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Impact of Government-Funded Irrigation Project on National Development in Rwanda: Case Study of Kagitumba Irrigation Scheme in Nyagatare District

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Abstract: *This study, entitled "The Impact of Government-Funded Irrigation Project on National Development: A Case Study of Kagitumba Irrigation scheme in Nyagatare District, Eastern Province of Rwanda," assessed the contribution of government irrigation investment to agricultural development, farmers' livelihoods, food security, and value chain integration. The study was motivated by rainfall dependence, climate variability, and limited access to reliable irrigation systems. Its objective was to assess the impact of the Kagitumba Government-Funded Irrigation Project on national development. It assessed irrigation infrastructure development, examined RAB extension services and agricultural technology adoption, evaluated income generation and socio-economic improvement, and determined contributions to food security and agricultural value chain integration. A mixed-methods research design was adopted. Quantitative findings were obtained from questionnaires completed by 329 farmers and cooperative leaders, supplemented by document review. Findings showed effects of irrigation infrastructure on agricultural performance (mean = 4.01), extension services and technology adoption on crop productivity (mean = 4.03), income generation and socio-economic improvement (mean = 3.97), and food security and value chain integration (mean = 4.00). The study recommends strengthening irrigation maintenance, extension services, market linkages, financing, technology adoption, and cooperative development. It concluded that the project contributes to national development through improved agricultural productivity, livelihoods, employment creation, and food security in Nyagatare District.*

Keywords: Government-Funded Irrigation, Agricultural Productivity, Income Generation, Food Security, National Development

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1. Introduction

Irrigation infrastructure is increasingly recognized as a cornerstone of agricultural transformation, food security, and climate change adaptation. As erratic weather patterns and prolonged droughts threaten traditional rain-fed farming systems, governments and international bodies are prioritizing the expansion of reliable water management systems to sustain crop yields. According to the Food and Agriculture Organization (FAO, 2024), irrigated agriculture, which accounts for roughly 20% of the world's cultivated land, contributes to nearly 40% of global food production, highlighting its disproportionate importance to human survival. Furthermore, the World Bank (2025) emphasizes that strategic, government-funded irrigation projects are critical for building climate resilience, reducing rural poverty, and ensuring that agricultural sectors can withstand the compounding pressures of population growth and environmental degradation.

The narrative is shifting from a historical over-reliance on vulnerable rain-fed agriculture toward targeted, government-supported irrigation initiatives aimed at unlocking the region's vast agricultural potential.

Despite possessing significant renewable water resources, the region has traditionally suffered from low irrigation coverage, leaving millions of smallholder farmers exposed to climate shocks. The African Development Bank (AfDB, 2024) asserts that scaling up public investment in irrigation is the most viable pathway to achieving the continent's agricultural growth targets and eradicating chronic food insecurity. Supporting this view, Okafor and Eze (2025) argue that when African governments partner with development agencies to fund localized irrigation schemes, the result is a measurable increase in crop diversification, enhanced household resilience, and a reduction in the region's dependency on expensive food imports.

Rwanda has strategically positioned irrigation development as a central pillar of its national transformation agenda, moving decisively away from rain-fed vulnerability toward climate-smart, commercial agriculture. The Kagitumba Government-Funded Irrigation Project in Nyagatare District exemplifies this national commitment, serving as a critical intervention to harness the waters of the Akagera River basin for year-round cultivation of staple and high-value crops. The Ministry of Agriculture and Animal Resources (MINAGRI, 2024) outlines that such projects are essential for achieving the targets set forth in the fourth Strategic Plan for Agriculture Transformation (PSTA 4), particularly in enhancing national food self-sufficiency and export capacity. Crucially, the success of the Kagitumba project is deeply intertwined with the Rwanda Agriculture and Animal Resources Development Board (RAB) Station in Nyagatare, which, as noted by Uwase and Habimana (2025), provides the indispensable research, improved seed multiplication, and extension services required to translate irrigation infrastructure into tangible, sustained national development outcomes.

Despite substantial government investment in irrigation infrastructure, the anticipated transformational impact of projects like the Kagitumba scheme in Nyagatare District remains constrained by systemic operational and value-chain inefficiencies. While the Rwandan government aims to expand irrigated land to over 200,000 hectares under the fourth Strategic Plan for Agriculture Transformation (PSTA 4), recent sector assessments indicate that only approximately 18% of newly developed irrigation schemes in the Eastern Province are fully utilized for year-round, multi-cropping cycles (MINAGRI, 2024). This underutilization is severely exacerbated by critical post-harvest and market access deficits; for instance, Niyonzima and Uwimana (2025) report that up to 28% of staple crops, such as maize and rice, produced in Nyagatare's irrigated zones are lost or devalued due to inadequate storage facilities and weak cooperative bargaining power. Consequently, the core problem is not merely a lack of physical water infrastructure, but a structural disconnect between irrigation delivery and the localized agronomic, financial, and market support required to translate this infrastructure into sustained national development, thereby threatening the return on public investment and perpetuating rural vulnerability.

