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Effects of Forest Landscape Restoration Initiatives on the Socio-Economic Development of Smallholder Farmers in Rwanda: A Case of Bweyeye Sector, Rwanda

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Abstract

This study investigated the effects of Forest Landscape Restoration (FLR) initiatives on the socio-economic development of smallholder farmers in Bweyeye Sector, Rusizi District, Rwanda. While FLR efforts aim to restore degraded landscapes, conserve biodiversity, and support rural livelihoods, their socio-economic impacts remain unclear, particularly for small-scale farmers. The study had three specific objectives: (1) to evaluate FLR by mapping forestland cover change from 2003 to 2023 using Geographic Information System (GIS) tools; (2) to assess the effects of FLR using descriptive statistics from a survey of 332 smallholder farmers across five cells in Bweyeye; and (3) to analyze the relationship between FLR and socio-economic development using correlation and regression analysis. GIS results showed a significant forestland cover loss of 45.73 square kilometers over the 20-year period, mainly due to agricultural expansion and infrastructure development, despite high community participation in FLR activities. Descriptive findings indicated improved socio-economic conditions among FLR participants, notably in income, food security, education, and healthcare access. Correlation analysis confirmed a strong positive relationship between FLR initiatives and socio-economic development. The study recommends that policymakers implement balanced land-use strategies and that the Rwanda Forestry Authority strengthens monitoring systems to track tree survival and land cover changes. Future research should explore long-term FLR impacts on job creation and housing.

Key words: *Forest Landscape Restoration, Socio-Economic Development, GIS Analysis, Agroforestry, Bweyeye sector, Rwanda*

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1. Introduction

Forest Landscape Restoration initiatives, particularly in rural areas such as Bweyeye sector of Rusizi district in Rwanda, are designed to significantly enhance the socio-economic development of smallholder farmers. The independent variables, include activities like reforestation, afforestation, agroforestry, and soil and water conservation practices that aim to restore degraded forestland. The dependent variable, the socio-economic development of smallholder farmers, encompasses factors such as income levels, food security, access to health and education services. Ideally, these restoration efforts would lead to increased agricultural productivity, enhanced biodiversity, improved soil fertility, and create the employment opportunities thus, improved livelihoods for smallholder farmers (Dave, application of the Barometer in 2018.).

However, while the ecological benefits of Forest Landscape Restoration are recognized and documented, the problem is about its potential socio-economic development on smallholder farmers, particularly their income levels, food security, access to health and Education. While national policies promote FLR, research on its actual socio-economic development on smallholder farmers in Rwanda remains scarce. Studies often lack a nuanced understanding of local contexts, hindering informed decision-making (Djenontin, I. N. S., Foli, S., & Zulu, L. C., 2018) . This inconsistency between the potential benefits of Forest Landscape Restoration initiatives and the actual situation faced by smallholder farmers in Bweyeye underscores a significant gap that needs to be addressed to fully document the socio-economic benefits of FLR initiatives.

Neglecting to address these challenges and effectively implement FLR initiatives in the Bweyeye sector could lead to several negative consequences. Firstly, the continued degradation of land could result in reduced agricultural productivity, worsening food insecurity and poverty among smallholder farmers. Secondly, the loss of biodiversity and ecosystem services, due to deforestation and land degradation, could have long-term environmental impacts, diminishing water quality, soil fertility, and climate regulation, further endangering the livelihoods of rural communities (Díaz et al., 2019). Lastly, without effective FLR initiatives, Rwanda may struggle to meet its commitments under international agreements such as the Paris Agreement (PA), Rwandese Nationally Determined Contributions (NDCs) and the AFR100 initiative, potentially affecting the country's international reputation and access to climate finance.

1.1 Research Objectives

1.1.1 General objective

The general objective of this study was to examine the effects of Forest Landscape Restoration initiatives on the socio-economic development of smallholder farmers in Bweyeye sector of Rusizi district, Rwanda, within the period 2003-2023.

