure on the relationship between community engagement and socioeconomic growth. The analysis shows a significant positive interaction effect with a BETA coefficient of 0.278. The t-value of 7.072 and a p-value of 0.001 indicate a highly significant interaction effect. Thus, H10 is accepted.

Table 7. Moderation Analysis

Hypothesis	Relation	BETA	T-value	P-value	Decision
H9	CE x TI -> URSM	0.214	3.145	0.001	Accepted
H10	CE x TI -> SEG	0.278	7.072	0.001	Accepted

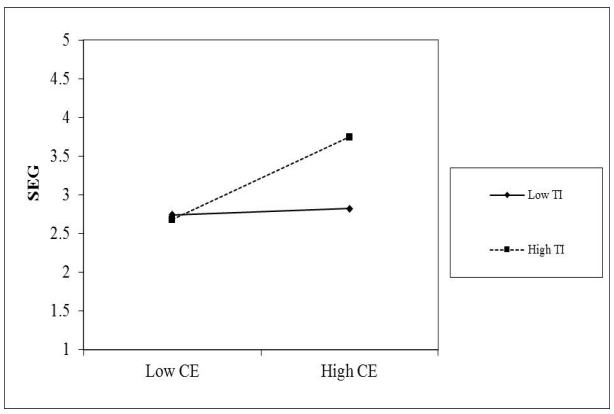

Figure 6. TI as a Moderator Between CE and SEG

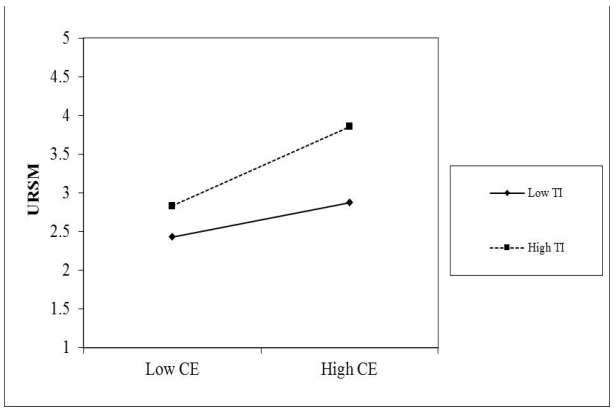

Figure 7. TI as a Moderator Between CE and URSM

DISCUSSION

The aim of the study was to investigate the impact of SDGs and GIS innovation on community engagement. We also study the community engagement impact on socioeconomic growth and urban and rural system mechanisms, community engagement used as a mediator, and technology infrastructure as a moderator. Our findings, which examined how the implementation of the SDGs affected community involvement, are in line with other studies that discovered a beneficial relationship between the two (Smith et al., 2019; Johnson & Wilson, 2020). Our research supports the notion that when sustainable development objectives are successfully implemented, community engagement improves, resulting in a rise in community members' participation and involvement in local development projects. The SDGs' inherent nature, which emphasizes the necessity of integrating multiple stakeholders, including local communities, in the sustainable development process, might be ascribed to the coherence of our findings with earlier studies (Boiral et al., 2019). The SDGs provide a framework for local collaboration, dialogue, and partnerships, supporting community engagement as a means of achieving the goals (Muhirwa et al., 2023). This convergence of our findings and current literature implies that the SDGs act as a catalyst for community engagement by offering a shared vision and a common language for sustainable development activities. Hence H1 is proved.

Our research regarding the way GIS innovation affects community involvement is in line with earlier studies that have highlighted the positive relationship between GIS and community involvement (Heikkinen et al., 2020). GIS technology's integration into urban and rural planning procedures enables locals to actively participate in decision-making, contribute local expertise, and communicate with stakeholders. The similarity of our findings with previous research can be attributed to GIS technology's intrinsic advantages in promoting data visualization, spatial analysis, and community involvement (Kalogeropoulos et al., 2023). GIS systems allow community members to access and engage with geospatial data, allowing them to get a better awareness of their local settings and contribute meaningfully to planning processes (Cunha & Silva, 2023). Hence H2 is proved.

