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The Influence of Documentation Completeness on the Sustainability of Rural Electrification Projects in Kirehe District, Rwanda

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Abstract: **This study examined the influence of documentation completeness on the sustainability of rural electrification projects in Kirehe District, Rwanda. A cross-sectional mixed-methods research design was used within a case study framework. Quantitative data were collected through structured questionnaires, while qualitative data were obtained from key informant interviews and documentary review. Quantitative data were analysed using descriptive and inferential statistics in SPSS Version 30, whereas qualitative data were analysed thematically. Of the planned sample of 391 participants, 376 provided valid responses, representing a response rate of 96.1%. The findings showed that documentation completeness was rated highly, with a mean score of 4.22. Complete technical manuals, as-built drawings, and other essential project records were found to support maintenance activities, facilitate access to technical information, and reduce the risk of losing important project knowledge after completion. Documentation completeness was also found to be a significant positive predictor of project sustainability ($\beta = 0.620$, $p < 0.001$). The overall regression model explained 60.1% of the variation in project sustainability ($R^2 = 0.601$). These findings highlight the importance of having complete, accurate, accessible, and up-to-date documentation to support the continued operation and maintenance of rural electrification systems. The study concludes that documentation completeness plays an important role in sustaining rural electrification projects in Kirehe District. It recommends that project implementers and relevant institutions ensure that essential technical documents are properly prepared, verified, stored, and handed over to those responsible for operating and maintaining the systems. Strengthening these practices can improve maintenance efficiency, preserve technical knowledge, and support the long-term delivery of reliable electricity services in rural communities.**

Keywords: **Documentation completeness; Project sustainability; Rural electrification; Project management; Kirehe District.**

1. INTRODUCTION

Access to electricity plays an important role in improving people's lives by supporting education, healthcare, business activities, and household welfare. Rural electrification projects are particularly important because they extend electricity services to communities that may otherwise remain underserved. However, connecting households and installing electricity infrastructure do not necessarily guarantee long-term benefits. For these benefits to continue, electricity systems must remain functional and receive proper maintenance after project completion. One factor that may contribute to this continuity is documentation completeness, which concerns the availability, accuracy, and accessibility of essential project records, such as technical drawings, equipment specifications, installation records, and operation and maintenance manuals. These documents provide important information for operating, maintaining, and repairing electricity systems throughout their useful life (International Organization for Standardization [ISO], 2024a, 2024b).

The importance of sustaining electricity infrastructure is evident in the continuing global challenge of providing reliable electricity access. According to the *Tracking SDG 7: The Energy Progress Report 2025*, more than 666 million people worldwide still lacked access to electricity (International Energy Agency [IEA] et al., 2025). This situation highlights the need not only to expand electricity infrastructure but also to ensure that completed projects continue to serve their intended purpose. Proper documentation can contribute to this objective by helping technicians understand how systems were installed, identify faults, and carry out maintenance using the correct technical information. When essential records are missing or incomplete, maintenance activities may become more difficult, potentially delaying repairs and affecting service continuity. Documentation completeness is therefore an important issue to consider when examining the sustainability of rural electrification projects.

Documentation is particularly important during the operation and maintenance of infrastructure because the people responsible for maintaining a system may not be the same individuals who installed it. Complete and accessible records help preserve technical knowledge and reduce dependence on information held by particular individuals. In rural electrification projects, these records may include as-built drawings, equipment inventories, electrical specifications, installation reports, maintenance schedules, and operating instructions. The ISO 55000:2024 standard emphasizes the importance of managing physical assets throughout their life cycles to ensure that they continue to provide value (ISO, 2024a). Similarly, ISO 55001:2024 provides requirements for establishing and maintaining an effective asset management system (ISO, 2024b). Although these standards address asset management more broadly, their principles highlight why reliable project information is important for the continued use and maintenance of electricity infrastructure.

These concerns are especially relevant in sub-Saharan Africa, where expanding electricity access remains a major development priority. The IEA et al. (2025) reported that hundreds of millions of people in the region continued to lack electricity access. Efforts to address this challenge involve extending existing electricity networks and developing alternative solutions, including mini-grids and stand-alone systems (IEA, 2025). As these investments increase, attention must also be given to how the installed infrastructure will be maintained after implementation. Complete technical documentation can help electricity service providers and maintenance personnel understand the systems they manage, identify the correct equipment, and follow appropriate maintenance procedures. This makes documentation an important consideration in efforts to protect investments and sustain electricity services in rural communities.

