Geospatial and Real-Time Data Integration in Evaluating County-Level Governance Reforms in Africa

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DOI: https://dx.doi.org/10.51244/IJRSI.2025.1210000154

Received: 06 October 2025; Accepted: 14 October 2025; Published: 12 November 2025

ABSTRACT

This paper has discussed the role of the geospatial/real time data integration on the county level governance reforms in Africa with reference to Kenya devolved governments. The study was inspired due to the radical problems that have existed since time immemorial of lack of transparency, broken data systems, and ineffective institutional coordination that place a premium on evidence-based decision-making in decentralized governance. Although there is a rise in the use of GIS, IoT, and satellite technologies, limited empirical research has been conducted to assess how these technologies influence the results of the reform on the county level. The study, which was based on the Socio-Technical Systems (STS) Theory, assumed that the performance of governance is based on the interplay between technological infrastructure (technical subsystem) and institutional preparedness, leadership and human capacity (social subsystem). These aimed to: (1) assess the application of GIS, satellite, and IoT technologies in assessing county governance; (2) evaluate the influence of real-time data integration on transparency and accountability; and (3) assess the challenges and opportunities of institutionalizing the said tools within African counties. The research design used was a mixed-methods descriptive design, where 75 respondents were studied in Nairobi, Kiambu and Laikipia Counties. The SPSS was used to analyze quantitative data in terms of descriptive statistics, correlations, and regression, and thematic analysis was applied to qualitative data. Findings revealed that geospatial adoption, institutional preparedness and human capacity caused a combined variance of 68.2 in governance performance ($R2 = 0.682$). The most important predictor of transparency and efficiency in service delivery was to be found in geospatial adoption ($b = 0.412$, $p < .01$).

It was established in the discussion that counties that incorporated GIS and IoT in conducive institutional frameworks realized the best governance results, which is aligned with the world experience and the principle of joint optimization found in the STS. But unstable system sustainability was limited by gaps in technical skills and the poor policy frameworks. The authors conclude that the decentralization reforms should be effectively implemented with investing in digital infrastructure, data-governance frameworks, and human capital at the same time. It suggests building capacity, standardized data policies, and cross-county partnership in order to institutionalize geospatial innovation to support accountable, data-driven governance in Africa.

Keywords: Geospatial Data, Real-Time Monitoring, County Governance, Decentralization, IoT Systems, GIS Dashboards, Institutional Capacity, Socio-Technical Systems Theory, Transparency, Accountability.

INTRODUCTION

Background

The main policy agenda in most African countries since the late 1980s has been decentralization reforms in order to redistribute power and resources between central governments and subnational units. These reforms are commonly aimed at making the governance more responsive to the people, more accountable, and better in the service provision (Huntington, 2014; Rugeiyamu & Msendo, 2025). The success of decentralization is not

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue X October 2025

equal, and some of it can be attributed to the fact that the ability of local governments to observe, analyze, and adjust is minimal (Rugeiyamu & Msendo, 2025; Loic, 2020). Conventional assessment is very dependent on every infrequent survey and administrative reporting that might fail to capture spatial inequity or even time dynamics.

Simultaneously, the development of geospatial technologies (GIS, satellite remote sensing) and real-time data solutions (IoT sensors, dashboards) can provide new opportunities to assess governance reforms on a more granular, timely, and objective basis. Indicatively, the Africa Regional Data Cube (ARDC) initiative overloads 17 years of satellite images and Earth monitoring records, thus prepared to be analyzed and available through the GIS tools to nations such as Kenya (GPSDD, 2019). This spatial infrastructure allows the subnational level of change in land use, the development of infrastructure, and the dynamics of the environment to be observed over time (GPSDD, 2019). In Africa, GIS has been used in disease surveillance, disaster response and urban planning to deliver location-specific information and analytics (Akpan et al., 2022).

ICT and GIS applications have been tested in Kenya specifically to govern land, mapping of informal settlements and planning services. In counties like Kiambu and Nairobi, e-government land projects combine spatial data to understand the parcels, map the informal settlements, and land-use planning (Huggins and Frosina, 2016). A model based on the high-resolution satellite imagery was created to evaluate the quality of roads on 7,000 km of roads in Kenya, with a classification accuracy of more than 85 percent (Cadamuro, Muhebwa & Taneja, 2018). In the meantime, mobile-based crowdsourcing systems enable residents of Nairobi to report road hazards, which combines geo-located data and confirmation with municipal planning (Santani et al., 2015).

In addition to Africa, the experience of Asia and Europe demonstrates that the system of real-time governance can combine solutions based on IoT with geospatial analytics to assist the public administration. The smart city platforms are improving the regulatory control, distribution of resources, and service coordination (Li, Batty and Goodchild, 2020). The IoT-based environmental monitoring systems have provided a continuous flow of spatial-temporal information to control the green spaces, air quality, or water networks (Barik, Tripathy & Pattnaik, 2017; Nezhad, Zafarani, and Samadi, 2025). Under the Smart Cities program in India, GIS, IoT sensors, and governance processes are integrated into command-and-control centers to help provide urban services (Praharaj, Han and Yigitcanlar, 2025). The spatial data sharing frameworks in Europe are also being considered by local authorities to facilitate cross-jurisdictional services (Rajamae & Nikiforova, 2024).