The positive correlation between community participation and economic development highlighted by past studies is supported by our findings on the effect of community engagement on socioeconomic advancement. Economic prosperity and well-being are influenced by community members' active involvement in decision-making procedures and local development initiatives (Tomaso et al., 2021). The methods by which community engagement improves socioeconomic advancement can be attributed to the congruence of our findings with current literature. Community participation promotes social capital, trust, and social cohesiveness, all of which are necessary for economic development (Wildsmith-Cromarty et al., 2022). Community participation ensures that efforts correspond with local needs, aspirations, and capacities by incorporating community members in development project design, resource allocation, and implementation (Crews et al., 2019). Hence H3 is proved.

Our results on the benefits of community engagement on urban and rural system mechanisms are in line with earlier studies emphasizing the positive relationship between effective system mechanisms and community involvement (Ma et al., 2020). Community involvement plays a crucial role in forming and bolstering urban and rural systems by mobilizing local knowledge, promoting stakeholder collaboration, and promoting group decision-making (Agarwal, 2020). The mechanisms by which community engagement affects urban and rural system dynamics can be attributed to the congruence of our findings with the current literature. Community participation improves information sharing, communication, and cooperation among varied stakeholders, resulting in better urban and rural system planning, resource allocation, and management (Dorr et al., 2023). Collective intelligence and local insights contribute to the effectiveness and sustainability of system mechanisms by incorporating community members in governance and decision-making processes (Geekiyanage et al., 2020). Hence H4 is proved.

Our findings on the role of community engagement in mediating the relationship between SDG implementation and socioeconomic growth are consistent with previous research that has highlighted the importance of community engagement as a pathway through which SDGs can be translated into tangible socioeconomic outcomes (Stiftung Mercator, 2020). Community engagement is an important link between the SDGs' wider aims and targets and their specific implementation and impact. The processes by which community participation influences the association between SDGs and socioeconomic growth can be attributed to the coherence of our findings with current literature. Community involvement ensures that the SDGs are implemented in accordance with local requirements, priorities, and ambitions (Farrier et al., 2019). SDGs are more likely to meet the specific challenges and opportunities of local contexts when community members are involved in decision-making processes, resource allocation, and project implementation (Schlör & Venghaus, 2022). Hence H5 is proved.

Our findings on the role of community engagement in mediating the relationship between SDG implementation and urban and rural system mechanisms are consistent with previous research that has emphasized the importance of community involvement in shaping and improving system mechanisms in the context of sustainable development (Bai et al., 2020). Community participation is a vital channel for translating SDG goals and targets into effective and contextually relevant activities at the local level. The methods by which community participation mediates the relationship between SDGs and urban and rural system mechanisms can be attributed to the coherence of our findings with the current literature (Massari et al., 2022). Participation from a variety of stakeholders during the planning, decision-making, and implementation phases makes system mechanisms more receptive to the unique requirements, values, and aspirations of local communities (Muhirwa et al., 2023). By including members of the local

community in the design and management of urban and rural systems, more inclusive, sustainable, and resilient solutions can be achieved. Hence H6 is proved.

Our research supports earlier studies that have emphasized the significance of community involvement in fostering the beneficial effects of GIS innovation on economic development (Coleman & Georgiadou, 2021) in terms of how it mediates the relationship between GIS innovation and socioeconomic growth. The successful application of GIS technology and the promotion of their integration into regional development processes depend heavily on community involvement (Amoah et al., 2021). The processes by which community participation mediates the association between GIS innovation and socioeconomic growth can be attributed to the congruence of our findings with current literature. Community participation ensures that GIS technology are adapted to local requirements, goals, and capacities, resulting in effective deployment in addressing local socioeconomic concerns (Melzi et al., 2023). GIS innovation becomes more contextually relevant and actionable by incorporating community members in data collecting, analysis, and decision-making processes, leading to increased economic prospects and growth (Shehzad et al., 2023). Hence H7 is proved.

Our research supports earlier studies (Batty et al., 2018) that highlighted the importance of community involvement in shaping and improving system mechanisms through the use of GIS technologies. Our findings regarding the mediating role of community engagement between GIS innovation and urban and rural system mechanisms are consistent with Connolly et al. (2022). Community engagement facilitates collaborative decision-making, fosters the integration of local knowledge, and supports inclusive government, serving as a crucial link between GIS innovation and the efficient operation of urban and rural systems. In order to ensure that GIS technologies are used successfully to answer local requirements and improve system performance, community engagement promotes the active participation of community people in the planning, design, and management of urban and rural systems (Umstattd Meyer et al., 2019). GIS innovation becomes more contextually relevant and sensitive to the distinctive challenges and opportunities of urban and rural contexts by integrating a variety of stakeholders and utilizing local expertise (Parker et al., 2021). Hence H8 is proved.