1.1.2 Specific objectives

The specific objectives of this study are the following:

(i) To evaluate forest landscape restoration by mapping forestland cover change in Bweyeye sector from 2003 to 2023.
(ii) To analyze the relationship between forest landscape restoration and the socio-economic development of smallholder farmers in Bweyeye sector.

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2. Materials and methods

2.1 Profile of Rusizi District

Rusizi district is one of 30 districts of Rwanda and one of the seven districts comprising the western province of Rwanda. It has a total surface area of 940.95Km2 divided in 18 administrative sectors including Bweyeye Sector. Rusizi district borders with Nyamasheke district in the North, Nyamagabe and Nyaruguru districts in the East with a big part of Nyungwe National Park (NNP), in between. It shares international borders with Burundi in the South and Democratic Republic of Congo (DRC) in the West. The average temperature varies between 20 ° and 23 ° C and average annual rainfall amounts to 1,450 mm (Rusizi, 2018).

This study focuses on the Bweyeye sector, one of the 18 sectors of Rusizi district. Bweyeye sector is composed by 5 administrative cells which are: Gikungu, Kiyabo, Murwa, Nyamuzi and Rasano. This sector is located in the remote southwestern corner of Rusizi district, bordering Burundi. It is characterized by a mix of hills, valleys, and wetlands and is predominantly reliant on small-scale agriculture, which presents significant challenges for agriculture due to the steep slopes and the risk of soil erosion.

However, these conditions also offer unique opportunities for Forest Landscape Restoration initiatives, including reforestation, afforestation and agroforestry, which can help stabilize these areas and improve agricultural productivity. The remoteness of Bweyeye contributes to its relatively underdeveloped infrastructure and limited access to markets, which affects the socio-economic development of its smallholder farmers. Bweyeye sector has been identified as a critical zone for Forest Landscape Restoration initiatives due to its significant land degradation challenges (Rusizi, 2023).

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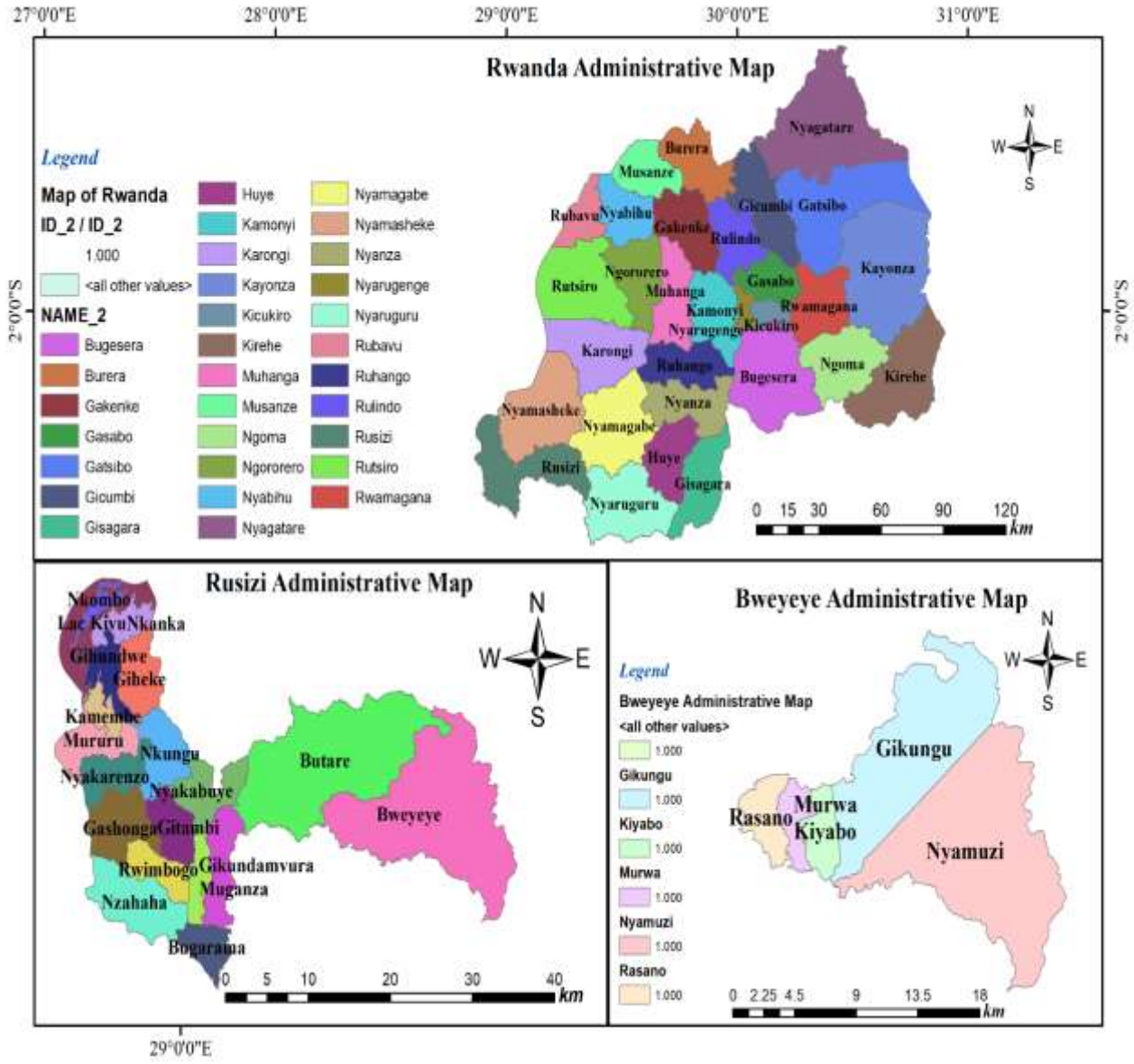