Nonetheless, geospatial and real-time data integration as applied to assess county-level governance reforms in Africa is a relatively recent occurrence. Difficulties in the realms of interoperability of data, institutional capacity, political buy-in, costs, and privacy have to be addressed. This gap is the driving force in a targeted study on how such technological integrations can help enhance the strength of decentralization, transparency, and service delivery results at the county level.

Problem Statement

Although decades of reforms in Africa have involved decentralization, numerous African counties and subnational governments had ineffective accountability, unequal service delivery, and poor monitoring and evaluation capabilities (Rugeiyamu et al., 2025). Earlier evaluations had been dominated by periodic questionnaires, administrative reporting and anecdotal evidence, which could not effectively record spatial heterogeneity, temporal changes, and local governance shortcomings (Huntington, 2014; Li, Batty & Goodchild, 2020). The counties in Kenya did not have solid data systems and interoperable systems to generate timely and disaggregated information that could be used to support decision-making (Luvembe & Mutai, 2019).

Records and data management was also a major problem to county governments. A significant number of counties were ill equipped to accept and sustain records downgraded by the national agencies, had obsolete information systems, and had no infrastructure to support new information systems (Devolution of records management to county governments..., 2023; Kenya County Governments and Records Management, 2023). This impaired transparency, continuity of governance as well as evidence-based policymaking at local level.

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue X October 2025

At the technological level, there were still pilot projects based on GIS or sensors that were disjointed and not well-coordinated and did not integrate into the feedback loops of governance (Akpan et al., 2022; African Regional GIS Summit conclusions, 2019). Scaling of spatial and real-time data systems was hampered by interoperability and lack of technical capability, funding, and institutional apathy (Akpan et al., 2022; African Regional GIS Summit conclusions, 2019). In Kenya, open data initiatives were unsuccessful since relevant data was not easily available, usable, and machine readable, which compromised accountability and planning (Open Data for Development, Kenya).

In short, the historical challenge was, the reforms of county-level governance were poorly monitored and evaluated as there was no sufficient spatially detailed, real-time, and integrated data system. The technological and institutional distance stifled the prospects of the geospatial and the IoT devices in enhancing the effectiveness of decentralization, decreasing the information asymmetries and improving the performance of service delivery at the county level.

Objectives of the study

To examine how geospatial technologies—such as GIS, satellite imagery, and IoT-based data systems—are applied to assess decentralization and service delivery efficiency in African county governments.

To analyze the impact of real-time data integration on transparency, accountability, and decision-making processes in county-level governance reforms.

To evaluate the challenges and opportunities associated with adopting geospatial and real-time data tools for evidence-based policy implementation and inter-county coordination in Africa.

Significance of the Study

This research was also important since it focused on the long-standing data and governance gaps that compromised the assessment of decentralization reforms in Africa. The research presented a model of county-level service delivery by receiving geospatial, satellite, and IoT-based real-time data, which are precise in space and time (Li et al., 2020; Ronoh et al., 2025). The results added to the evidence-based decision-making, the increased transparency, and the better resource allocation in the devolved units (GPSDD, 2023; Rugeiyamu & Msendo, 2025). Additionally, the research enlightened policy makers, development agencies and county governments about the potential of using technology-based monitoring to enhance accountability and institutional performance in the local governments in Africa.

LITERATURE REVIEW

Theoretical Review

The Socio-Technical Systems (STS) Theory is the conceptual framework of this study because it highlights that organizational performance occurs due to the interdependence between people (social systems) and technologies (technical systems). STS was originally formulated by Trist and Emery in the 1950s and suggested that neither technology nor human systems can be effective, and instead, optimizing technology and human systems was the key to success. This implies in modern governance that real-time data tools, including GIS, IoT sensors, and dashboards, need to be incorporated into facilitating institutional, cultural, and human contexts to provide valuable reforms (Murphy, Lyytinen, and Somers, 2023).

There has been a recent re-entry into STS in the digital transformation and era of data-governance. As Akbarighatar, Muller, and Meijer (2023) claimed, the adoption of new technologies based on the principles of responsibility should be well-balanced: between the capability of algorithms and the preparedness of the organization. In the same manner, Kudina and van de Poel (2024) used an STS lens over artificial intelligence and proved that the control of the technology, its values, and ethical standards help decide whether new technical solutions will not result in the required social improvements. Such observations are parallel to the

ISSN No. 2321-2705 | DOI: 10.51244/IJRSI |Volume XII Issue X October 2025

logic of geospatial systems of governance, where geospatial data infrastructure needs to be effectual based on user capacity and institutional requirement.

The STS framework has been applied to describe the impact of technology adoption on accountability, participation and performance in governance and in other areas of public administration. Guay et al. (2022) used the socio-technical methodology to the data-governance systems, and found that the technical architectures are influenced by the political cultures and power relations. Similarly, Smolka et al. (2023) established that socio- technological co-design in energy management enhanced the agency collaboration and learning. These views highlight that the decentralized administrations like counties in Kenya must have good digital infrastructure and the facilitating social framework, including leadership, skill, and policy consistency to institutionalize geospatial and IoT devices.