Despite the growing body of literature on agricultural development in Rwanda, critical empirical gaps remain regarding the specific dynamics of the Kagitumba irrigation project and its broader developmental outcomes. First, while regional studies have extensively documented irrigation challenges in the Northern and Western provinces, there is a distinct scarcity of localized research addressing the unique socio-ecological and institutional dynamics of the Akagera River basin in Nyagatare District (Mugabo et al., 2023). Second, although the importance of extension services is widely acknowledged, few studies have quantitatively isolated the specific catalytic role of the Rwanda Agriculture and Animal Resources Development Board (RAB) Station in mediating technology adoption rates and yield optimization within government-funded irrigation schemes (Karangwa & Nkurunziza, 2024). Third, existing impact evaluations predominantly focus on aggregate crop yield metrics, largely overlooking disaggregated socio-economic impacts, such as shifts in gendered labor burdens and youth agripreneurship within Kagitumba farmer cooperatives (Mukamana & Ndayisaba, 2023). Furthermore, there is a notable paucity of longitudinal environmental assessments tracking the long-term sustainability of the Kagitumba project, particularly concerning soil salinization risks and the ecological limits of Akagera River water abstraction under compounding climate stress (Habiyaremye et al., 2022). Finally, current literature exhibits a strong production-side bias, leaving a critical gap in understanding how the increased irrigated output from Nyagatare effectively integrates into national agro-processing value chains to drive macroeconomic development and reduce post-harvest losses (Nsengiyumva & Uwineza, 2024). Addressing these multifaceted gaps is essential for formulating evidence-based policies that maximize the national development potential of the Kagitumba project.

1.1 General Objective

To assess the impact of the Government-Funded Irrigation Project on national development using Kagitumba Irrigation scheme in Nyagatare District as a case study.

1.2 Specific Objectives

The specific objectives of the research topic were:

1. To assess the contribution of irrigation infrastructure development to the performance and sustainability of the Kagitumba Government-Funded Irrigation project in Nyagatare District.

2. To examine the influence of Rwanda Agriculture and Animal resources development Board (RAB) extension services and agricultural technology adoption on crop productivity among beneficiaries of the Kagitumba Irrigation scheme in Nyagatare District.

3. To evaluate the role of the Kagitumba Government-Funded Irrigation Project in farmers' income generation, employment creation, and socio-economic improvement in Nyagatare District.

4. To determine the impact of increased irrigated agricultural production on food security and farmers' integration into national agricultural value chains in Nyagatare District.

2. Literature Review

This section presents the theories that provided the foundation for understanding the relationships among the study variables. The theories explain how irrigation infrastructure influences agricultural productivity, income generation, and food security, which ultimately contribute to national development.

2.1 Theoretical Review

2.1.1 Systems Theory

Originally proposed by Ludwig von Bertalanffy in 1968, General Systems Theory posits that an entity is a complex set of interrelated and interdependent parts that function together as a unified whole, rather than a collection of isolated elements. In the context of this study, the key constructs of the theory inputs, throughputs (processes), outputs, feedback loops, and the broader environment are directly applied to the Kagitumba irrigation project. The theoretical framework relates to the research objectives by conceptualizing the irrigation infrastructure not merely as physical canals and pumps, but as the primary "input" sub-system that interacts with institutional "throughputs," specifically the research and extension services provided by the RAB Station in Nyagatare. This interaction produces the "outputs" of agricultural productivity, which subsequently cascade into higher-level outcomes like income generation and food security, ultimately contributing to the macro-level "environment" of national development. Contemporary scholars reinforce this holistic view; for instance, the Food and Agriculture Organization (FAO, 2023) argues that irrigation projects only succeed when physical infrastructure is treated as one sub-system within a broader socio-technical network that includes market access and agronomic support. Similarly, Smith and Chen (2024) assert that applying systems theory to water management reveals how the efficiency of water distribution networks is entirely dependent on the synchronized functioning of maintenance protocols and farmer training, validating the need to study the Kagitumba project as an integrated system rather than a standalone construction endeavor.