Figure 2:1. Map of the study area
Source: Primary Data, 2024

2.2 Research design and data collection methods

This study employed a quantitative research design to comprehensively assess the effects of Forest Landscape Restoration (FLR) initiatives on the socio-economic development of smallholder farmers in the Bweyeye Sector of Rusizi District over the period from 2003 to 2023. The research utilized both primary and secondary data sources, enabling a robust analysis of ecological and socio-economic changes over two decades.

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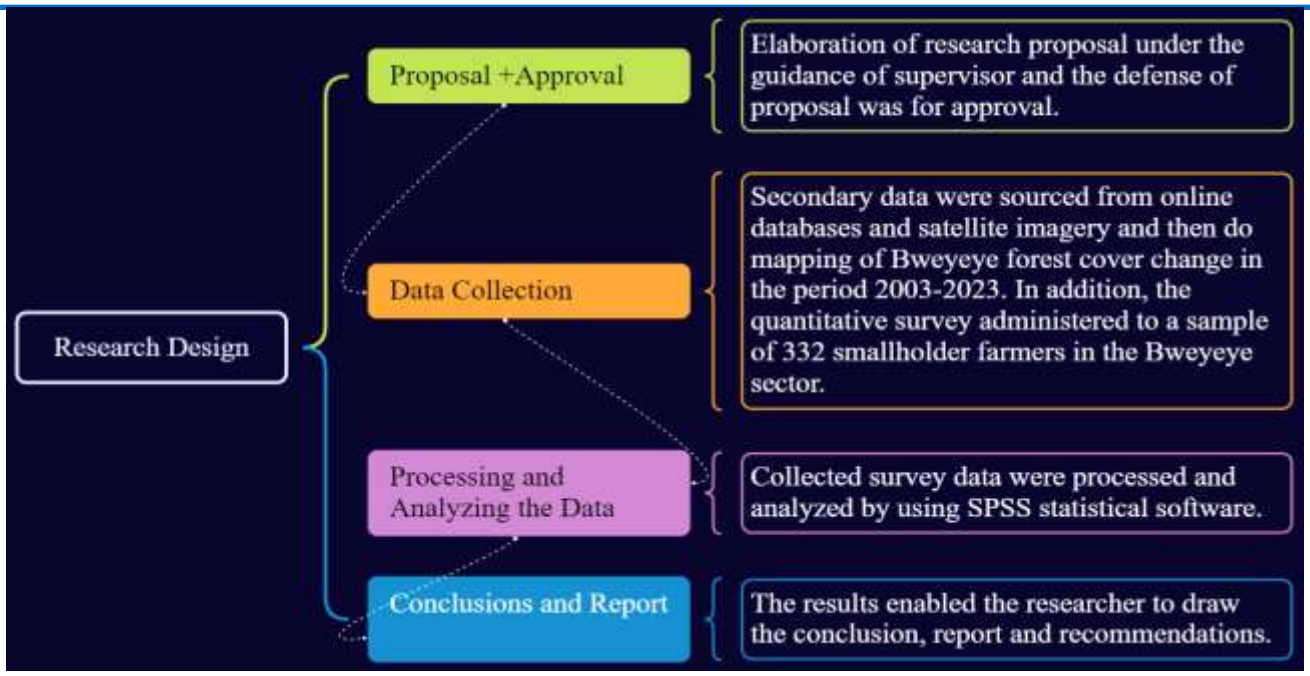