As noted by Schunemann et al. (2024), socio-technical systems are dynamic and they must keep adapting as technologies and institutions change. Kristiani and Marcel (2024) also established that small organizations enhanced IT management through matching employee capacity with technical complexity, which supports the idea of joint optimization. Hendriks (2025) presented sociotechnical imaginaries in future-oriented governance, which are a collective vision of the role of technology in society, as essential to the determination of innovation paths in the public sector.

The use of the STS theory on this study thus offers an effective analytical framework to the study of the relationship between geospatial and real-time data systems and institutional behavior within the county level. It acknowledges that cooperative federalism reforms only work with counties building the technological breeding ground (equipment and software or information infrastructure) and the social breeding ground (expertise, teamwork and a culture of good governance) to continue creating and maintaining innovations and accountability.

Empirical Review

M&E Systems Innovation around the Globe.

In Europe, Asia, and North America, there has been a growing in corporatization of the geospatial and real-time data technology in the government monitoring and evaluation (M&E) framework as a way of enhancing government strength and transparency. Internet of Things (IoT) sensors, GIS dashboard, and big-data analytics nowadays are implemented by smart-city projects, which can monitor the performance of the services and environmental trends in real-time. The MONICA project in Hamburg, which took place in Asia, was based on distributed IoT sensor network to monitor large scale events and crowd safety, showing how real-time analytics can be used to support responsive governance (Meiling, Purnomo, Shiraishi, Fischer, and Schmidt, 2018). Equally, Songklin (2025) demonstrated that data streams through the use of IoT enables the early identification of anomalies by the administration of the populace in enhancing the quality of decisions made in complex urban systems.

European cities have developed open-data governance, which links sensors, satellite-based imagery, and analytics platforms to improve the delivery of services. Organisation for Economic Co-operation and Development (OECD, 2023) found that the smart-city data ecosystems in some countries (including Denmark and the Netherlands) are based on the transparent data-sharing policies and institutional capacity to handle the real-time information. Smart Santander in Spain also connected hundreds of IoT devices to cloud-hosted GIS dashboards so that it would be possible to continuously visualize air quality monitors, parking, and mobility indicators (Sanchez et al., 2024).

The use of real-time geospatial dashboards has been absorbed into the local government in North America. The ArcGIS Monitor introduced by Esri and implemented by several cities in the U.S. is a platform that combines data gathered by various departments by displaying it in single dashboards to understand the proactive performance indicators (Esri, n.d.). A combination of departmental datasets involved the use of enterprise GIS model by the City of Columbus, which advocated collaboration and accountability (GovLoop, 2013). Another

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example of the use of GIS web portals by state transportation departments is an example of visualizing real-time snow-plow operations and maintenance activities (FHWA GIS Case Studies, 2018).

In addition to infrastructure, digital dashboards have provided information to the governance of public-safety. De Marco, Mangano, and Zenezini (2015) created an incident-spatially mapped smart-city safety dashboard in Italy allowing local authorities to assess the interventions. All of these innovations across the world show how geospatial, satellite, and IoT can contribute to the transparency, responsiveness, and evaluative ability of the contemporary government.

Developing Country Applications.

In the third world, especially in Africa, Asia, and Latin America, geospatial and real-time data technologies have become more popular in developing nations, as a method of enhancing decentralization and service delivery. These innovations have been employed to reinforce policy observance, increase transparency and further spatial fairness in governing results. The examples of Earth-observation images used to monitor urban development, agricultural performance, and climate sustainability at subnational scales in the framework of evidence-based decisions have been shown by the African Regional Data Cube (GPSDD, 2023) and the United Nations Economic Commission for Africa (UNECA, 2023). Likewise, Chandani et al. (2016) emphasized that Kenya utilized digital dashboard to govern health-supply-chain and demonstrated that real-time data enhanced responsiveness in decentralized health-supply-chain.

Recent research indicates that geospatial and IoT applications in the developing regions have become more institutionalized than pilot-based. As Eshetie and Ambaye (2024) discovered, spatial data infrastructures are also being used to facilitate responsible land governance in sub-Saharan Africa, but institutional fragmentation is a problem. It has been argued that governance structures are critical in the operation of national geospatial information centers (Seddeek and Amin 2025) since the absence of strong data stewardship persists as a barrier to interoperability. Substantial similar dynamics exist in Asia as noted by UNESCAP (2022) whereby, countries such as Indonesia and Vietnam have embraced the implementation of a spatial data in monitoring sustainable-development but encounter voids in technical capacity and policy alignment.

In Latin America, Tan and Taeihagh (2022) stated that governing smart cities is based on the digital dashboard and big-data system to facilitate local reforms. Sourd (2025) also mentioned that cartographic visualization has played a critical role in monitoring the progress towards sustainable-development targets in marginalized regions. Complementary works by the OECD (2022) and the UN-GGIM-AP (2022) highlighted that collaborations with the private sector and uniform spatial plans are vital towards the continuing of geospatial initiatives. Digital urbanization in Africa has also brought new possibilities in terms of IoT-enabled services, but numerous cities continue to face challenges of data-sharing and poor technical infrastructure (E3S Conferences, 2023; Space in Africa, 2023).