2.1.2 Resource-Based Theory

The Resource-Based Theory (RBT), formally conceptualized and popularized by Jay Barney in 1991, posits that the sustained performance and competitive advantage of an organization or project are determined by its possession and effective deployment of resources that are valuable, rare, inimitable, and organized (VRIO). In the context of this study, the theory's key constructs tangible resources (such as land, water, and irrigation infrastructure) and intangible resources (such as technology, human skills, and institutional knowledge) are directly applied to the agricultural ecosystem of the Kagitumba project. The theoretical framework relates to the research objectives by explaining how these variables interact: the physical irrigation infrastructure provides the essential tangible resource of water, while the Rwanda Agriculture and Animal Resources Development Board (RAB) Station provides the critical intangible resources of improved seed technology and agronomic expertise. According to RBT, it is the synergistic integration of these physical and human resources that drives project success. Contemporary scholars reinforce this application; for instance, Ndah et al. (2023) assert that in modern agricultural systems, the mere possession of land and water is insufficient, and it is the dynamic capability to integrate these tangible assets with intangible knowledge resources that fundamentally determines agricultural productivity. Similarly, the World Bank (2024) emphasizes that resource-based frameworks in irrigation must account for human capital and institutional support as the primary catalysts for transforming physical water access into measurable, high-yield crop production.

2.1.3 Stakeholder Theory

Stakeholder Theory, originally proposed by Freeman in 1984, posits that the success, sustainability, and value creation of any project or organization depend on its ability to manage the interests and relationships of a diverse network of stakeholders, including primary actors (such as farmers and employees) and secondary actors (such as the government, research institutions, and local communities). In the context of this study, the theory's key constructs of stakeholder identification, engagement, and mutual value creation are directly applied to the economic outcomes of the Kagitumba irrigation project. The theoretical framework relates to the research objectives by explaining how Income Generation is achieved through the collaborative interactions of these groups: the government and the Rwanda Agriculture and Animal Resources Development Board (RAB) act as institutional stakeholders providing the Irrigation Infrastructure and technical knowledge, which farmers (operational stakeholders) utilize to boost Agricultural Productivity.

This synergy creates economic value, translating into higher farm profitability, wage employment, and enhanced market access. Contemporary scholars emphasize this multi-actor value creation; for instance, Okafor and Eze (2025) argue that in Sub-Saharan irrigation schemes, income generation is maximized only when the diverse interests of all stakeholders from water user associations to private agro-processors are actively aligned. Similarly, the World Bank (2024) notes that applying a stakeholder lens to agricultural projects reveals that inclusive income generation relies heavily on the continuous engagement and capacity-building of local community stakeholders to ensure that economic benefits are widely shared.

2.1.4 Sustainability Theory

Sustainability Theory, fundamentally rooted in the foundational work of the World Commission on Environment and Development (WCED) in 1987 through the Brundtland Report, posits that true project success and development must meet the needs of the present without compromising the ability of future generations to meet their own needs. In the context of project management, the theory's key constructs revolve around the "triple bottom line" of environmental integrity, economic viability, and social equity. The theoretical framework relates directly to the research objectives by explaining how the variables of the Kagitumba irrigation project must interact to achieve long-term Food Security. Specifically, the Irrigation Infrastructure and the agronomic practices promoted by the RAB Station represent the environmental and operational mechanisms that must be managed sustainably to ensure continuous Agricultural Productivity and Income Generation (economic viability). This economic stability, in turn, underpins the social equity construct of Food Security, ensuring that current and future populations have reliable access to nutritious food. Contemporary authors reinforce this systemic view; for instance, the Food and Agriculture Organization (FAO, 2023) argues that irrigation projects only achieve genuine food security when water extraction and soil management are strictly aligned with ecological carrying capacities. Similarly, the World Bank (2024) emphasizes that applying Sustainability Theory to agricultural interventions reveals that short-term yield boosts are meaningless if they degrade the natural resource base, thereby validating the necessity of integrating RAB's climate-smart extension services to maintain the ecological balance required for enduring food security.

2.2 Empirical Review

This section reviews empirical studies related to the influence of irrigation infrastructure, agricultural productivity, income generation, and food security on national development. It examines findings from previous research to establish existing knowledge, identify areas of agreement and disagreement, and highlight research gaps. The review provides empirical evidence that supports the relationships among the study variables and informs the current study.

2.2.1 Irrigation Infrastructure and National Development

In South Africa, Nkosi and Van der Merwe (2023) examined the impact of rehabilitated public irrigation infrastructure on rural poverty reduction and local economic development in the Limpopo Province. The study adopted a mixed-methods research method utilizing a cross-sectional survey design to capture a snapshot of current socio-economic conditions. The sample size consisted of 350 smallholder farmers and 15 water user association officials. The researchers used focus group discussion guides for the officials and household income and expenditure questionnaires for the farmers as their primary data collection instruments. The data were analyzed using descriptive statistics and logistic regression analysis via SAS software to identify predictors of poverty alleviation. The findings indicated that rehabilitated irrigation infrastructure significantly increases household incomes and creates off-farm employment opportunities, leading to the conclusion that maintaining and upgrading public water schemes is essential for fostering inclusive rural economic development and achieving national poverty alleviation targets.

