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Abstract

The study examined the influence of digital data collection tools on the performance of the Small-Scale Irrigation Technology (SSIT) Project in Ngoma District, Rwanda. Anchored in Systems Theory and the Technology Acceptance Model, the study assessed how digital data collection tools, real-time data transmission, and interactive dashboards and reporting influenced project performance. A mixed-methods cross-sectional design was employed. From a target population of 145 stakeholders, a sample of 106 respondents was selected using stratified random and convenience sampling techniques. Quantitative data were analyzed using SPSS through descriptive statistics, correlation analysis, ANOVA, and multiple regression, while qualitative data were analyzed thematically. The findings indicated that digital monitoring technologies positively influenced project performance, particularly by improving timeliness, accountability, resource utilization, and decision-making. High mean scores were recorded for digital data collection tools (M = 4.20), real-time data transmission (M = 4.18), and interactive dashboards (M = 4.14), indicating strong agreement among respondents regarding their contribution to monitoring efficiency. Multiple regression results showed that digital data collection tools ($\beta = .440$, $p = .013$), real-time data transmission ($\beta = .264$, $p = .002$), and interactive dashboards ($\beta = .370$, $p = .004$) significantly predicted project performance. Collectively, the three components explained 65.7% of the variance in project performance ($R^2 = .657$, $F = 197.070$, $p < .001$). The Durbin–Watson statistic of 1.967 indicated no problematic autocorrelation in the model. The qualitative findings further highlighted improved reporting timeliness, reduced data errors, enhanced responsiveness, greater transparency, and more informed decision-making. The study concluded that digital data collection tools were the strongest predictor of SSIT project performance, followed by interactive dashboards and real-time data transmission. These findings underscore the importance of integrating digital technologies into agricultural project monitoring and evaluation to improve data quality, operational efficiency, accountability, and the sustainability of irrigation interventions. The study recommends strengthening the use of digital data collection tools, improving rural internet connectivity, integrating interactive dashboards into district-level monitoring and evaluation systems, and providing continuous training in digital data management and analysis. It further recommends stronger stakeholder collaboration and appropriate data governance and cybersecurity measures. Future studies should examine the long-term sustainability of digital monitoring interventions, farmers' digital readiness, the cost–benefit implications of digital technologies, and the application of predictive analytics and artificial intelligence in irrigation project management.

Keywords: *Digital data collection tools; Small-scale irrigation; Project performance; Digital technology; Ngoma District*.

1.0 Introduction

Digital technologies have become increasingly important in project monitoring and management because they facilitate timely data collection, improve information accuracy, and support evidence-based decision-making. Digital data collection tools, including mobile applications, electronic questionnaires, GPS-enabled devices, and cloud-based reporting platforms, enable project teams to capture, store, process, and share information more efficiently than conventional paper-based methods. Such tools help managers to identify implementation challenges, monitor progress against planned targets, allocate resources appropriately, and respond to emerging risks. Recent evidence further supports the relevance of these technologies to agricultural development. In a meta-analysis of digital information interventions, Beach et al. (2025) found positive average effects on agricultural productivity and farmers' income, although the magnitude of these effects varied across interventions and settings. Similarly, Kawerau et al. (2024) examined digital and participatory tools in agricultural research and demonstrated that the choice of data collection method influences the information obtained from smallholder farmers. Collectively, these findings highlight the potential of digital technologies to improve agricultural information management. At the same time, they emphasize the need to assess their effectiveness within specific project contexts.

Globally, the application of digital technologies in project management has created opportunities to strengthen monitoring processes and improve institutional accountability. Mobile-based data collection, automated reporting, digital dashboards, and electronic information management systems can reduce the delays associated with manual data processing and make implementation gaps easier to identify. Digital systems can also support the integration of field-level information into management processes, allowing project teams to compare implementation progress with established targets and identify areas requiring corrective action. However, the effectiveness of these technologies depends on data quality, system accessibility, staff competence, connectivity, and the extent to which collected information informs management decisions. Beach et al. (2025) observed that although digital information interventions can generate positive agricultural outcomes, the available evidence does not establish uniform effects across intervention types and geographical settings. This suggests that technological adoption should be accompanied by appropriate institutional arrangements, staff training, and procedures for verifying and using collected information. These considerations are particularly important for agricultural infrastructure projects, where effective implementation requires reliable communication among project managers, field personnel, agricultural extension workers, local authorities, and beneficiaries.