In developing countries, maintaining rural electricity systems can be challenging, particularly where communities are located far from technical support centres. In such circumstances, access to accurate project records may help maintenance personnel identify problems and determine the appropriate corrective action without unnecessary delays. Documentation can also support the replacement of faulty equipment by providing information about component specifications and system configurations. The IEA (2025) highlights the importance of grid expansion and decentralized electricity solutions in extending access to underserved communities. However, the long-term benefits of these investments depend partly on how effectively the resulting infrastructure is managed.

Ensuring that complete technical records are available after project completion may therefore help reduce operational difficulties and support the continued delivery of electricity services.

In Rwanda, expanding electricity access has been an important part of the country's development agenda. Government efforts and investments in the electricity sector have supported the extension of electricity services through both grid and off-grid solutions. The Rwanda Energy Group's Strategic Plan 2024–2034 sets out priorities for continued electricity sector development and improved service delivery (Rwanda Energy Group [REG], 2024). However, the success of these efforts should not be measured only by the number of connections established or the amount of infrastructure installed. It is also important to consider whether completed projects continue to provide electricity reliably. Proper documentation can support this objective by giving technicians and responsible institutions access to the information needed to operate, maintain, and repair installed systems. This is consistent with the asset management principles outlined in ISO 55000:2024, which emphasize maintaining the value and performance of assets throughout their life cycles (ISO, 2024a).

The need for complete documentation becomes more apparent as Rwanda continues to develop its electricity distribution infrastructure. Planning documents published by REG provide guidance for expanding electricity access and developing the distribution network (REG, 2022, 2023). As infrastructure expands, accurate records of installed equipment, network layouts, technical specifications, and completed works become increasingly useful for routine maintenance and future upgrades. If these records are incomplete, outdated, or difficult to access, technicians may have to spend additional time identifying system components or determining the appropriate procedures for repairs. Effective documentation management

can help address these challenges by ensuring that essential technical information remains available to those responsible for maintaining the infrastructure. Documentation should therefore be viewed not simply as a requirement for closing a project but also as a practical resource for its continued operation.

In Kirehe District, Eastern Province, rural electrification projects can contribute to household welfare, business development, and the delivery of essential community services. However, these benefits depend partly on whether electricity systems remain functional after project completion. When technical problems arise, the availability of complete project records can help technicians identify faults, understand system configurations, and determine the correct procedures for repairs. Similarly, accurate equipment inventories and maintenance records can support the planning of routine servicing and the replacement of faulty components. These practical uses of documentation are consistent with the principles of effective asset management described in ISO 55000:2024 and ISO 55001:2024 (ISO, 2024a, 2024b). Nevertheless, the extent to which documentation completeness supports the sustainability of rural electrification projects in Kirehe District needs to be established through empirical research.

Although the importance of technical documentation is recognized in asset management standards, there is a need for more context-specific evidence on its influence on the sustainability of rural electrification projects in Kirehe District. In particular, it is important to understand whether project records are sufficiently complete, accurate, and accessible to support ongoing operation and maintenance. It is also necessary to examine how documentation practices relate to the continued functionality of installed electricity systems. National energy plans and international asset management standards provide useful guidance, but they do not independently establish the nature or strength of this relationship within Kirehe District. Investigating this issue can help identify weaknesses in project documentation and provide evidence to guide improvements in the management of completed rural electrification projects.

Against this background, this study examines the influence of documentation completeness on the sustainability of rural electrification projects in Kirehe District, Rwanda. It focuses on the availability, accuracy, adequacy, and accessibility of project records and their relationship with the continued operation and maintenance of electricity infrastructure. By examining this relationship, the study seeks to provide evidence that can help project implementers and responsible institutions improve documentation practices and protect investments in rural electrification. Ultimately, better documentation management may contribute to more effective maintenance and the continued delivery of electricity services to rural communities.

2. METHODOLOGY

2.1 Research Design

This study adopted a cross-sectional mixed-methods design within a case study context.

2.2 Target population

The target population comprised project managers, project engineers, REG and EDCL technical staff, local government leaders, and beneficiary households. These participants provided relevant perspectives on rural electrification projects.

2.3 Sample Size

The sample size for this study was determined using Slovin's formula, which is commonly used in social research to determine an appropriate sample size when the population size is known but the population variance is unknown. The formula is as follows:

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

Where:

- **n** = Sample size
- **N** = Total population (18,060)
- **e** = Margin of error (0.05)

By substituting the values into the formula, $n=\frac{18060}{1+18060(0.05)^2}=\frac{18060}{1+45.15}=\frac{18060}{46.15}=391$

The sample size became 391 respondents, which was considered adequate to ensure representation of policy implementers and end users while maintaining manageable data collection logistics.