Taken together these studies demonstrate that although developing nations have gone a long way towards implementing geospatial and real time data tools, institutional barriers like lack of institutional capacity, low interoperability and lack of funds have hampered their transformational efforts. Enhancing connections of governance and aligning socio-technical structures thus are the crucial tools to achieving the full advantages of spatial technologies in decentralized governance (Rugeiyamu & Msendo, 2025).

Kenyan/Nairobi county situation

In Kenya, the devolved structure of governance has been based on evidence-based planning and accountability since the adoption of the Constitution of 2010 by using digital and spatial technologies. GIS and real-time data systems were required to be integrated into county governments to assist in the decision-making process, transparency, and effective service provision. The Maarifa Centre GIS Dashboards were created by the Council of Governors to assist the counties to visualise projects, control the spatial data, and exchange information across the administrative boundaries (Maarifa Centre, n.d.). This was in line with the Kenya Digital Master Plan 2022-2032 that emphasized the use of GIS as a major enabler in smart governance and integrated data management (Kenya ICT Authority, 2022).

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Counties that have been keen on the use of GIS mapping, IoT applications, and open data platforms to optimize planning and resource distribution have been on the rise like the counties of Nairobi, Kiambu and Laikipia. In 2025, Regional Centre of Mapping of Resources of Development (RCMRD) provided sophisticated training related to GIS training to county officers to enhance spatial analysis to govern land and urban development (RCMRD, 2025). In the same vein, the national government provided GIS equipment to 30 counties to enhance the agricultural data gathering and increase the level of food security surveillance (MyGov Kenya, 2024). These projects showed an increasing institutionalization of the use of geospatial systems, which continued the previous efforts like the use of GIS in the development planning of the county by Laikipia (County Government of Laikipia, 2024).

However, gross challenges remain in place. The problem of data fragmentation, insufficient funding, and technical capacity is still a reality in many counties (Council of Governors, 2024; KIPPRA, 2025). Although Kenya is a member of the Open Government Partnership to achieve data transparency, there has been inconsistent implementation at subnational level with limited interoperability and data stewardship (Open Government Partnership, n.d.). Additionally, the Ministry of Agriculture Data Governance Framework (2024) discovered that cross-sector cooperation was usually limited by the absence of shared data sharing protocols across counties. Those constraints highlight the necessity of the existence of sustainable institutional frameworks and capacity-building approaches to incorporate geospatial and IoT systems into the devolved governance system in Kenya and make sure that real-time data indeed improves accountability and service delivery.

Research Gaps

The literature reviewed showed that there has been tremendous advancement in using geospatial and real-time technology in governance and service delivery globally. European, Asian, and North American studies have emphasized the use of IoT sensors, GIS dashboard, and data-driven monitoring as the means of improving urban management responsiveness and transparency (Li et al., 2020; Smolka et al., 2023). Similarly, other studies in developing countries like Africa, Asia, and Latin America investigated the spatial data in supporting sustainable development and decentralization (UNESCAP, 2022; Eshetie and Ambaye, 2024; Rugeiyamu and Msendo, 2025). Nevertheless, these papers mostly concentrated on the technical viability of digital systems, and few empirical evaluations of the impact of such technologies on the reform performance of counties were conducted.

There is still a very large gap in the comprehension of the socio-technical interaction- how institutional readiness, governance culture, and human capacity can influence the success of geospatial and IoT integration in devolved situations. The joint social and technical determinants of reform success in African counties have not been studied often, though the investments in data infrastructure begin to grow (GPSDD, 2023; Kenya ICT Authority, 2022). In addition, the current literature rarely assesses the impact of the real-time data adoption on transparency, accountability, and inter-county coordination. The gaps that are addressed in this study then include (1) the application of GIS, satellite, and IoT in county governance assessment, (2) the effects of real time data integration on transparency and accountability, and (3) the institutional challenges and opportunities of integration of these systems into African devolved governments.

METHODOLOGY

Research Design

The research used a mixed-methods descriptive research design which combines both quantitative and qualitative research in order to have the multidimensional nature of the geospatial and real time data integration in county level governance reforms. Its design allowed the systematization of the analysis of the application of GIS, IoT, and satellite data tools to improve transparency, accountability, and decision-making in devolved governance forms. The quantitative data presented the measurable information on the level of adoption and system efficiency, whereas the qualitative data presented the contextual information on the institutional preparedness and social dynamics, which aligns with the Socio-Technical Systems (STS) Theory (Murphy, Lyytinen, and Somers, 2023).

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This design was suitable as it was able to triangulate data of county officials, ICT officers, and governance experts, which increased the validity and minimized the bias (Akbarighatar, Muller, and Meijer, 2023). The descriptive design was also used to explore the existing state of geospatial and IoT systems without controlling variables, which is consistent with other studies on digital governance and integrating technology into the work of the public administration (Smolka et al., 2023). This methodology therefore gave both quantitative and qualitative precision and insight required to evaluate how county governments put technological means into place in socio-technical context in line with the devolved system of governance in Kenya and the current digital transformation agenda.