Across Africa, digital monitoring has considerable potential to address persistent challenges in agricultural development, particularly where project teams experience difficulty in collecting reliable information and communicating implementation progress. Small-scale irrigation initiatives require regular information about water distribution, equipment functionality, irrigation schedules, maintenance requirements, and farmers' participation. When such information is collected inconsistently or reported late, project managers may struggle to identify operational problems and take corrective action promptly. Digital data collection tools can help address these challenges by standardizing information gathering, improving record accessibility, and facilitating the sharing of field-level observations. Beach et al. (2025) reported average increases of 6% in both agricultural yields and farmers' income. However, these findings relate to digital agricultural information interventions in general rather than to project monitoring tools specifically. Kawerau

et al. (2024) further examined the use of visual and digital methods in agricultural research in Uganda, which illustrates the relevance of alternative data collection approaches for understanding smallholder farmers' experiences. Nevertheless, the benefits of digital monitoring depend on infrastructure availability, technical capacity, data quality assurance, and the integration of collected information into project management decisions.

In Rwanda, irrigation development is an important strategy for increasing agricultural productivity, reducing dependence on unreliable rainfall, and strengthening farmers' resilience to climate variability. The Rwanda Agriculture and Animal Resources Development Board (RAB, n.d.) identifies small-scale irrigation technologies as a key component of the country's efforts to expand irrigated agriculture and improve agricultural production. The government's irrigation programmes support farmers' access to irrigation equipment and include interventions aimed at improving the operation and maintenance of irrigation schemes. Recent research also shows growing interest in using digital technologies to address agricultural water-management challenges. Bamurigire et al. (2026), in a study of smallholder rice farmers in the Muvumba Valley irrigation scheme in Eastern Rwanda, used KoboToolbox to collect information on farming practices, field monitoring, and farmers' readiness to adopt technology-based agricultural solutions. Their findings indicated strong interest in smart farming technologies among the surveyed farmers. In addition, the Food and Agriculture Organization of the United Nations (FAO, 2024) documented the Small-Scale Open Source Satellite-based Irrigation Advice (SOSIA) tool, which uses near-real-time satellite and weather information to support irrigation scheduling. These developments demonstrate the growing relevance of digital information systems to irrigation management. They also reinforce the need to investigate their contribution to project performance.

Evidence from Rwanda also highlights the importance of monitoring tools in improving project evaluation and management. In their study of ICT-based monitoring tools used to evaluate the Generation Water Project in Bugesera and Nyamagabe districts, Mbarushimana and Sanja (2024) examined the mWater survey tool and portal in relation to data collection, analysis, visualization, and project performance evaluation. Their findings indicated a statistically significant positive association between data collection and project performance evaluation. The study provides contextually relevant evidence of the potential contribution of digital monitoring tools to project oversight in Rwanda. However, because the research focused on a water project rather than a small-scale irrigation technology project, its findings cannot automatically be generalized to agricultural irrigation interventions. Furthermore, effective monitoring requires more than the availability of digital tools; it also depends on the accuracy and completeness of collected information, the timeliness of reporting, and the extent to which monitoring results inform corrective action. These considerations warrant further investigation within the context of agricultural projects in Rwanda.

The Small-Scale Irrigation Technology (SSIT) Project in Ngoma District provides a relevant context for examining these issues. According to the Rwanda Rural Rehabilitation Initiative (RWARRI, 2021), the project, implemented in partnership with Ngoma District under the government's SSIT programme led by RAB, aimed to improve smallholder farmers' livelihoods, agricultural productivity, and climate resilience through green technologies. The initiative established solar-powered pumping systems and two water reservoirs, each with a capacity of 500 cubic metres, serving irrigation sites in the Zaza and Mutenderi sectors. The project was designed to irrigate approximately 10 hectares in each sector and targeted 1,205 smallholder farmers. Beneficiaries also received training in climate-smart agriculture, gender mainstreaming, social

inclusion, organizational skills, and bookkeeping. Water Users' Associations were established to support the management of irrigation infrastructure and promote the continuity of project benefits. These characteristics make the project an appropriate setting for investigating how digital data collection tools can support monitoring, accountability, and operational decision-making in a rural agricultural intervention.

Given the project's infrastructure and intended benefits, effective monitoring is essential for tracking implementation activities, identifying maintenance requirements, documenting irrigation operations, and supporting coordination among farmers, Water Users' Associations, and project stakeholders. Digital data collection tools can facilitate these processes by enabling field personnel to record operational information electronically, update monitoring records, and communicate emerging challenges more promptly. When integrated with real-time data transmission and interactive dashboards, these tools may also improve access to monitoring information and enable project managers to make better-informed decisions. Evidence from Rwanda's water sector suggests that digital survey platforms can support data collection and performance evaluation (Mbarushimana & Sanja, 2024), while the FAO's SOSIA initiative illustrates how near-real-time agricultural information can support irrigation-related decisions (FAO, 2024). However, these examples demonstrate the potential of digital technologies rather than prove their effectiveness in the Ngoma SSIT Project. Their actual contribution to project performance must therefore be assessed using evidence specific to the project.