Our findings on the moderating effect of technological infrastructure on the relationship between community engagement and urban and rural system mechanisms are consistent with earlier research by Gan et al. (2020), which emphasized the significance of technological support in enhancing the effectiveness of community engagement in shaping and improving system mechanisms. Information sharing, teamwork, and involvement amongst community members and stakeholders are greatly facilitated by technology infrastructure, which includes digital platforms, communication networks, and data management systems (Pal & Yasar, 2023). The processes by which Technology Infrastructure modifies the relationship between community participation and urban and rural system mechanisms are to blame for our findings being consistent with previous research. Effective community participation requires the right tools and resources, which an adequate technology infrastructure offers (Khajehshahkoohi et al., 2022). Information exchange, real-time communication, and collaborative decision-making are possible with these tools. Technology infrastructure improves community participation in urban and rural system design, development, and governance by making data more accessible, encouraging openness, and enabling meaningful interactions (Ali et al., 2020). Hence H9 is proved.

Our research supports earlier studies that have emphasized the significance of technological support in maximizing the beneficial effects of community engagement on economic development (Gan et al., 2019; Hamidi et al., 2021). Our findings on the role of Technology Infrastructure in moderating the relationship between community engagement and socioeconomic growth are consistent with this. Communities cannot fully utilize their engagement efforts for socioeconomic growth without the support of technology infrastructure, such as digital connectivity, information access, and digital literacy (McManamay et al., 2021). The processes by which Technology Infrastructure moderates the association between community participation and socioeconomic growth can be attributed to the congruence of our findings with current literature. Adequate technology infrastructure provides community people with the tools and resources they need to access information, interact with markets, and engage in economic activities (Li et al., 2022). Technology infrastructure improves the economic potential and prospects for communities engaged in local development processes by providing digital connectivity, supporting e-commerce platforms, and developing digital skills (Sarabdeen & Alofaysan, 2023). Hence H10 is proved.

CONCLUSION

This study expounded the intricate web of relationships between SDGs, GISI, community participation, urban and rural system dynamics, and technological infrastructure. The findings shed light on how these factors interact and contribute to socio-economic growth and long-term development effects. The study's findings confirm the positive influence of SDG implementation on community engagement, emphasizing the importance of participatory techniques in development initiatives. Furthermore, the study emphasizes the critical significance of GISI in increasing community engagement and optimizing urban and rural planning. These findings highlight the need of using geospatial technologies into development plans in order to improve decision-making and resource allocation. Furthermore, the study confirms the critical importance of community engagement in fostering socioeconomic progress and successful urban and rural system processes. Recognizing community engagement as a link between SDG implementation and development outcomes emphasizes the need of encouraging inclusive and collaborative development processes. Furthermore, the study highlights technology infrastructure as a significant moderator in the

interaction between community engagement and the mechanisms of the urban-rural system. This research highlights the relevance of digital connectivity and resources in increasing the impact of community-driven development projects. The theoretical implications of this research help to expand development theories and models, improving our grasp of the complexity of sustainable development. Integrating community involvement, GISI, and technological infrastructure into theoretical frameworks provide a more holistic view of development processes' participatory and linked nature.

IMPLICATIONS

Theoretical Implications

Theoretical implications of this research have significance in furthering our understanding of the complex relationships between sustainable development, community participation, GISI, and technology infrastructure. For starters, the study emphasizes the importance of incorporating community interaction as a core component into existing development theories and models. Recognizing the important role of community engagement in driving socioeconomic progress and improving urban and rural systems can help to expand theoretical frameworks and better reflect the participatory nature of sustainable development processes. Second, the research emphasizes the importance of incorporating GISI into development theories. Theoretical models can gain a more comprehensive understanding of how spatial information contributes to effective development planning, resource allocation, and infrastructure development by emphasizing the positive impact of geospatial technologies on promoting community engagement and optimizing urban and rural planning. Furthermore, the study's identification of community participation as a mediator between SDGs, GISI, and development outcomes adds to our understanding of the causal pathways that connect these components. This theoretical understanding can help guide future study into the mechanisms and processes by which sustainable development programs and technological advancements affect various development outcomes. Furthermore, the inclusion of Technology Infrastructure as a moderator in the relationship between community involvement and urban-rural system mechanisms emphasizes the enabling role of digital infrastructure in boosting community engagement's impact on development outcomes. Integrating Technology Infrastructure as a moderating element into theoretical models might provide useful insights into how digital access and resources affect the effectiveness of community-driven development initiatives. Finally, the study's emphasis on the interconnection of the SDGs emphasizes the complexities of sustainable development efforts. Theoretical models that recognize the interdependence of various SDGs can lead to more integrated and holistic development plans.