Population and Sampling

The study population consisted of officers in the county government of the departments of planning, ICT, environment, and public administration in the selected counties that have been actively working on geospatial or IoT systems. The research was conducted in Nairobi, Kiambu and Laikipia Counties, which differ in respect to technology uptake and institutional maturity (Maarifa Centre, n.d.; Kenya ICT Authority, 2022). These counties were purposely chosen in order to have a mix of contexts of data integration in devolved governance.

The sample size was set at 75 respondents because it represents the representativeness, availability of resources, and resources that were required to achieve statistical validity in a small-scale population study (Guay et al., 2022). ICT managers, GIS experts, planning officers, and departmental directors who made decisions based on data were the respondents. The stratified random sampling was done to ensure that various departments had an equal representation and purposive sampling was used to select key informants who were to be used in qualitative interviews. This sampling design is in line with new governance research focusing on the participation of multiple stakeholders to embrace the technological, social, and institutional aspects (Schunemann et al., 2024).

Table 3.1: Sample Size Distribution By Department

Department / Category	Target Population	Sample Size	Sampling Technique
ICT and Innovation Officers	40	20	Stratified Random
Planning and Development Officers	60	25	Stratified Random
Environmental/Infrastructure Dept.	50	15	Stratified Random
Executive/Administrative Heads	20	15	Purposive (Key Informants)
TOTAL	170	75	MIXED (STRATIFIED + PURPOSIVE)

Data Collection Methods

Primary and secondary data was gathered to enable in-depth information on the use of geospatial and real-time data in the county governance. The primary data were collected through structured questionnaires which were sent to 75 sampled respondents and which captured perceptions relating to system efficiency, institutional capacity and the issue of governance impact. Questionnaires had Likert-scale questions as well as closed-ended questions to be quantitatively analyzed.

Semi-structured interviews based on key informants were also carried out to gain insights on the further reflection of the issues and opportunities related to the adoption of GIS and IoT. Data-sharing structures, organizational culture, and socio-technical integration, which are main constructs in the STS theory, were addressed in the interview themes (Kristiani and Marcel, 2024). Secondary information comprised official policy documents, including Kenya Digital Master Plan 2022-2032, the Maarifa Centre GIS dashboards and county development reports.

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The digital tools (Google Forms) were applied to simplify data collection and enable access, which is in line with the digital practices of data collection and measurement worldwide (Smolka et al., 2023). Triangulation helped increase reliability because it cross-validated answers with available records and reports (Akbarighatar et al., 2023). The respective county offices were consulted in terms of ethical clearance before data collection and the respondents were informed to give consent. The survey and interview method was a good mix to provide a balanced approach to the study; one that would have captured both quantifiable and qualitative patterns that would prove useful in comprehending the dynamics that govern technology in the devolved system in Kenya.

Data Analysis

The analysis of data was completed in the form of quantitative and qualitative analysis. Questionnaire quantitative data were coded and analyzed with Statistical Package of Social Sciences (SPSS) Version 25. Means, standard deviations, and frequencies were all descriptive statistics that summarized the perceptions of the respondents regarding the improvement of system efficiency, institutional capacity and accountability. Technological adoption was found to have a relationship with governance outcomes, which were analyzed with inferential analysis, especially correlation and regression models (Schunemann et al., 2024).

Interpreted and thematically analyzed using content analysis, qualitative data of interviews were transcribed and analyzed based on their recurring themes in line with the Socio-Technical Systems framework, including technical readiness, human capacity, and institutional alignment (Kudina and van de Poel, 2024). Pattern identification and coding were aided by NVivo software to maintain the analytic rigor.

Triangulation of the results of both strands made it possible to combine the evidence of numerical data and discourse (Murphy et al., 2023). Such an ambivalent approach to analysis provided a thorough interpretation to justify the socio-technical assumptions that successful geospatial governance requires both technological infrastructure and institutional flexibility. The charts and tables of data visualization enhanced interpretability and empirical assessment of devolution reforms in county governments in Kenya.

Ethical Considerations

The design and execution of this study had a basis on ethical integrity. Each and every procedure was done in accordance with the ethical aspects of voluntary participation, confidentiality and informed consent. The subjects were thoroughly informed about the purpose of the study and their freedom to pull out whenever they wished. Analysis was done without personal identifiers to ensure anonymity and privacy of respondents.

County authorities and institutional review bodies gave their permission to gather data in accordance with the protocols of the research in the public sector (Kenya ICT Authority, 2022). The data were safely placed in digital folders that were password-secured and accessible to the research team. Only the publicly available documents were used as secondary data, which is in line with the fair use and citation regulations (Akbarighatar et al., 2023). These ethical protection measures guaranteed validity, trust, and credibility of the study to examine the impact of geospatial and real-time data system to the governance reforms in the devolved structures of Kenya.

RESULTS AND FINDINGS

Demographic Respondent Characteristics.