1.1 Statement of the Problem

Despite the growing use of digital technologies in agriculture, important questions remain regarding their contribution to the performance of individual irrigation projects. Existing research has examined digital agricultural information and its relationship with productivity and income (Beach et al., 2025), the application of digital and participatory methods in agricultural research (Kawerau et al., 2024), and ICT-based monitoring tools in Rwandan water projects (Mbarushimana & Sanja, 2024). Research on irrigation technology adoption and smart irrigation in Rwanda has also highlighted the relevance of technological readiness and access to agricultural information (Bamurigire et al., 2026; RAB, n.d.). Nevertheless, these studies do not directly establish the extent to which digital data collection tools influence the performance of the SSIT Project in Ngoma District. In particular, project-specific evidence is needed on the contribution of digital data collection tools, real-time data transmission, and interactive dashboards to reporting timeliness, data quality, accountability, resource utilization, and decision-making. This constitutes the empirical and contextual gap that the present study seeks to address.

1.2 Objectives of the Study

This study therefore sought to examine the influence of digital data collection tools on the performance of the Small-Scale Irrigation Technology Project in Ngoma District, Rwanda. In line with the study's analytical framework, it considered digital data collection tools, real-time data transmission, and interactive dashboards and reporting as related components of digital monitoring. By investigating these dimensions, the study sought to establish how digital monitoring practices contribute to project performance, particularly in terms of operational efficiency, accountability, timely reporting, resource utilization, and informed decision-making. The findings are expected to provide evidence that can assist project managers, agricultural institutions, local authorities, and development partners in strengthening digital monitoring

systems and improving the management and sustainability of small-scale irrigation investments in Rwanda. The specific objectives of the study were:

i. To assess the influence of digital data collection tools on the performance of the SSIT Project in Ngoma District.

ii. To examine the influence of real-time data transmission on the performance of the SSIT Project in Ngoma District.

iii. To determine the influence of interactive dashboards and reporting on the performance of the SSIT Project in Ngoma District.

1.3 Research Hypotheses

The study tested the following null hypotheses at the 0.05 level of significance:

i. H_{01}: Digital data collection tools have no significant influence on the performance of the SSIT Project in Ngoma District.

ii. H_{02}: Real-time data transmission has no significant influence on the performance of the SSIT Project in Ngoma District.

iii. H_{03}: Interactive dashboards and reporting have no significant influence on the performance of the SSIT Project in Ngoma District.

2.0 Literature Review

This section reviews the theories that underpin the study and the empirical literature on digital data collection tools, real-time data transmission, interactive dashboards and reporting, and project performance. It also identifies the research gaps that the study sought to address and presents the conceptual framework that guided the investigation.

2.1 Theoretical Review

2.1.1 Systems Theory

Systems Theory, which is rooted in the work of von Bertalanffy (1968), views an organization or project as a set of interrelated and interdependent components that work together to achieve a common purpose. A system receives inputs from its environment, transforms them through internal processes, and produces outputs, while feedback enables it to monitor its performance and adjust its operations. Katz and Kahn (1978) extended these ideas to organizations by describing them as open systems that depend on continuous exchanges of information and resources with their environment. From this perspective, the performance of a system depends not only on the quality of its individual parts but also on how effectively those parts interact.

In the context of the present study, the SSIT Project can be viewed as a system composed of field personnel, farmers, Water Users' Associations, irrigation infrastructure, and project management structures. Digital data collection tools function as input mechanisms that capture field-level information; real-time data transmission serves as the channel through which this information flows among the subsystems; and interactive dashboards and reporting provide the feedback that enables managers to detect deviations and take corrective action. A weakness in any one of these components can disrupt the entire monitoring cycle and undermine project performance. Systems Theory is therefore relevant because it explains why the three digital monitoring components

should be integrated rather than treated as isolated tools. However, the theory has been criticized for being abstract and for offering limited guidance on the behavioral factors that determine whether people actually use new technologies. The Technology Acceptance Model addresses this limitation.

2.1.2 Technology Acceptance Model

The Technology Acceptance Model (TAM) was developed by Davis (1989) to explain why individuals accept or reject information technology. The model proposes that two beliefs, namely perceived usefulness and perceived ease of use, are the principal determinants of a user's intention to adopt a technology. Perceived usefulness refers to the degree to which a person believes that using a particular system will enhance his or her job performance, while perceived ease of use refers to the degree to which a person believes that using the system will be free of effort (Davis, 1989). Subsequent extensions of the model incorporated social influence and cognitive instrumental processes (Venkatesh & Davis, 2000). The Unified Theory of Acceptance and Use of Technology later integrated performance expectancy, effort expectancy, social influence, and facilitating conditions into a single framework (Venkatesh et al., 2003).

TAM is relevant to this study because the benefits of digital data collection tools, real-time data transmission, and interactive dashboards can only be realized if project staff, field officers, and farmers accept and consistently use them. Where users perceive mobile data collection applications, SMS feedback platforms, and dashboards as useful for their work and easy to operate, they are more likely to adopt them, which in turn improves the quality and timeliness of monitoring information. Conversely, where tools are perceived as complex or irrelevant, adoption may be partial and the expected performance gains may not materialize. The model therefore complements Systems Theory by explaining the human and behavioral conditions under which digital monitoring systems contribute to project performance.