Figure 2.2: **Research Design**

Primary data were collected through a structured survey administered to a sample of 332 smallholder farmers. The sample size was determined using Yamane's formula, based on the population of 1,932 smallholder farmers in Bweyeye Sector. To ensure representativeness, a stratified sampling technique was used, dividing the population into five strata based on the sector's administrative cells: Gikungu, Kiyabo, Murwa, Nyamuzi, and Rasano. Within each stratum, simple random sampling was applied to select participants, thus allowing for an unbiased and accurate representation of the overall population.

Table 2:**1. Distribution of sample size in respective cells for quantitative data**

Total Population (N)	**Strata (Cells)**	**Proportionate Population (Ni)**	**Proportionate sampling**	**Sample size**
N=1,932	Gikungu,	330	$\frac{330 * 332}{1,932}$	=57
	Kiyabo	503	$\frac{503 * 332}{1,932}$	=87
	Murwa	228	$\frac{228 * 332}{1,932}$	=39
	Nyamuzi	334	$\frac{334 * 332}{1,932}$	=58
	Rasano	527	$\frac{527 * 332}{1,932}$	=91
Total		**1,932**		**=332**

Source: Rusizi District, 2024

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The main data collection instrument was a structured questionnaire using a five-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The questionnaire, initially developed in English, was translated into Kinyarwanda to ensure respondents' full understanding. It was administered by three trained local enumerators who had participated in a pilot testing phase to refine their understanding of the questions. The questionnaire gathered data on participation in FLR activities such as reforestation, afforestation, agroforestry, and soil and water conservation as well as key socio-economic indicators, including income levels, food security, and access to education and healthcare.

Secondary data were obtained from the United States Geological Survey (USGS) through the use of satellite imagery. ArcGIS software (ArcMap 10.8) was used to process the images and create land use and land cover maps for the years 2003, 2008, 2013, 2018, and 2023. The spatial analysis conducted using ArcGIS enabled the quantification and visualization of forestland changes over time. This process included downloading high-resolution satellite images, preprocessing them to correct distortions, generating maps for each year, and conducting spatial analysis to detect and interpret changes in forest cover.

The combination of field survey data and spatial analysis provided a comprehensive understanding of the ecological and socio-economic impacts of FLR initiatives in the Bweyeye Sector.