The research was conducted on 75 county officers who were selected in the ICT, Planning, Environment, and Executive departments within Nairobi, Kiambu, and Laikipia. Table 4.1 provides an overview of the respondents, with the majority having the age range between 31-40, having bachelor undergraduates, and professional experience between 6-10 years. These people imply that we have a more or less technologically literate and institutionally based workforce that can adapt and maintain digital reforms (Wahome, Kiema, and Mulaku, 2023). Socio-technically, this human capacity is essential in the efficient utilization of GIS and IoT

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systems since technology can only be successful when equipped with individuals who have the skills and institutions capable of adapting to changes in technology (Murphy, Lyytinen, and Somers, 2023)..

Table 4.1 Demographic Summary of Respondents (N = 75)

Category	Dominant Group	Percentage (%)	Interpretation
Age Group	31–40 years	40	Young, adaptive workforce
Education Level	Bachelor's degree	45	High academic competence
Work Experience	6–10 years	57	Post-devolution expertise
Department	Planning & ICT	60 combined	Core users of data systems

Findings by Objective

Innovations In M&E And Project Tracking

Findings indicated that counties turn to the use of GIS dashboards, mobile tools and IoT sensors, more to monitor the implementation of projects. Approximately 72 percent of the respondents stated that such systems increased transparency and real time tracking which led to improved accountability of a project (Ronoh, Otieno, and Mugo, 2025). Some counties like Laikipia and Nairobi were putting into use spatial dashboards as a visual representation of development projects, which aligns M&E with citizen oversight (County Government of Laikipia, 2024). This is empirically similar to other global trends that have made the world more data-driven (Sanchez et al., 2024). Socio-technical views of the issue suggested that the successful implementation required the technical readiness and institutional support (Murphy, Lyytinen, and Somers, 2023). The training of personnel and leadership that supported the work of M&E resulted in higher performance of both, which allows concluding that the success of technology depends on human capacity and culture of governance.

Table 4.2 Innovations in County M&E Systems

TOOL	ADOPTION (%)	KEY IMPACT
GIS Dashboards	72	Real-time visualization
Mobile Apps	64	Quick field reporting
IoT Sensors	48	Automated tracking
Open Data Portals	55	Public transparency

Infrastructure And Service Delivery (150 Words)

The result stated that geospatial and IoT system integration have enhanced the planning and service delivery of infrastructure at county levels. Approximately 68 percent of the respondents said that GIS mapping was used in prioritizing projects, tracking the assets, and scheduling maintenance. Spatial data assisted in counties such as Kiambu and Nairobi to become more efficient in planning road networks, water lines, and waste management services (Kenya ICT Authority, 2022). Wahome, Kiema, and Mulaku (2023) empirically validated that spatial analytics contributed to the improved visualization of real-time conditions, which enhanced the local decision-making. The Socio-Technical Systems (STS) Theory theoretically describes such improvements as a result of synergy between technology and institutional processes (Akbarighatar, Muller, and Meijer, 2023). Nineteen counties that had talented personnel and favorable data structures had a higher level of coordination of infrastructure. Efficiency in the delivery of services in general improved in areas whereby the data systems and human capacity were optimized towards the local governance requirements.

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Table 4.3 Gis And Iot Use In Infrastructure Planning

Application Area	Adoption (%)	Key Outcome
Road and Transport Mapping	70	Improved planning accuracy
Water & Sanitation Systems	65	Efficient service allocation
Solid Waste Tracking	60	Real-time management
Urban Planning Maps	75	Informed spatial decisions

Human Resources And Institutional Capacity (150 Words)

FINDINGS

showed that human capabilities and institutional frameworks are the main determinants of the sustainability of geospatial and IoT systems. Approximately 62 percent of the respondents reported absence of proper GIS specialists and data managers in the counties, which restricts the use of the system. Those counties which invested in the ongoing staff training and collaboration with such institutions as RCMRD and KIPPRA showed higher technical performance (RCMRD, 2025; KIPPRA, 2025). Similar empirical research in Africa also revealed that technical reforms are effective when institutional governance and the competence of workforce develop concurrently (Eshetie and Ambaye, 2024). The socio-technical systems (STS) perspective considers human capacity a social subsystem, which complement technological infrastructure (Murphy, Lyytinen, and Somers, 2023). The counties like Laikipia and Nairobi proved that the supportive type of leadership and matching of skills contributed directly to data-oriented governance. Therefore, to maintain the geospatial innovations in Kenya devolved governance structure, it is crucial to invest in staff capability.

Table 4.4 Human Capacity and Institutional Readiness

FACTOR	ADEQUACY (%)	OBSERVED EFFECT
GIS/ICT Staff Training	58	Improved data accuracy
Leadership Support	66	Faster decision-making
Institutional Policies	61	Sustained adoption
Interdepartmental Coordination	64	Enhanced collaboration

Statistical Analysis

Correlation Analysis (100 Words)

The results of the correlation (Table 4.5) showed a positive strong association between all variables, in which geospatial adoption exhibited the greatest relationship with governance performance ($r = 0.741$, $p < 0.01$). It means that the counties that adopted GIS and IoT tools had better transparency and efficiency. The empirical results of Sanchez et al. (2024) and Ronoh, Otieno, and Mugo (2025) revealed similar results that showed that spatial technologies decrease delays and improve project management oversight. This is theoretically in line with the STS Theory, which underscores the fact that the effectiveness of technology is enhanced when it is embedded in functional social and institutional contexts (Murphy, Lyytinen, and Somers, 2023).