2.2 Empirical Review

2.2.1 Digital Data Collection Tools and Project Performance

Empirical studies increasingly show that digital data collection tools can improve the quality and usefulness of project information. In a meta-analysis of digital information interventions in agriculture, Beach et al. (2025) found positive average effects on yields and farmers' income, although the size of these effects varied considerably across intervention types and settings. Earlier, Aker et al. (2016) reviewed information and communication technology (ICT) initiatives in agriculture and concluded that mobile technologies can reduce the cost of collecting and disseminating information. They cautioned, however, that the effects of such initiatives depend on their design and on the context in which they are implemented. Similarly, Fabregas et al. (2019) argued that digital agricultural advisory services can be delivered at low cost and at scale, while emphasizing the need for rigorous evaluation to establish which approaches produce meaningful results.

Studies on data collection methods also highlight the importance of tool design. Kawerau et al. (2024) investigated visual digital tools in agricultural research in Uganda and showed that the choice of data collection method affects the information obtained from smallholder farmers. In Indonesia, Apriyanto et al. (2022) developed a real-time monitoring and information management system to digitalize plant collection data in a botanical garden, demonstrating how digital systems can replace manual recording and improve data management. In Rwanda, Bamurigire et al. (2026)

used KoboToolbox to collect information on farming practices, field monitoring, and technology readiness among smallholder rice farmers in the Muvumba Valley irrigation scheme and reported strong interest in smart farming technologies. Together, these studies suggest that digital data collection tools can enhance data accuracy, completeness, and timeliness. However, most of them focus on agricultural productivity, research methods, or technology readiness rather than on the performance of a specific irrigation project.

2.2.2 Real-Time Data Transmission and Project Performance

Real-time data transmission refers to the immediate or near-immediate transfer of field information to the people responsible for analysis and decision-making. Van Besouw and Bond-Barnard (2021) examined smart project management information systems for engineering projects and showed how such systems can support project performance monitoring and reporting by making up-to-date information available to project teams. The Project Management Institute (2021) similarly emphasizes that timely and accurate information is essential for measuring project performance, managing risks, and communicating with stakeholders. In agriculture, the Food and Agriculture Organization of the United Nations (FAO, 2024) documented the SOSIA tool, which uses near-real-time satellite and weather information to provide irrigation scheduling advice to small-scale farmers.

Within Rwanda, Mbarushimana and Sanja (2024) found a statistically significant positive association between data collection using the mWater platform and the performance evaluation of the Generation Water Project in Bugesera and Nyamagabe districts. Harelimana and Umugwaneza (2024) examined the effects of monitoring and evaluation on the performance of a dairy community processing centre in Rwanda, while Mugire and Njenga (2023) assessed monitoring and evaluation in the Rural Electricity Distribution Project in Rulindo District. These studies collectively underline the importance of monitoring and evaluation in Rwandan development projects. Nevertheless, they were conducted in the water, dairy, and energy sectors, and they did not isolate the specific contribution of real-time data transmission to the performance of small-scale irrigation projects.

2.2.3 Interactive Dashboards and Reporting and Project Performance

Interactive dashboards present monitoring information in visual and summarized formats, such as charts, maps, and performance indicators, which allow managers to track progress against targets. Mbarushimana and Sanja (2024) examined the visualization component of the mWater portal alongside data collection and analysis, indicating that the presentation of data is an integral part of ICT-based project monitoring. Van Besouw and Bond-Barnard (2021) similarly identified reporting as a key function of smart project management information systems. Kabeyi (2019) traced the evolution of project management and of monitoring and evaluation as professional practices, highlighting how planning, control, and reporting functions have developed over time.

Although dashboards are widely promoted as decision-support tools, empirical evidence on their contribution to the performance of agricultural projects in Rwanda remains limited. Most available studies treat dashboards as a component of broader monitoring systems rather than as a distinct variable. As a result, little is known about the extent to which interactive dashboards and reporting influence reporting timeliness, accountability, resource utilization, and decision-making in small-scale irrigation projects.