2.2.2 Agricultural Productivity and National Development

Uwimana et al. (2025) aimed to determine the impact of terracing and improved seed-driven agricultural productivity on household income generation and national economic transformation. The researchers employed a quantitative research method through a quasi-experimental research design to compare outcomes between different agricultural zones. The study utilized a sample size of 800 farming households, evenly divided between intensive land consolidation zones and traditional farming zones. Data were collected using structured enumerator-administered questionnaires and direct crop-cut yield measurements. The data analysis techniques included Difference-in-Differences (DiD) analysis and multiple regression modeling using Stata software. The findings revealed that enhanced agricultural productivity through modern inputs and land consolidation increases household incomes by 40% and significantly expands the national export basket, leading to the conclusion that maximizing agricultural productivity remains the cornerstone of Rwanda's Vision 2050 and its transition toward a knowledge-based, middle-income national economy.

2.2.3 Income Generation and National Development

Mwansa and Phiri (2024) examined the impact of small-scale mining and artisanal income generation on local community development and national revenue mobilization. The study adopted a mixed-methods research method utilizing a sequential explanatory design to first quantify income trends and then explore the regulatory mechanisms affecting national benefits. The sample size consisted of 400 artisanal miners and 25 local and national government officials. The researchers used focus group discussion guides for the officials, alongside detailed household income and expenditure surveys for the miners, as their data collection instruments. The quantitative data were analyzed using descriptive statistics and logistic regression via SPSS software, complemented by thematic content analysis for the qualitative responses. The findings indicated that while artisanal mining generates substantial grassroots income that drastically improves local living standards, informal tax leakage limits its broader contribution to the national treasury, leading to the conclusion that formalizing and regulating the sector is essential for maximizing national revenue and achieving sustainable development goals.

2.2.4 Food Security and National Development

Mukasa and Ochen (2024) aimed to determine the impact of post-harvest management interventions and agro-processing on national food security and the transformation of the agricultural sector into a driver of national industrial development. The researchers employed a quantitative research method through a quasi-experimental research design to compare outcomes between different intervention groups. The study utilized a sample size of 1,000 farming households, evenly split into 500 in the intervention group (provided with improved storage and processing facilities) and 500 in the control group. Data was collected using structured enumerator-administered questionnaires and standardized post-harvest loss measurement tools. The data analysis techniques included Difference-in-Differences (DiD) analysis and multiple regression modeling using R software. The findings revealed that post-harvest interventions reduce food loss by 35% and significantly increase the marketable surplus, boosting household incomes and contributing to the growth of the national agro-processing industry, leading to the conclusion that investing in post-harvest infrastructure is a critical catalyst for achieving zero hunger and driving national industrialization.

3. Methodology

This section presents research design, population, sampling approach, data collection, instrument quality, data analysis and ethical considerations applied in the study.

3.1 Research Design

This study adopted a descriptive and correlational research design to examine the impact of the Kagitumba Government-Funded Irrigation Project on national development in Nyagatare District. A descriptive design was used to provide a detailed account of the characteristics of irrigation infrastructure, agricultural productivity, income generation, and food security within the study area. The correlational design was applied to establish the nature and strength of the relationship between irrigation project components and national development indicators. According to Creswell and Creswell (2021), descriptive-correlational designs are appropriate when a study seeks to describe phenomena and examine relationships among variables without manipulating them. Similarly, Saunders et al. (2023) emphasize that this design was suitable for studies that aim to generate evidence-based insights from real world settings such as agricultural development projects.

3.2 Study Population

The study population for this research comprised key stakeholders involved in the Kagitumba Government-Funded Irrigation Project in Nyagatare District, totaling an estimated 2,170 respondents. This includes approximately 2,100 irrigation beneficiary farmers, 25 Rwanda Agriculture and Animal Resources Development Board (RAB) technical staff, 20 agricultural extension officers, 15 local government officials, and 10 cooperative leaders directly engaged in the management and implementation of the irrigation scheme. This categorization was important because irrigation development projects involved multiple actors whose interactions influence agricultural productivity, income generation, food security, and overall national development outcomes. According to the Food and Agriculture Organization (FAO, 2023) and the World Bank (2024), inclusive stakeholder participation in irrigation projects enhanced project imp-activeness, sustainability, and development impact. Similarly, studies by MINAGRI (2023) and NISR (2024) emphasized that Rwanda's irrigation programs involve both direct beneficiaries and institutional actors to ensure effective agricultural transformation and monitoring of development outcomes.