2.3 Illustration of research methodology

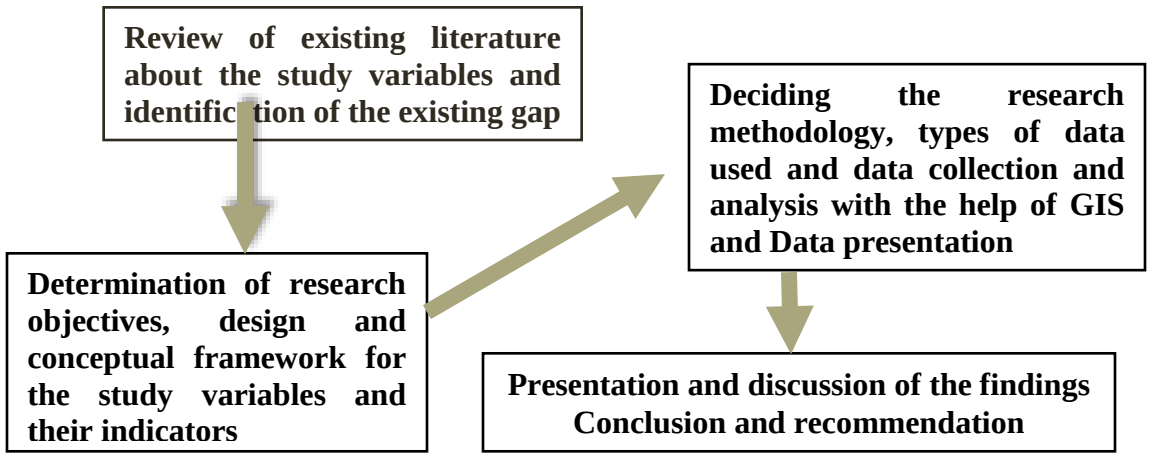

Figure 2.1: Methodology flowchart followed by the researcher

2.Data analysis

The data analysis phase was crucial for extracting meaningful insights aligned with the study's objectives. For the first objective, Geographic Information System (GIS) tools were used to generate and interpret Land Use Land Cover (LULC) maps for the years 2003 to 2023, highlighting temporal changes in forestland and related landscapes. For the second objective, descriptive statistics were computed using SPSS to summarize key socio-economic indicators such as income, food security, and access to education and healthcare. The third objective involved correlation analysis using Pearson's coefficient to examine the relationship between Forest Landscape Restoration (FLR) initiatives and socio-economic development. Finally, regression analysis was

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conducted to model the impact of specific FLR activities known as reforestation, afforestation, agroforestry, and soil and water conservation on socio-economic outcomes. This allowed the researcher to quantify the effects of each FLR component and determine which had the most significant influence on smallholder farmers' welfare in Bweyeye Sector.

3. Results

3.1 GIS Based Land Use Land Cover Analysis (2003–2023)

The GIS based Land Use and Land Cover (LULC) analysis highlights the changes in forestland, grassland, cropland, water bodies, and built-up areas over the two-decade period from 2003 to 2023. These changes are visually represented through the maps generated for the years 2003 (Figure 3:1), 2008 (Figure 3:2), 2013 (Figure 3:3), 2018(Figure 3:4), and 2023(Figure 3:5). The analysis focuses primarily on forestland changes, as this constitutes the central theme of this research. Gains and losses in forestland are critically examined to assess the effectiveness of Forest Landscape Restoration (FLR) initiatives and their contribution to addressing social-economic development of smallholder farmers in the Bweyeye Sector. After producing the five maps showing the visual change the researcher provided a statistical analysis of LULC change in Bweyeye (2003 - 2023) on the Table 3.1 and then provided also a figure that highlight the Gains and Losses for forestland, grassland, cropland, water bodies, and built-up of the Figure 3:6 Furthermore, after presenting all the data, the researcher has discussed and interpreted the results.