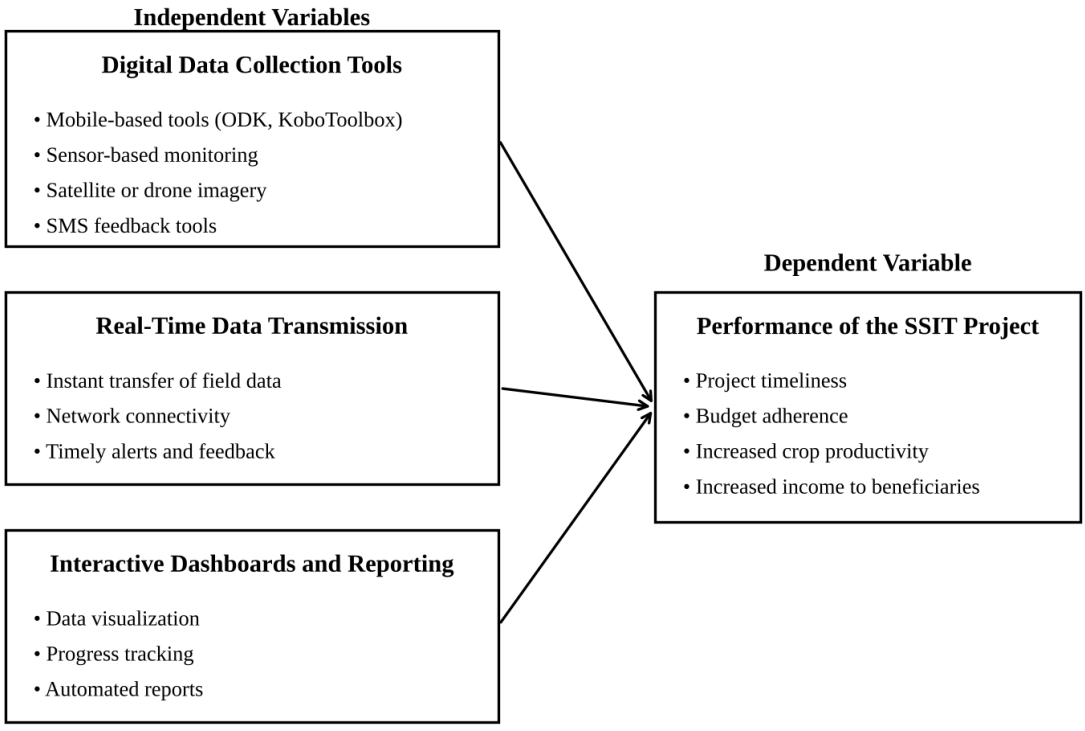
2.3 Research Gaps

The reviewed literature reveals three main gaps. First, there is a contextual gap, since most studies were conducted outside the irrigation sector or outside Rwanda, and none focused specifically on the SSIT Project in Ngoma District. Second, there is a conceptual gap, because previous studies often examined digital tools as a single construct or focused on agricultural outcomes such as yields and income. They did not assess digital data collection tools, real-time data transmission, and interactive dashboards as distinct components of a monitoring system. Third, there is a methodological gap, as few studies combined quantitative and qualitative evidence to explain how digital monitoring practices influence project performance. The present study addresses these gaps by using a mixed-methods design to examine the individual and combined influence of the three digital monitoring components on the performance of the SSIT Project.

2.4 Conceptual Framework

The conceptual framework presented in Figure 1 illustrates the hypothesized relationships between the independent and dependent variables. The independent variables are digital data collection tools, real-time data transmission, and interactive dashboards and reporting. The dependent variable is the performance of the SSIT Project, measured through project timeliness, budget adherence, increased crop productivity, and increased income to beneficiaries.

Figure 1: Conceptual Framework



Source: Researcher (2025)

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3.0 Research Methodology

3.1 Research Design

This study adopted a mixed-methods, cross-sectional research design that combined quantitative and qualitative techniques. This approach provided a comprehensive understanding of how digital monitoring tools influence the performance of the SSIT Project in Ngoma District. The quantitative strand measured the strength and direction of the relationships between the study variables, while the qualitative strand captured stakeholders' experiences and explanations of these relationships. Combining the two strands enabled the triangulation of findings and enhanced the credibility of the conclusions (Kothari, 2014).

3.2 Target Population

The target population for this study consisted of direct stakeholders involved in the implementation, monitoring, and utilization of the Small-Scale Irrigation Technology (SSIT) Project in Ngoma District, totalling 145 individuals. These stakeholders were considered appropriate because they possessed first-hand knowledge of how project data were collected, transmitted, reported, and used in decision-making.

3.3 Sample Size Determination

The sample size for this study was determined using Slovin's formula**,** which is appropriate when the population is finite and known:

$$n = \frac{N}{1 + N(e)^2}$$

Where:

- **n** = Sample size
- **N** = Total population (145)
- **e** = Margin of error (0.05)

Substituting the values into the formula gives $n=\frac{145}{1+145(0.05)^2}=\frac{145}{1+0.3625}=\frac{145}{1.3625}=106$

Therefore, the sample size was 106 respondents. This sample provided a reasonable level of precision while reducing the cost and time required for data collection.

3.4 Sampling Techniques

The study employed stratified random sampling and convenience sampling. Stratified random sampling was used to group respondents according to their roles in the SSIT Project and to select participants from each stratum, thereby ensuring that the views of all stakeholder categories were represented. Convenience sampling was applied to key informants who were available and willing to participate in interviews during the data collection period. This combination ensured adequate representation in the quantitative strand while allowing in-depth insights to be obtained in the qualitative strand.