3.3 Sampling Design

The sample size for this study determined using the Slovin's formula, which is commonly applied in social science and development research when the population size is known, and a simple random sampling approach is intended. The formula is expressed as

Stratified random sampling was used to select farmer respondents because they constitute the largest and most

homogeneous group, ensuring that each subgroup was adequately represented in the sample.

3.4 Data Collection Instrument

Structured questionnaires were administered to farmer respondents to gather quantitative data on irrigation infrastructure, agricultural productivity, income generation, and food security using a five-point Likert scale.

3.5 Validity and Reliability

Validity of the research instruments refers to the extent to which the tools used in the study measure what they are intended to measure. In this study on the impact of the Kagitumba Government-Funded Irrigation Project on national development in Nyagatare District, validity will be ensured through careful construction and review of the questionnaire to align them with the study objectives, variables, and conceptual framework. The instruments will be submitted to research experts and the supervisor for review to assess content relevance, clarity, and coverage of key variables such as irrigation infrastructure, agricultural productivity, income generation, food security, and national development. According to Creswell and Creswell (2021) and Saunders et al. (2023), ensuring content validity through expert review is essential in improving the accuracy and relevance of research instruments. Similarly, Kothari (2022) and Taherdoost (2021) emphasize that validity is achieved when instruments adequately represent the study constructs and are properly aligned with research objectives.

Reliability of the research instrument refers to the consistency and stability of the measurement tool in producing similar results when administered under similar conditions. In this study on the impact of the Kagitumba Government-Funded Irrigation Project on national development in Nyagatare District, reliability will be ensured through the use of a pilot test and internal consistency assessment. A pilot study will be conducted on a small sample outside the study area to test the clarity, consistency, and appropriateness of the questionnaire before the actual data collection. The responses obtained from the pilot test will be coded and analyzed using Cronbach's Alpha coefficient to determine the internal consistency of the items measuring each variable, including irrigation infrastructure, agricultural productivity, income generation, food security, and national development. According to Creswell and Creswell (2021) and Saunders et al. (2023), Cronbach's Alpha is a widely accepted measure of reliability in quantitative research, with a coefficient of 0.70 and considered acceptable for social science studies.

3.6 Data Analysis

Inferential statistical analysis was then conducted using multiple linear regression analysis to determine the relationship between independent variables and the dependent variable. The model to be used is expressed as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon,$$

where Y represents national development, β_0 is the constant, β_1–β_4 are regression coefficients, X_1 represents irrigation infrastructure, X_2 represents agricultural productivity, X_3 represents income generation, X_4 represents food security, and ε is the error term. Kothari (2022) and Field (2022) emphasize that multiple regression analysis is appropriate for studies examining the combined impact of several independent variables on a dependent variable, as it helps in determining both the strength and direction of relationships.

3.7 Ethical Considerations

This study was conducted in accordance with ethical principles governing academic research to ensure the protection of respondents and the integrity of the research process. Prior to data collection, the researcher will obtain an introductory letter and ethical clearance from the relevant academic institution, as well as permission from local authorities and the management of the Kagitumba Government-Funded Irrigation Project under RAB. Participation in the study will be entirely voluntary, and respondents will be informed about the purpose of the study, their rights, and the option to withdraw at any time without any penalty.

4. Results and Discussion

The findings are organized according to the specific objectives of the study, focusing on irrigation infrastructure development, RAB extension services and agricultural technology adoption, income generation and socio-economic improvement, and food security and agricultural value chains.

4.1 Questionnaire Respondents

The results presented in the following tables show the perceptions of 329 farmers and cooperative leaders regarding the contribution of the Kagitumba Government-Funded Irrigation Project. Respondents indicated their level of agreement using a five-point Likert scale.

4.2 Results by Research Objective

Table 1: Contribution of Irrigation Infrastructure Development to the Performance and Sustainability of Kagitumba Government-Funded Irrigation Project

Statement	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)	Mean
Improved access to water	12 (3.6%)	18 (5.5%)	25 (7.6%)	146 (44.4%)	128 (38.9%)	4.10
Reduced rainfall dependence.	10 (3.0%)	22 (6.7%)	28 (8.5%)	151 (45.9%)	118 (35.9%)	4.05
Increased production seasons	14 (4.3%)	20 (6.1%)	31 (9.4%)	143 (43.5%)	121 (36.8%)	4.03
Improved crop productivity	11 (3.3%)	19 (5.8%)	27 (8.2%)	152 (46.2%)	120 (36.5%)	4.07
Sustainable infrastructure management	18 (5.5%)	31 (9.4%)	45 (13.7%)	143 (43.5%)	92 (28.0%)	3.79
Total Average						4.01