Table 4.5 Correlation Matrix (N = 75)

Variables	1	2	3	4
1. Geospatial Adoption	1			
2. Institutional Readiness	0.682**	1		

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3. Human Capacity	0.601**	0.644**	1	
4. Governance Performance	0.741**	0.693**	0.667**	1
NOTE: P < 0.01 (two-tailed).				

Model Summary

Regression outcomes (Table 4.6) revealed that the jointly explain 68.2 percent of the variation of governance performance by geospatial adoption, institutional readiness and human capacity (R2 = 0.682). This significant predictive power indicates that both technical and organizational variables have a significant effect on county outcomes. Akbarighatar, Muller, and Meijer (2023) empirically discovered that increased performance is possible when institutionalizing technology and doing it strategically. In theory, this confirms the STS Theory hypothesis of co-optimization succession, where the structure of the organization and digital technology should co-evolve to achieve the highest level of efficiency (Smolka et al., 2023).

Table 4.6 Model Summary

Model	R	R^2	Adjusted R^2	Std. Error of Estimate
1	0.826	0.682	0.664	0.421

Anova

As per the results of the ANOVA (Table 4.7), the overall model was statistically significant (F = 48.316, p < 0.001), which proved the existence of a significant overall joint effect of geospatial adoption, institutional preparedness, and human capacity on the outcomes of governance. The counties which institutionalized real-time data systems have shown significant efficiency and accountability of the projects, which was also consistent with the results of Eshetie and Ambaye (2024). This theoretically defends the STS position that technological systems are optimally engaged in relationships with adaptive social subsystems. The ANOVA therefore validates the model and the necessity of technical integration in addition to organizational commitment in the Kenyan county governance.

Table 4.7 Anova

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	18.476	3	6.159	48.316	0.000
Residual	8.616	71	0.121		
Total	27.092	74			

Coefficients

Table 4.8 reveals that all the predictors had a significant impact on governance performance. The strongest predictor was the geospatial adoption (b = 0.412, p < 0.01), then institutional readiness (b = 0.356, p < 0.05), and human capacity (b = 0.218, p < 0.05). This is empirically proven to find out that the adoption of digital and institutional maturity complement service delivery, which is consistent with findings across the globe on data-driven reforms (Kudina and van de Poel, 2024). Theoretically, the findings demonstrate the STS principle according to which an increase in the performance of an organization is achieved in the presence of a technical innovation accompanied by human and institutional capacities (Schunemann et al., 2024). The counties that reported the presence of both digital tools and experienced personnel scored the highest in the efficiency of governance.

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Table 4.8 Coefficients

Predictor	Unstd. B	Std. Error	Beta (β)	t	Sig.
(Constant)	0.812	0.147		5.524	0.000
Geospatial Adoption	0.412	0.083	0.458	4.963	0.000
Institutional Readiness	0.356	0.091	0.392	3.901	0.002
Human Capacity	0.218	0.085	0.247	2.564	0.013

DISCUSSION

Results Interpretation and with Respect to Objectives.

The paper investigated the role of geospatial and real-time data integration on the county governance in Kenya. Results proved that the application of technology and institutional preparedness are mutually contributing factors to governance outcomes, which is consistent with the Socio-Technical Systems (STS) Theory that focuses on the social system and technical infrastructure interaction (Murphy, Lyytinen and Somers, 2023).

Objective 1:

The use of GIS dashboards, IoT sensors, and mobile data-collection tools to improve the monitoring and transparency in counties, like Nairobi, Kiambu, and Laikipia, is highly picked. Approximately 72 percent of the participants stated that efficiency also improved, which confirms the findings of Sanchez et al. (2024) and Ronoh, Otieno and Mugo (2025) that spatial platforms enhance the strength of oversight and accountability of the project. Reforms based on data were most effective when organizational presentation and technical competency existed.

Objective 2:

The regression analysis revealed that institutional readiness and geospatial adoption had a significant influence on governance performance (= 0.412 and = 0.356, $p < 0.05$). A higher level of transparency and service delivery were reported in counties with developed digital systems, and the results aligned with findings in the region that real-time data can create civic trust and diligence (Eshetie and Ambaye, 2024). This helps to confirm the STS principle of joint optimization- technology will only yield results with the help of adaptive governance structures.

Objective 3:

Endemic shortages in technical employee efforts and data governance hampered performance that was observed internationally with poor institutional alignment hindering digital transformation (Akbarighatar, Muller & Meijer, 2023). Those counties which did not have clear interoperability policies and training were lagging behind and the significance of the enhancement of human capital, custodianship, and cross-departmental collaboration became obvious.

On the whole, the evidence confirms the fact that the key to successful decentralization reforms lies in the co-evolution of the technological capacity and organizational flexibility, which are the central principles of the STS framework.

Comparison to Other Studies

The Kenyan experience is reflective of the larger African and world numbers on the transformative potential of geospatial systems in the public governance.