3.5 Data Collection Instruments

The study used a structured questionnaire, an interview guide, and a document review checklist to collect relevant data. The questionnaire contained closed-ended statements measured on a five-point Likert scale, ranging from strongly disagree to strongly agree, to assess the influence of digital data collection tools, real-time data transmission, and interactive dashboards on SSIT project performance in Ngoma District. This approach ensured standardized, efficient, and cost-effective data collection. The interview guide was used to obtain in-depth explanations from key informants, while the document review checklist guided the examination of project monitoring reports.

3.6 Data Analysis

Quantitative data were coded and analyzed using the Statistical Package for the Social Sciences (SPSS). Descriptive statistics, including frequencies, percentages, means, and standard deviations, were used to summarize respondents' perceptions. Pearson correlation analysis was used to establish the strength and direction of the relationships between the digital monitoring components and project performance. Analysis of variance (ANOVA) and multiple regression analysis were then used to determine the combined and individual influence of the independent variables on project performance. Qualitative data from interviews and document reviews were analyzed thematically, and the emerging themes were used to corroborate and explain the quantitative results. The multiple regression model was specified as

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon$$

Where Y represents project performance; X_1, X_2, and X_3 represent digital data collection tools, real-time data transmission, and interactive dashboards and reporting, respectively; β_0 is the constant; β_1 to β_3 are the regression coefficients; and ε is the error term.

4.0 Results and Discussion

4.1 Demographic Characteristics of Respondents

This section presents background information on the respondents. Such characteristics are important because they help to explain the diversity and expertise of the participants, which may influence their perceptions of digital monitoring tools and project performance. Table 1 presents the gender distribution of the respondents.

Table 1: Gender of Participants

	N	%
Female	44	42.7%
Male	59	57.3%

Source: Research findings (2025)

As shown in Table 1, 57.3% of the respondents were male, while 42.7% were female. This slight gender imbalance reflects a common pattern in agricultural and irrigation-related projects in Rwanda, where men are often more engaged in field and coordination roles. Nevertheless, the

substantial representation of women indicates increasing female participation in development projects, which is consistent with Rwanda's gender mainstreaming policies. Gender inclusivity in project management promotes equitable perspectives on technology adoption and enhances the sustainability of project interventions.

4.2 Presentation of Findings

This section presents and interprets the quantitative and qualitative findings on the influence of digital data collection tools, real-time data transmission, and interactive dashboards on the performance of the Small-Scale Irrigation Technology (SSIT) Project in Ngoma District, Rwanda. Quantitative findings are presented using descriptive and inferential statistics, while qualitative findings are drawn from interviews with key informants involved in project implementation and monitoring. The results are organized according to the study objectives and are discussed in relation to relevant empirical studies reviewed in Section 2.0 to provide a comprehensive understanding of how digital monitoring technologies contribute to project performance.

Table 2: Descriptive Statistics for Digital Data Collection Tools

Statements concerning digital data collection tools	SD	D	N	A	SA	Mean	S.D
The use of mobile-based data collection tools (ODK, KoboToolbox) improved project tracking	-	3 (2.8%)	19 (18%)	30 (28.5%)	52 (49.5%)	4.25	0.855
Sensor-based monitoring (soil moisture, water flow) supported efficient irrigation planning	1 (0.9%)	2 (1.9%)	15 (14%)	44 (41.9%)	42 (40.0%)	4.20	0.801
Satellite or drone imagery was used to assess field coverage and performance	-	3 (2.8%)	17 (16%)	49 (46.6%)	35 (33.3%)	4.12	0.755
SMS feedback tools enabled farmers to report issues quickly and easily	1 (0.9%)	3 (2.8%)	19 (18%)	35 (33.3%)	46 (43.8%)	4.18	0.874
Digital tools reduced manual errors in data collection	-	4 (3.8%)	20 (19%)	30 (28.5%)	50 (47.6%)	4.22	0.868
Overall Mean						**4.20**	

Note. SD = strongly disagree (1); D = disagree (2); N = neutral (3); A = agree (4); SA = strongly agree (5); S.D = standard deviation.

Source: Research findings (2025)

The results in Table 2 show a high overall mean of 4.20 (SD = 0.83), indicating that respondents agreed that digital data collection tools improved SSIT project performance. The highest-rated item (M = 4.25) related to mobile-based data collection tools, followed by error reduction (M =

4.22) and sensor-based monitoring (M = 4.20). These results suggest that digital tools enhanced the accuracy, efficiency, and timeliness of irrigation performance monitoring. This finding is consistent with Tashobya and Mbabazi (2023), whose study at World Vision Uganda found that KoboToolbox reduced data processing time by 42% and increased data accuracy ($p < 0.05$). Similarly, Bisimwa and Irechukwu (2023) reported 92% data completeness in Goma when ODK tools were used instead of paper-based systems. These results corroborate the mean scores obtained in this study, which indicate that digital tools minimize manual errors (M = 4.22, SD = 0.868) and improve project tracking. Moreover, Olaremi et al. (2023) found that 78% of respondents in Nigerian tertiary institution projects acknowledged that daily digital monitoring reduced delays. The alignment of these regional findings with the present Rwandan evidence suggests that digitized monitoring and evaluation (M&E) systems offer broad benefits for project performance.