2.4 Data Collection Instruments

Three instruments were used: a structured questionnaire, an interview guide, and a document review guide. The questionnaire collected quantitative data from participants.

3. RESULTS

3.1 Demographic Characteristics of Respondents

This section presents the demographic information of respondents who participated in the study. Understanding the demographic profile provides context for interpreting the study findings, as respondents' gender may influence their perceptions of project handover processes and sustainability outcomes.

Table 1: Gender of Participants

	N	%
Female	154	41.0%
Male	222	59.0%

Source: Research findings (2025)

The results in Table 1 show that majority of respondents were male (59%) compared to female participants (41%). This finding suggests that men are more involved in the implementation and management of rural electrification projects in Kirehe district than women. The gender disparity may reflect the broader national trend in Rwanda's energy sector, where technical and managerial roles are still predominantly male-dominated. However, the participation of 41% female respondents demonstrates increasing gender inclusion in community energy projects, aligning with Rwanda's gender mainstreaming policies in the infrastructure sector.

3.2 Presentations of Findings

This section presents and discusses the study findings in relation to the specific objectives, focusing on the influence of documentation completeness, stakeholder capacity building, and acceptance testing and sign-off on the sustainability of rural electrification projects in Kirehe District, Rwanda. The findings are presented using frequencies, percentages, means, and standard deviations, followed by inferential statistical analyses to establish the relationships between the study variables. Qualitative data from key informant interviews and document reviews are incorporated to provide additional context and complement the quantitative results. Integrating these data sources facilitates triangulation, strengthens the interpretation of the findings, and provides a comprehensive understanding of the factors influencing the sustainability of rural electrification projects in Kirehe District.

3.2.1 Influence of document completeness on sustainability of electrification projects

Table 2: Descriptive statistics

Statements concerning document completeness	SD	D	N	A	SA	Mean	S.D
As-built designs were handed over to the local maintenance teams in Kirehe.	3 (0.8%)	4 (1.1%)	34 (9.0%)	155 (41.2%)	180 (47.9%)	4.34	0.753
Completion reports were compiled and shared with all stakeholders before project closure.	-	11 (2.9%)	50 (13.3%)	193 (51.3%)	122 (32.4%)	4.13	0.747
In Kirehe electrification projects, Operation & Maintenance manuals provided were in Kinyarwanda and easy to understand.	3 (0.8%)	7 (1.9%)	54 (14.4%)	164 (43.6%)	148 (39.4%)	4.19	0.806

Safety and compliance certificates were issued by national regulatory bodies before handover.	2 (0.5%)	11 (2.9%)	44 (11.7%)	149 (39.6%)	170 (45.2%)	4.26	0.817
The technical drawings/specs were stored and accessible at sector or district offices.	4 (1.1%)	10 (2.7%)	46 (12.2%)	162 (43.1%)	154 (41.0%)	4.20	0.834
Overall Mean						**4.22**	

Key: 1= strongly Disagree, 2= Disagree, 3= Neutral, 4= Agree, 5= strongly Agree, S.D= standard deviation.

Source: Research findings (2025)

The results in Table 2 show that documentation completeness was highly rated (M = 4.22, SD = 0.79), reflecting strong agreement among respondents that handover documents were well prepared and shared. The highest-rated indicator, "as-built designs were handed over to the local maintenance teams" (M = 4.34), demonstrates that technical records are effectively transferred to maintenance units, while the issuance of safety and compliance certificates (M = 4.26) indicates conformity to regulatory standards that underpin sustainability. Although still positive, "completion reports were compiled and shared" (M = 4.13) scored lowest, suggesting minor limitations in full stakeholder dissemination. The small standard deviations (0.75–0.83) confirm consensus across respondent categories, implying well-institutionalized documentation practices. The data suggest that structured document handovers preserve system traceability and support knowledge continuity for technicians and district officers.

Qualitative data supported the quantitative findings. The conducted interviews revealed two dominant themes, "information accessibility" and "document usability." A district engineer emphasized,

"*Unlike earlier electrification programs, the new Kirehe projects ensure all manuals and drawings are translated into Kinyarwanda, which helps local technicians conduct independent maintenance*."

Document reviews from REG and EDCL Kirehe confirmed that each completed project had archived completion reports, safety certificates, and digital technical drawings stored at the district infrastructure unit. The convergence of quantitative data, qualitative interviews, and documentary evidence thus indicates that documentation completeness in Kirehe significantly supports the sustainability of rural electrification systems.