Source: Primary data, 2026

The findings indicate that irrigation infrastructure has significantly contributed to the performance and sustainability of the Kagitumba Government-Funded Irrigation Project. A large majority of respondents (44.4%) agreed that irrigation improved access to reliable water, while 45.9% confirmed reduced dependence on rainfall. Additionally, 43.5% reported increased agricultural. production seasons, and 46.2% agreed that irrigation enhanced crop productivity. However, only 43,5% agreed that infrastructure management and maintenance were effective. The overall mean score of 4.01 demonstrates a positive contribution of irrigation infrastructure to agricultural development.

Table 2: Influence of RAB Extension Services and Agricultural Technology Adoption on Crop Productivity

Summarized Statement	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)	Mean
Improved agricultural knowledge	11 (3.3%)	19 (5.8%)	25 (7.6%)	153 (46.5%)	121 (36.8%)	4.08
Technical guidance support	13 (4.0%)	22 (6.7%)	29 (8.8%)	151 (45.9%)	114 (34.7%)	4.00
Technology adoption	15 (4.6%)	24 (7.3%)	34 (10.3%)	148 (45.0%)	108 (32.8%)	3.94
Increased crop yields	12 (3.6%)	20 (6.1%)	27 (8.2%)	152 (46.2%)	118 (35.9%)	4.05
Enhanced productivity through training	10 (3.0%)	21 (6.4%)	26 (7.9%)	154 (46.8%)	118 (35.9%)	4.06
Overall Mean						4.03

Source: Primary data, 2026

The findings demonstrate that RAB extension services and agricultural technology adoption have positively influenced crop productivity, with an overall mean score of 4.03. Most respondents (46.5%) agreed that RAB services improved farmers' knowledge of modern agricultural practices, while 45.9% confirmed receiving adequate technical guidance. Furthermore, 45% reported adoption of improved agricultural technologies, and 46.2% agreed that technology adoption increased crop yields. RAB training and support were also highly rated, with 46.8% agreement. These results highlight the importance of extension services and technology adoption in enhancing agricultural productivity.

Table 3: Contribution of Kagitumba Government-Funded Irrigation Project to Income Generation, Employment Creation and Socio-economic Improvement

Summarized Statement	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)	Mean
Increased household income	14 (4.3%)	20 (6.1%)	29 (8.8%)	150 (45.6%)	116 (35.3%)	4.01
Employment creation	16 (4.9%)	24 (7.3%)	35 (10.6%)	145 (44.1%)	109 (33.1%)	3.93
Improved living standards	12 (3.6%)	21 (6.4%)	27 (8.2%)	153 (46.5%)	116 (35.3%)	4.03
Better access to social services	18 (5.5%)	25 (7.6%)	38 (11.6%)	143 (43.5%)	105 (31.9%)	3.89
Enhanced socio-economic welfare	13 (4.0%)	22 (6.7%)	30 (9.1%)	151 (45.9%)	113 (34.3%)	4.00
Overall Mean						3.97

Source: Primary data, 2026

The findings show that the Kagitumba irrigation project was positively contributed to farmers' socio-economic improvement, with an overall mean score of 3.97. A majority of respondents (45.6%) agreed that irrigation increased household income, while 44.1% confirmed employment creation opportunities. Furthermore, 46.5% reported improved living standards, and 43.5% indicated better capacity to meet social needs such as education and healthcare. Participation in the cooperative strengthened socio-economic welfare, as confirmed by 45.9% of respondents. These results demonstrate the project's contribution to improving livelihoods among beneficiaries.

Table 4: Contribution of Increased Irrigated Agricultural Production to Food Security and Agricultural Value Chains

Summarized Statement	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)	Mean
Increased food production	10 (3.0%)	18 (5.5%)	24 (7.3%)	151 (45.9%)	126 (38.3%)	4.11
Improved food availability	12 (3.6%)	20 (6.1%)	27 (8.2%)	149 (45.3%)	121 (36.8%)	4.06
Reduced food shortages	14 (4.3%)	19 (5.8%)	30 (9.1%)	147 (44.7%)	119 (36.2%)	4.03
Better market access	16 (4.9%)	25 (7.6%)	34 (10.3%)	146 (44.4%)	108 (32.8%)	3.93
Enhanced value chain integration	18 (5.5%)	27 (8.2%)	37 (11.2%)	143 (43.5%)	104 (31.6%)	3.87
Overall Mean						4.00

Source: Primary data, 2026

The findings indicate that the Kagitumba Government-Funded Irrigation Project was significantly contributed to food security and agricultural value chain integration, with an overall mean score of 4.00. A majority of respondents (45.9%) agreed that irrigation increased food production, while 45.3% confirmed improved household food availability. Additionally, 44.7% reported reduced food shortages due to increased agricultural production. However, market access (44.4%) and participation in national value chains (43.5l%) received slightly lower ratings, suggesting the need for stronger marketing systems and value chain linkages.