Qualitative insights from the interviews supported the quantitative findings. Key informants reinforced these results; for instance, one project coordinator remarked:

> "Before adopting KoboCollect, we relied on paper forms that delayed reporting for weeks. Now, data is instantly visible on the dashboard, and we can respond within a day."

A field officer added:

> "Using soil moisture sensors and mobile feedback tools helped us plan irrigation schedules and reduce water wastage."

Recurring qualitative themes included improved timeliness, error minimization, and enhanced farmer participation. Document reviews of the SSIT monthly monitoring reports (2024–2025) showed that the data backlog was reduced from 14 days to less than 48 hours after the deployment of digital tools. These narratives corroborate the quantitative mean scores and underscore the strong influence of digital tools on project performance.

Table 3: Correlation Analysis between Digital Data Collection Tools and SSIT Project Performance

		Project timeliness	Budget adherence	Increased crop productivity	Increased income to beneficiaries
Digital data collection tools	Pearson Correlation	.641*	.669**	.623**	.565**
	Sig. (2-tailed)	.011	<.001	.001	<.001
	N	105	105	105	105

Note. **Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed).

Source: Research findings (2025)

The results in Table 3 show strong positive correlations between digital data collection tools and

all indicators of project performance: project timeliness (r = .641, p = .011), budget adherence (r = .669, p < .001), increased crop productivity (r = .623, p = .001), and increased income to beneficiaries (r = .565, p < .001). All four coefficients were positive and statistically significant; three were significant at the 0.01 level and one (project timeliness) at the 0.05 level. The strongest correlation is observed with budget adherence (r = .669), implying that digital tools substantially enhance resource tracking and expenditure control. This finding aligns with Bisimwa and Irechukwu (2023), who found a correlation of r = .67 (p < .001) between mobile-based data systems and project budget compliance in agricultural monitoring in Goma. Likewise, Tashobya and Mbabazi (2023) reported r = .64 between digital field data collection and project timeliness. The strong correlation coefficients in this study (ranging from .565 to .669) therefore indicate that the use of digital data tools significantly strengthens SSIT project monitoring efficiency, reduces reporting delays, and minimizes budget variances. Qualitatively, project field officers noted that digital forms and mobile tools reduced "data duplication and late reporting," suggesting that the relationship is both statistically and operationally meaningful.

4.3 Discussion of Findings

The study established that digital data collection tools, such as KoboToolbox, ODK forms, sensor-based monitoring, mobile feedback platforms, and drone/satellite imagery, significantly improved SSIT project performance in Ngoma District. Quantitative findings showed high agreement (overall M = 4.20, SD = 0.83), indicating that respondents perceived digital tools as effective in enhancing the accuracy, timeliness, and completeness of monitoring data. The highest-rated item (M = 4.25) related to the use of mobile-based tools, demonstrating users' confidence in handheld systems for real-time field data capture. This is consistent with regional evidence, including the study by Tashobya and Mbabazi (2023), who observed a 42% reduction in data processing delays when KoboCollect was deployed.

The strong correlations between digital tools and the project indicators, namely timeliness (r = .641), budget adherence (r = .669), crop productivity (r = .623), and income outcomes (r = .565), further affirm the centrality of digital monitoring and evaluation systems in enhancing operational efficiency. These findings demonstrate that digital tools not only strengthen data quality but also serve as foundational elements for timely decision-making, efficient resource utilization, and reduction of monitoring errors. The regression results showed that digital tools had the highest standardized beta coefficient (β = .440), confirming them as the most influential predictor in the SSIT monitoring system. These findings imply that effective digital data collection directly contributes to improved project performance by enabling timely implementation of irrigation activities, minimizing resource wastage, improving financial accountability, increasing agricultural productivity, and ultimately enhancing farmers' livelihoods.

Qualitative insights reinforced these quantitative results. Interviewees repeatedly described significant improvements in reporting speed, accuracy, and farmer engagement. A project coordinator explained that before adopting digital tools, reporting delays extended up to two weeks; after adoption, reporting time fell to between 24 and 48 hours. Field officers also indicated that moisture sensors and mobile feedback systems improved irrigation scheduling and reduced water wastage, consistent with document review observations from monthly SSIT monitoring reports. These observations align with Bisimwa and Irechukwu (2023), who found increased data completeness (92%) using ODK platforms in agricultural contexts. The findings strongly support Systems Theory, which views project performance as the outcome of interactions among

interconnected components within a monitoring system (von Bertalanffy, 1968). Digital data collection tools function as critical system inputs that improve the quality of information flowing through the monitoring cycle, thereby enabling faster analysis, informed decision-making, and coordinated responses. The results suggest that strengthening one subsystem, namely digital data collection, enhances the effectiveness of the entire project implementation process, leading to improved performance outcomes.