Practical Implications

The practical implications of the study are important for guiding governments, organizations, and communities in their quest of sustainable development and enhanced urban and rural system processes. The study begins by emphasizing the critical significance of community engagement in fostering socioeconomic advancement and enhancing urban and rural institutions. To ensure that development projects are tailored to the specific requirements and aspirations of local residents, policymakers should prioritize and invest in activities that promote active community participation and collaboration. Second, the study emphasizes the significance of GISI in fostering greater community engagement and its effect on urban and rural planning. By incorporating geospatial technologies into planning and governance processes, valuable insights can be obtained into spatial patterns, resource allocation, and infrastructure development, resulting in more effective and efficient development plans. In addition, the study highlights the positive influence of implementing SDGs on community engagement. Policymakers should integrate local development objectives with the SDGs, acknowledging that active community participation is required to achieve these global goals. Furthermore, the study underlines the significance of Technology Infrastructure as a bridge between community participation and urban and rural system dynamics. To empower communities and enable them to participate more effectively in socioeconomic activities, policymakers should prioritize investments in digital infrastructure, such as high-speed internet connectivity and digital literacy programs. The study also emphasizes the significance of tackling equity and inclusivity in development efforts. Policymakers should develop inclusive engagement platforms that ensure marginalized and vulnerable people have an equal say in decision-making processes. More equitable development outcomes can be attained by doing so, minimizing gaps between urban and rural communities.

LIMITATIONS AND FUTURE DIRECTIONS

Despite its exciting results, this study contains limitations that should be noted in order to provide a more accurate review of the data. The study initially concentrated on a particular geographic area or region, which may limit the applicability of the findings to other situations. The various social, cultural, and economic elements of the study location may have an effect on how the variables are related to one another. Future research should attempt to include more diverse and representative people in order to increase the external validity of the findings. Second, the study made a lot of use of self-reported data from surveys and questionnaires, which is vulnerable to subjectivity and response bias. Despite efforts to assure anonymity and secrecy, participants' responses may have been influenced by social desirability bias. More objective and quantitative measurements could be used in future study to validate the conclusions acquired using self-report assessments. Third, the study's cross-sectional methodology limits its capacity to establish causality across factors. While mediation and moderation analyses provide useful insights into the linkages, longitudinal research would help to better understand the temporal dynamics and causal pathways

between sustainable development, community participation, GISI, and technology infrastructure.

Several future research directions can be offered based on the findings of this study. To begin, performing comparative research across different locations and countries can aid in the identification of context-specific elements influencing the linkages between sustainable development, community participation, GISI, and technology infrastructure. Understanding these environmental differences can help to inform more targeted and personalized development treatments. Second, additional study should be conducted to investigate the exact processes through which community engagement influences socioeconomic progress as well as urban and rural system dynamics. Qualitative research, focus groups, and case studies can provide detailed insights into the procedures, problems, and success factors associated with community-driven development programs. Moreover, future research could explore deeper technology infrastructure's position as a moderator in the interaction between community participation and urban-rural system processes. Investigating how digital connectivity, information access, and technology resources improve or impede community participation results can give significant recommendations for policymakers seeking to bridge the digital divide and promote inclusive development. Longitudinal studies tracking communities over time can also make clear the long-term effects of sustainable development projects and the viability of community engagement activities. Understanding the dynamics of these interactions through time can help to create and implement more long-lasting and effective development initiatives. Finally, future research should focus on the potential linkages between multiple SDGs and their cumulative effects on community engagement and development results. Understanding how progress in one SDG can affect progress in other SDGs and vice versa can contribute to more integrated and synergistic approaches to sustainable development.

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