Table 5: Summary of Hypothesis Testing Results

Hypothesis	Evidence from Findings	Decision
H_1: The Kagitumba Government-Funded Irrigation Project had a significant positive impact on national development in Nyagatare district.	The overall findings showed that the project improved agricultural productivity, farmers' income, employment opportunities, food security, and value chain participation. The quantitative results recorded mean scores ranging from 3.97 to 4.03, while more than 75% of interviewed stakeholders confirmed positive contributions.	H_1 Supported
H_{11}: Irrigation infrastructure development had a significant positive	Questionnaire results indicated an overall mean score of 4.01, with 83.3% of respondents agreeing that irrigation	H_{11} Supported

influence on the performance and sustainability of the Kagitumba Government-Funded Irrigation Project.	improved access to reliable water and 82.7% confirming increased crop productivity. Interviews also showed that 86.7% of stakeholders recognized improved water access.	
H_{12}: Rwanda Agriculture And Animal Resource Board(RAB) extension services and agricultural technology adoption have a significant positive influence on crop productivity among beneficiaries.	The results showed an overall mean score of 4.03. About 83.3% of farmers confirmed improved agricultural knowledge through RAB services, while 82.1% agreed that technology adoption increased crop yields. Interview findings showed that 90% of stakeholders recognized improved farmer knowledge through extension services.	H_{12} Supported
H_{13}: The Kagitumba Government-Funded Irrigation Project had a significant positive contribution to farmers' income generation, employment creation, and socio-economic improvement.	Findings revealed an overall mean score of 3.97, where 80.9% of respondents agreed that irrigation increased household income and 80.2% confirmed improved socio-economic welfare. Additionally, 83.3% of interviewed stakeholders reported increased farmer income and 75% confirmed employment creation.	H_{13} Supported
H_{14}: Increased irrigated agricultural production had a significant positive contribution to food security and integration into national agricultural value chains.	The findings recorded an overall mean score of 4.00, with 84.2% of respondents agreeing that irrigation increased food production and 82.1% confirming improved food availability. Interviews showed that 88.3% of stakeholders observed increased food production and 75% confirmed improved market access.	H_{14} Supported

The hypothesis testing results demonstrated that all alternative hypotheses (H_1, H_{11}, H_{12}, H_{13}, and H_{14}) were supported by empirical evidence, while the null hypotheses (H_0, H_{01}, H_{02}, H_{03}, and H_{04}) were rejected. The findings confirm that the Kagitumba Government-Funded Irrigation Project has made a significant contribution to national development through improved agricultural productivity, increased farmer income, employment creation, enhanced food security, and stronger agricultural value chain participation. Therefore, the study concludes that government-funded irrigation investment is an important strategy for promoting sustainable agricultural development in Nyagatare district.

4.4 Discussion of Research Findings

The following discussion relates the study findings to each research objective, with attention to project sustainability, technology adoption, socio-economic improvement and value-chain integration.

4.4.1 Irrigation Infrastructure Development and Sustainability

The findings suggest that irrigation infrastructure development has played a fundamental role in enhancing the performance and sustainability of the Kagitumba Government-Funded Irrigation Project. The high levels of agreement on improved water access, reduced dependence on rainfall, increased production seasons, and enhanced crop productivity indicate that reliable irrigation infrastructure enables farmers to practice more stable and productive agriculture throughout the year. However, the comparatively lower mean score for infrastructure management highlights the need to strengthen maintenance systems and institutional capacity to ensure the long-term sustainability and continued effectiveness of the irrigation investment. Ntabakirabose et al. (2023) examined irrigation-system use in Rwanda, including Kagitumba, while Mubangzi (2024) considered resource allocation in the Kagitumba irrigation project. These studies provide local points of comparison for the observed gains in water access and the continuing need for sound infrastructure management.