Digital tools further supported participatory monitoring and evaluation by enabling farmers to report issues directly via SMS platforms, which is consistent with Arnstein's (1969) argument that meaningful participation requires citizens to have a genuine voice in the decisions that affect them. The ability to visualize immediate reports or sensor readings strengthened transparency and accountability across project tiers. Furthermore, document analysis showed a reduction in data backlog from 14 days to less than 48 hours, confirming the operational improvements reported during interviews. The findings are also consistent with the Technology Acceptance Model (TAM) (Davis, 1989). The high level of agreement among respondents suggests that field officers perceived digital tools as useful and easy to use, encouraging their consistent adoption during project implementation. According to TAM, technologies that are perceived as useful and user-friendly are more likely to be accepted and effectively utilized. The successful adoption of digital monitoring tools therefore appears to have translated into improved monitoring quality, faster reporting, and better project performance, demonstrating that user acceptance is a critical driver of technology-enabled project success.

5.0 Conclusion

The study concludes that digital data collection tools significantly influence the performance of the Small-Scale Irrigation Technology (SSIT) Project in Ngoma District, Rwanda. The descriptive findings indicated strong respondent agreement regarding the contribution of digital data collection tools to project monitoring, while regression analysis confirmed a statistically significant positive influence ($\beta = .440$, $p = .013$). These findings suggest that digital tools improve data accuracy, reporting efficiency, monitoring effectiveness, and timely decision-making. Digital data collection tools emerged as the strongest predictor of project performance among the three digital monitoring components examined. Therefore, the first null hypothesis (H_{01}) was rejected.

The study further concludes that real-time data transmission significantly contributes to SSIT project performance. The regression results showed a positive and statistically significant influence ($\beta = .264$, $p = .002$), indicating that timely transmission of monitoring information supports communication, coordination, and prompt decision-making. Effective data transmission enables project stakeholders to identify implementation challenges and respond more quickly, thereby strengthening monitoring efficiency and accountability. Consequently, the second null hypothesis (H_{02}) was rejected.

The findings also establish that interactive dashboards and reporting systems significantly influence the performance of the SSIT Project. The regression analysis revealed a positive and statistically significant relationship ($\beta = .370$, $p = .004$), suggesting that dashboards improve access to project information, facilitate progress tracking, and support evidence-based decision-making. By presenting monitoring information in an accessible format, these systems can help project managers identify performance gaps, improve resource utilization, and strengthen accountability. Accordingly, the third null hypothesis (H_{03}) was rejected.

Overall, the study concludes that integrating digital data collection tools, real-time data transmission, and interactive dashboards strengthens the performance of the SSIT Project in Ngoma District. The regression model explained 65.7% of the variation in project performance ($R^2 = .657$, $F = 197.070$, $p < .001$), demonstrating the combined explanatory contribution of the three digital monitoring components. Digital data collection tools had the strongest individual influence, followed by interactive dashboards and real-time data transmission. These findings highlight the importance of strengthening digital monitoring capacity, improving the quality and timeliness of project information, and ensuring that monitoring results inform management decisions. Such measures can contribute to more efficient implementation, stronger accountability, and improved sustainability of small-scale irrigation investments.

6.0 Recommendations

The study recommends that project managers and implementing agencies strengthen the use of digital data collection tools in the Small-Scale Irrigation Technology (SSIT) Project in Ngoma District, as these emerged as the strongest predictor of project performance. Standardized digital platforms should be adopted to improve data accuracy, reporting timeliness, and monitoring efficiency. Real-time data transmission should be enhanced through reliable internet connectivity and offline data collection systems. In addition, interactive dashboards should be integrated into routine project monitoring to support evidence-based decision-making, accountability, and efficient resource utilization. The Government of Rwanda, the Rwanda Agriculture and Animal Resources Development Board, district authorities, and development partners should support these initiatives through adequate funding, appropriate digital infrastructure, continuous staff training, and effective data management and cybersecurity measures. Farmers and Water Users' Associations should also be encouraged to participate actively in digital reporting to improve information quality and facilitate timely responses to irrigation-related challenges.

Further research should examine the long-term sustainability and cost-effectiveness of digital monitoring systems in agricultural projects, particularly after external funding and technical support have ended. Comparative studies across different districts and irrigation projects would help to establish whether the relationships identified in Ngoma District apply in other contexts. Future research should also investigate the technical, institutional, and socio-economic factors influencing the adoption of digital data collection tools among farmers and project personnel. In addition, researchers should explore the potential application of artificial intelligence, predictive analytics, and Internet of Things technologies in improving irrigation monitoring, anticipating equipment failures, optimizing water use, and strengthening the overall performance and sustainability of agricultural development projects in Rwanda.

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