Table 3: Correlation Between Documentation Completeness and Project Sustainability

		System functionality	System continuity	Operation and maintenance cost reduction	Ease of use	Continued service delivery
Documentation completeness	Pearson Correlation	.521**	.422**	.510**	.546**	.525**
	Sig. (1-tailed)	<.001	<.001	<.001	<.001	<.001
	N	376	376	376	376	376

**. Correlation is significant at the 0.01 level (1-tailed).

Source: Research findings (2025)

The correlation results in Table 3 indicate that documentation completeness has a positive and significant relationship with all five sustainability dimensions, system functionality (r = .521), system continuity (r = .422), operation and maintenance cost reduction (r = .510), ease of use (r = .546), and continued service delivery (r = .525), all at $p < 0.01$. This implies that projects with comprehensive and accurate documentation, such as operation manuals, maintenance records, and as-built drawings, tend to exhibit higher sustainability outcomes. These findings suggest that the more complete the documentation during project handover, the easier it becomes for operators and communities to maintain the electrification systems, reduce maintenance costs, and ensure continuous service delivery. The moderate-to-strong correlations (ranging from .422 to .546) demonstrate that while documentation is not the sole driver of sustainability, it plays a critical enabling role in preserving system functionality and usability after project completion.

Table 4. Regression Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.775	.601	.598	.3492	1.790

a. Predictors: (Constant), Acceptance testing and signoff, Stakeholder capacity building, Documentation completeness

b. Dependent Variable: Sustainability of electrification projects

Source: Research findings (2025)

The regression model summary in Table 4 shows an R value of .775, indicating a strong positive relationship between the independent variables (documentation completeness, stakeholder capacity building, and acceptance testing) and the dependent variable (sustainability of electrification projects). The $R^2 = .601$ implies that approximately 60.1% of the variance in project sustainability can be explained by the combined influence of the three predictors, while the remaining 39.9% may be attributed to other external factors not captured in the model. The Durbin–Watson statistic (1.790) falls within the acceptable range (1.5–2.5), confirming the absence of serial correlation among residuals and thus validating the model's reliability.

4. DISCUSSION OF FINDINGS

The findings indicate that documentation completeness plays an important role in the sustainability of rural electrification projects in Kirehe District, Rwanda. Descriptive results showed a high level of agreement among respondents that essential technical and operational documents were adequately prepared, shared, and archived ($M = 4.22$, $SD = 0.79$). This suggests that documentation practices were generally well established in the projects studied, although the accessibility and practical use of these documents remain important considerations for long-term sustainability.

The inferential results further demonstrated a strong, positive, and statistically significant relationship between documentation completeness and project sustainability ($r = 0.620$, $p < 0.001$). The regression analysis also reported a statistically significant coefficient for documentation completeness ($\beta = 0.620$, $p < 0.001$), indicating that more complete documentation was associated with higher sustainability outcomes. The overall regression model was statistically significant ($p < 0.001$), providing further evidence of the explanatory value of the model. However, the proportion of variance explained by documentation completeness alone cannot be established from these statistics without the relevant model summary. Moreover, the findings demonstrate a significant association and predictive relationship, rather than proving causation.

These results highlight the practical importance of maintaining complete and accessible project records throughout implementation and after handover. In rural electrification projects, as-built drawings, operation and maintenance manuals, safety compliance certificates, and project completion reports provide essential information for troubleshooting, routine maintenance, and future repairs. When these records are properly prepared and made available to relevant stakeholders, local technicians can identify technical problems more efficiently and maintain systems without depending entirely on external contractors. Documentation completeness therefore extends beyond administrative compliance; it supports the continuity of technical knowledge and the effective operation of electricity infrastructure.

The findings are consistent with the arguments attributed to Oke, Olatunji, and Ajulo (2020), who linked documentation completeness with improved post-handover performance in construction projects. Similarly, the discussion of Ejohwomu et al. (2023) emphasizes the importance of standardized project records in improving operational readiness and reducing post-completion defects. These perspectives are relevant to rural electrification because the successful completion of construction activities does not automatically guarantee the continued delivery of reliable electricity services. Effective handover requires sufficient technical information to enable those responsible for operating and maintaining the infrastructure to perform their duties effectively. The present findings extend this discussion by demonstrating a statistically significant relationship between documentation completeness and sustainability in the context of rural electrification projects in Rwanda. The cited studies should be checked against their original publications to ensure that their findings and bibliographic details are accurately represented.

The results also reinforce the importance of structured document management in preserving institutional knowledge. Where project information is incomplete, poorly organized, or difficult to retrieve, local operators may struggle to identify equipment specifications, understand system configurations, or follow appropriate maintenance procedures. This can increase the time required to resolve faults and create unnecessary dependence on external technical support. Conversely, comprehensive documentation provides a reliable reference for maintenance activities and helps preserve project knowledge

when contractors leave or personnel change. These benefits are particularly important in rural settings, where access to specialized technical expertise may be limited.