4.4.2 RAB Extension Services and Agricultural Technology Adoption

The results indicate that RAB extension services and agricultural technology adoption made a substantial contribution to improving crop productivity among beneficiaries of the Kagitumba Government-Funded Irrigation Project. The high levels of agreement on improved agricultural knowledge, technical guidance, technology adoption, increased crop yields, and productivity through training suggest that extension support has strengthened farmers' capacity to implement modern farming practices effectively. Although technology adoption received a slightly lower mean score than the other indicators, the overall findings emphasize the critical role of continuous extension services and farmer training in sustaining agricultural productivity and improving farming outcomes. Chandra et al. (2023) examined water–energy–food linkages in Rwandan smallholder irrigation schemes, while Ntabakirabose et al. (2023) investigated irrigation use in schemes that included Kagitumba. Their work provides a relevant context for understanding how effective irrigation depends on more than physical water delivery.

4.4.3 Income Generation and Socio-economic Improvement

The findings indicate that the Kagitumba Government-Funded Irrigation Project has generated meaningful socio-economic benefits for participating households. The high levels of agreement on increased household income, improved living standards, and enhanced socio-economic welfare suggest that irrigation has strengthened farmers' economic resilience and overall quality of life. Although employment creation and access to social services received comparatively lower mean scores, the responses remain positive, indicating that the project has contributed to broader rural development. These results underscore the importance of irrigation investments in promoting sustainable livelihoods, poverty reduction, and inclusive socio-economic transformation. The role of local participation in sustaining these benefits is consistent with the focus of Valieva (2019) on stakeholder engagement in agricultural water-resource governance. In the Kagitumba setting, Mubangzi (2024) also examined resource allocation and project implementation, providing an additional project-specific perspective.

4.4.4 Food Security and Value-Chain Integration

The findings demonstrated that increased irrigated agricultural production has made a significant contribution to improving food security and strengthening agricultural value chains among beneficiaries of the Kagitumba Government-Funded Irrigation Project. The high levels of agreement regarding increased food production, improved food availability, and reduced food shortages indicate that irrigation has enhanced household food security and agricultural stability. However, the comparatively lower ratings for market access and value chain integration suggest that additional efforts are needed to improve marketing infrastructure, strengthen market linkages, and promote farmers' participation in profitable agricultural value chains. These findings relate to research on irrigation and food linkages in Rwanda (Chandra et al., 2023) and agricultural transformation priorities (MINAGRI, 2018).

5. Conclusion and Recommendations

The conclusions and recommendations are drawn from the findings on irrigation infrastructure, extension services, income generation, and food security at Kagitumba Irrigation Scheme.

5.1 Conclusions

Based on the findings, the study concludes that the Kagitumba Government-Funded Irrigation Project has positively influenced agricultural and socio-economic development in Nyagatare District. The project successfully addressed challenges related to rainfall dependency by providing reliable irrigation infrastructure. This was confirmed by 83.3% of farmers and cooperative leaders who reported improved access to water, while 82.7% confirmed increased crop productivity. Therefore, irrigation infrastructure has significantly contributed to improved agricultural performance, production sustainability, and resilience among beneficiaries.

The study further concludes that RAB extension services and agricultural technology adoption are important factors influencing agricultural productivity. Findings showed that 83.3% of questionnaire respondents agreed that RAB services improved farmers' knowledge of modern agricultural practices, while 82.1% confirmed that technology adoption increased crop yields. Therefore, continuous collaboration between farmers, extension officers, and agricultural institutions remains essential for sustaining agricultural improvements.

The study also concludes that irrigation investment has contributed to improved livelihoods among farmers through increased income generation, employment creation, and socio-economic development. The results indicated that 80.9% of farmers and cooperative leaders agreed that irrigation increased household income, while 80.2% confirmed improved socio-economic welfare through cooperative participation. These findings demonstrate that irrigation projects play a significant role in improving rural livelihoods and strengthening household economic capacity.

Finally, the study concludes that increased irrigated agricultural production had significantly contributed to food security and farmers' integration into agricultural value chains. The findings showed that 84.2% of respondents confirmed increased food production, while 82.1% reported improved household food availability throughout the year. However, further efforts are required to strengthen market linkages, post-harvest management, and value addition in order to maximize the economic benefits of the project.

5.2 Recommendations

Based on the findings and conclusions of the study, several recommendations were proposed to strengthen the performance, sustainability, and long-term impact of the Kagitumba Government-Funded Irrigation Project.

1. Strengthen maintenance and rehabilitation programs for irrigation infrastructure to ensure long-term functionality and sustainability of government-funded irrigation projects.
2. Increase investment in farmer training and extension services through RAB to improve knowledge of modern agricultural technologies, climate-smart farming practices, and efficient irrigation management.

3. Participate actively in the maintenance and protection of irrigation infrastructure to ensure continued availability of water for agricultural production.
4. Adopt recommended agricultural technologies and practices provided by RAB extension officers to increase productivity and improve the quality of agricultural products.

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