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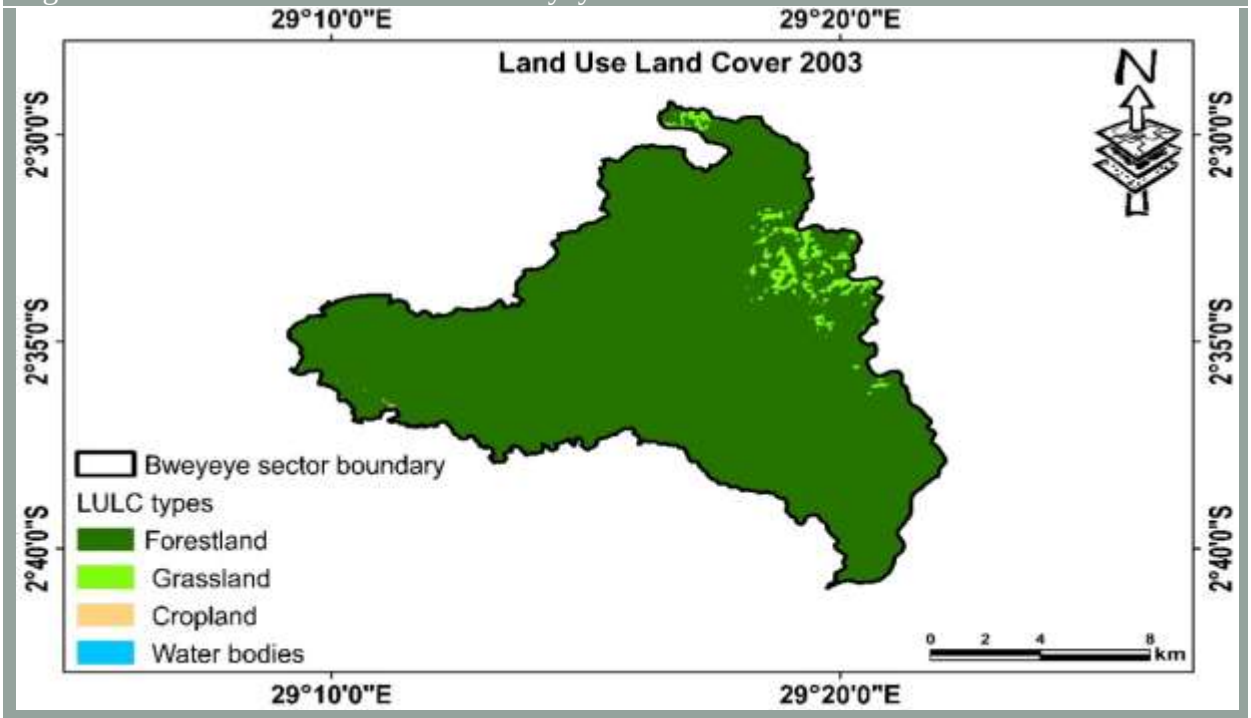
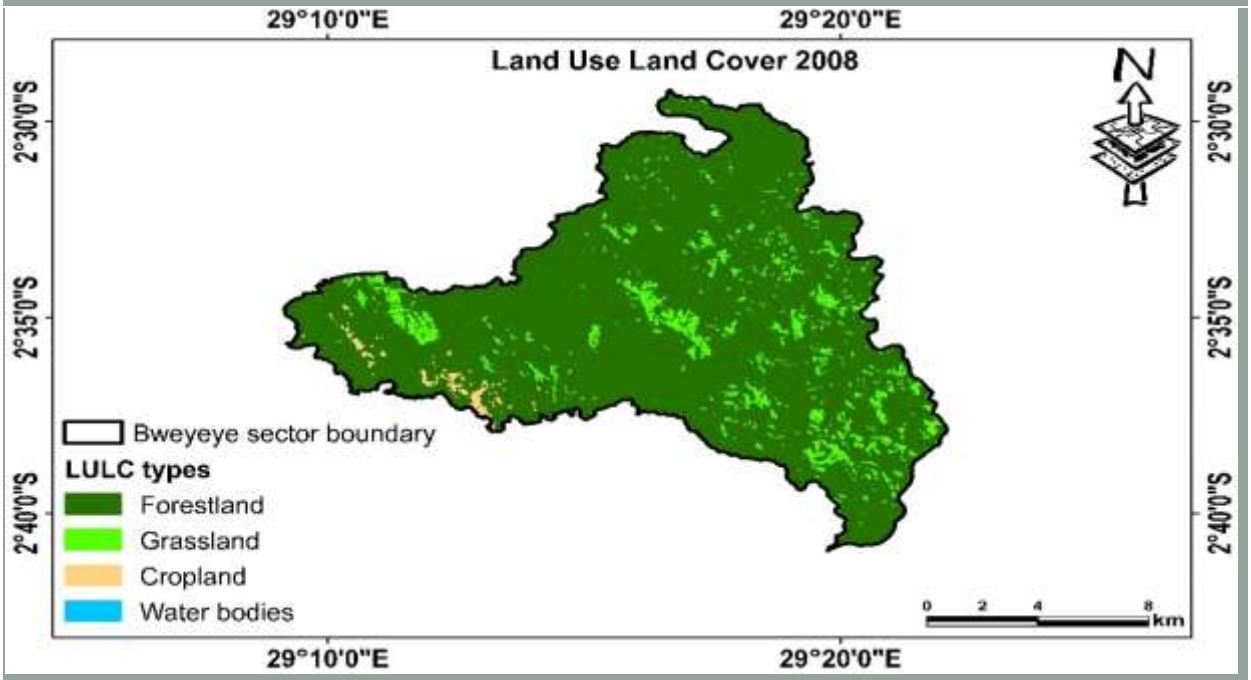
Figure 3:1. Land Use Land Cover in Bweyeye sector in 2003