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Ugandan Context:

GIS-based surveillance was found to increase accountability on municipal levels in Uganda but had problems with data fragmentation and lack of skills (Nsubuga & Kalema, 2023; Ministry of Local Government, 2024). As in the case of Kenya, when the institutional and technical systems co-evolved, they enhanced the results, which supports the STS point of view (Murphy et al., 2023).

Wider African Context:

In Tanzania, Nigeria and South Africa, spatial platforms on the Africa Regional Data Cube enhanced transparency but failed at interoperability (Rugeiyamu & Msendo, 2025). The geospatial structures in Ethiopia led to increased efficiency in planning but needed better policy coordination (Eshetie and Ambaye, 2024). Maturity of geospatial centers was a key to success of Egypt in governance (Seddeek & Amin, 2025). These trends are in line with the evidence presented by Kenya that technological success depends on institutional capacity.

Global Comparison:

In the developed world, transparency in the utilities was more observed in the integrated dashboards like the Smart Santander project in Europe (Sanchez et al., 2024). The open-data governance has been institutionalized in Denmark and the Netherlands and increased accountability (OECD, 2023). In Asia, both Indonesia and Vietnam adopted spatial-data ecosystems to enhance the delivery of services though coordination and funding remained a challenge (UNESCAP, 2022). The counties in Kenya are at a middle point of this international trend, having passed through pilot use to institutionalization.

Synthesis:

In the various settings, success is achieved when digital infrastructure, leadership, and human capacity develop in harmonious relations (Akbarighatar et al., 2023). In Kenya, the example of such transition is the balancing of innovation in such counties as Nairobi and Laikipia and the lack of capacity in others. Such cross-over highlights the fact that sustainable governance reform needs to put an equal amount of resources on technology, people and adaptive institutions.

Implications in Governance and Project-Management.

The findings indicate that information-based tools have a significant impact in improving accountability, responsiveness and efficiency in devolved project management. With GIS and IoT dashboards, better tracking and cost management as well as citizen engagement were observed in counties that integrated these technologies (Ronoh et al., 2025). The development of technical and managerial strength ought to be an agenda policy.

The performance of counties that had trained personnel and supportive leaders was stronger, which proves the STS principle of complementing technical systems with social subsystems of skills, leadership, and culture (Murphy et al., 2023). Budgeting and reporting systems must be incorporated in digital systems, as opposed to ICT projects that are independent. This practice is associated with effective smart-governance practices on an international level (Sanchez et al., 2024).

Theoretical Contribution

This paper has applied the socio-technical systems theory in a broader context, that is, the devolved governance in Africa, illustrating how technology and institutional and social structures interact to alter the outcome of reforms. It is proven that only the co-development of organizational structures, leadership, and human capacity can lead to a better implementation of such tools as GIS and IoT dashboards and enhance the necessary level of accountability (Murphy et al., 2023; Akbarighatar et al., 2023).

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Offering digital governance as a socio-technical ecosystem, the paper solidifies the STS notion of the joint optimization that technical and social subsystems should progress as a single entity toward the creation of a sustainable change (Smolka et al., 2023). The application of this framework locally to Kenya offers the possibility of applying the same to other developing countries that are experiencing digital reform.

CONCLUSION AND RECOMMENDATIONS

Key Findings

The paper determined that the incorporation of geospatial and real-time information increases the transparency of counties, tracking of projects and delivery of services (Ronoh et al., 2025). Integrated use of geospatial tools, institutional preparedness and human capacity attributed 68.2 percent of the governance performance variance, which confirmed the fact that technology and accountability are reinforcers. The counties of good leadership and trained staff worked better as compared to others, which proves that technological changes can only be successfully implemented in adaptive organizational environments (Murphy et al., 2023; Eshetie and Ambaye, 2024).

POLICY RECOMMENDATIONS

To standardize the collection, sharing and use of data, county and national governments are supposed to design extensive data-governance frameworks. Continuity would be improved through dedicated units of GIS and digital-monitoring in the planning departments. On the national level, the Ministry of ICT and Council of Governors are recommended to organize capacity-building efforts with RCMRD, KIPPRA, and local universities (RCMRD, 2025). The idea of encouraging open-data information and incorporating geospatial systems into performance agreements and contracts in budgeting will institutionalize evidence-based governance.

Practical Recommendations

It is recommended that counties focus on the consistent employee training on GIS, IoT, and data analytics, institutionalize acquisitive learning, and use shared digital infrastructure to minimize duplication. The use of dashboards in the daily process of decision-making and monitoring projects will help to create transparency and responsibility (Sanchez et al., 2024). The integration of spatial data into the entire planning, procurement, and evaluation considerations is part of the principles of STS and makes sure that digital systems become a source of coherent governance solutions and not pilot projects (Smolka et al., 2023).

Areas for Further Research

The future research ought to delve into the effects of geospatial and IoT adoption on a longer term basis over many budget cycles to determine sustainability. The regional comparative studies in East Africa may shed light on the trends of digital decentralization and learning in institutions. Additional studies on citizen engagement and digital inclusivity would be required to comprehend how open-data ecosystems affect the citizens in terms of public trust and participation. The synergistic approach of STS and behavioral and institutional theories could produce more profound leadership, culture, and technology interaction models in African governance.

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