At the local level, the findings are consistent with the concerns attributed to Basomingerwa and Kwena (2021) regarding documentation-related delays and inefficiencies in Rwandan construction projects. In the context of Kirehe District, the importance of documentation is especially evident in the transition from project implementation to routine operation. Complete records can help district infrastructure officers, energy-sector personnel, and community-level operators understand their responsibilities and respond to technical problems. Nevertheless, the presence of documentation alone is insufficient. Its contribution to sustainability also depends on whether the records are accurate, regularly updated, accessible to intended users, and understandable to those responsible for maintenance. The references cited in this discussion should be verified against the original sources before publication.

Qualitative findings from key informant interviews and document reviews provided further insight into how documentation completeness supports project sustainability. Informants from Rwanda Energy Group (REG), district infrastructure offices, and community-level operations identified as-built drawings, operation and maintenance manuals, safety compliance certificates, and project completion reports as important documents during project handover. The document review also indicated that these records were available in physical and digital formats in the offices examined. However, interview findings suggested that access to documentation varied across project sites. Some community operators relied mainly on printed manuals translated into Kinyarwanda to support routine maintenance. This evidence illustrates the importance of making technical information available in formats that local users can understand and apply. It also suggests that document availability should be accompanied by appropriate training, clear access arrangements, and regular updates.

The findings can be interpreted through the lens of Knowledge Transfer Theory, which emphasizes the importance of transferring, retaining, and applying knowledge within organizations and among relevant stakeholders. In rural electrification projects, complete documentation provides a formal means of preserving technical knowledge beyond the implementation and handover stages. When combined with practical training and accessible maintenance guidance, it enables local operators to apply the knowledge required to manage and maintain electricity infrastructure. Documentation thus helps connect project implementation with long-term operation, reducing the risk of knowledge loss when contractors or technical personnel leave.

The study generally establishes that documentation completeness is an important factor associated with the sustainability of rural electrification projects in Kirehe District. Its contribution lies in supporting technical continuity, facilitating maintenance, improving access to project information, and strengthening the capacity of local stakeholders to manage electricity infrastructure. To maximize these benefits, project implementers and relevant authorities should ensure that handover documentation is complete, accurate, accessible, appropriately translated where necessary, and regularly updated. These measures can help strengthen maintenance practices and support the long-term sustainability of rural electrification services.

5. CONCLUSION

Based on the empirical findings, the study concludes that the sustainability of rural electrification projects in Kirehe District, Rwanda, is influenced by documentation completeness, stakeholder capacity building, and acceptance testing and sign-off. These factors support the transition from project implementation to effective operation and maintenance, thereby promoting the long-term functionality and reliability of electricity infrastructure.

The study concludes that documentation completeness is an important contributor to project sustainability because accurate, updated, and accessible records facilitate maintenance, troubleshooting, and continuity of operations. Complete documentation also reduces dependence on individual personnel and supports future system improvements.

The study further concludes that stakeholder capacity building is a major contributor to sustainability, as demonstrated by its standardized regression coefficient ($\beta = .688$). Equipping local stakeholders with appropriate technical knowledge and skills strengthens system management, promotes community ownership, and improves the timely maintenance of electrification infrastructure.

Additionally, acceptance testing and sign-off contribute to project sustainability ($\beta = .650$) by verifying that completed installations meet the required technical and safety standards before handover. These procedures strengthen accountability, identify defects early, and clarify responsibilities for subsequent operation and maintenance. The findings demonstrate that all three factors contribute substantially to the sustainability of rural electrification projects, with stakeholder capacity building recording the highest standardized coefficient ($\beta = .688$), followed by acceptance testing and sign-off ($\beta = .650$)

and documentation completeness (β = .620). The study therefore concludes that strengthening documentation practices, developing stakeholder capacity, and implementing rigorous acceptance procedures are essential for improving the long-term sustainability of rural electrification projects in Kirehe District, Rwanda.

6. RECOMMENDATION

Rwanda Energy Group (REG), Energy Development Corporation Limited (EDCL), and district authorities should strengthen documentation management systems by ensuring that complete, accurate, and up-to-date technical records, including as-built drawings, operation and maintenance manuals, safety certificates, and commissioning reports, are properly prepared, stored, and made accessible to relevant stakeholders.

Furthermore, technical manuals should be translated into Kinyarwanda where appropriate, and complete documentation should be provided to local technicians and operators during project handover. These measures will facilitate troubleshooting, improve maintenance practices, reduce dependence on external technical assistance, and support the long-term sustainability of rural electrification projects in Kirehe District.

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