Source: Primary Data, 2024

Figure 3:2. Land Use Land Cover in Bweyeye sector in 2008



Source: Primary Data, 2024

Figure3.3. Land Use Land Cover in Bweyeye sector in 2013

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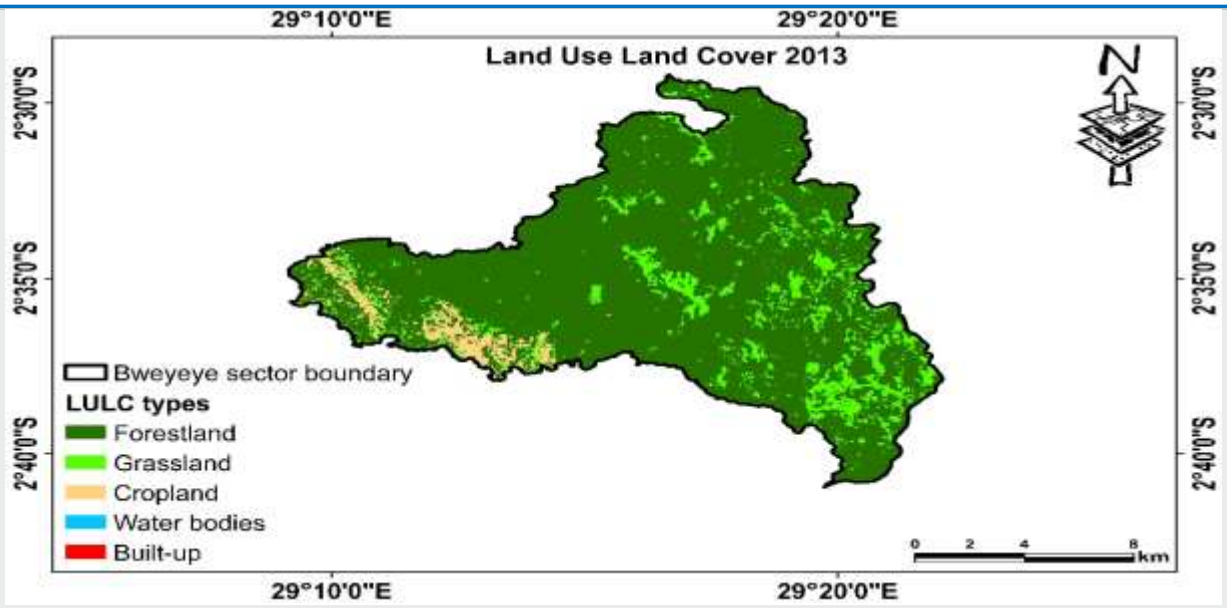
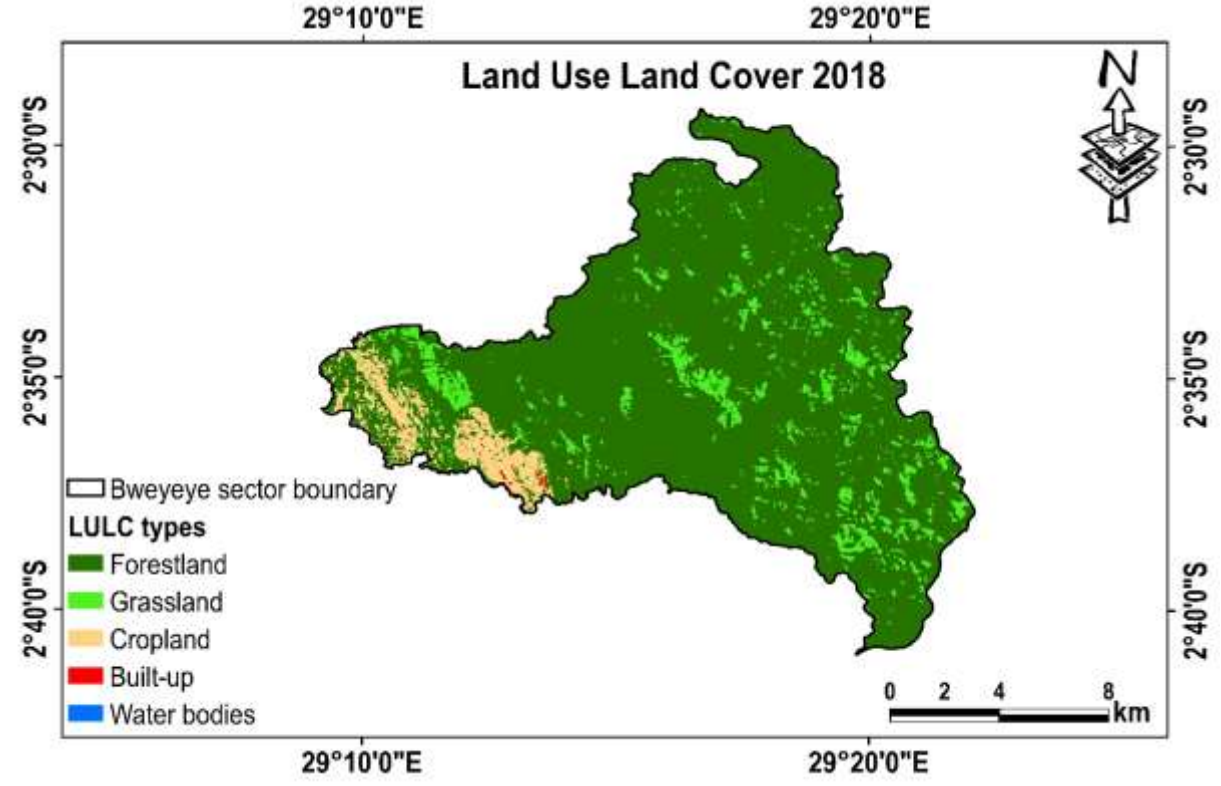


Source: Primary Data, 2024

Figure 3.4. Land Use Land Cover in Bweyeye sector in 2018



Source: Primary Data, 2024

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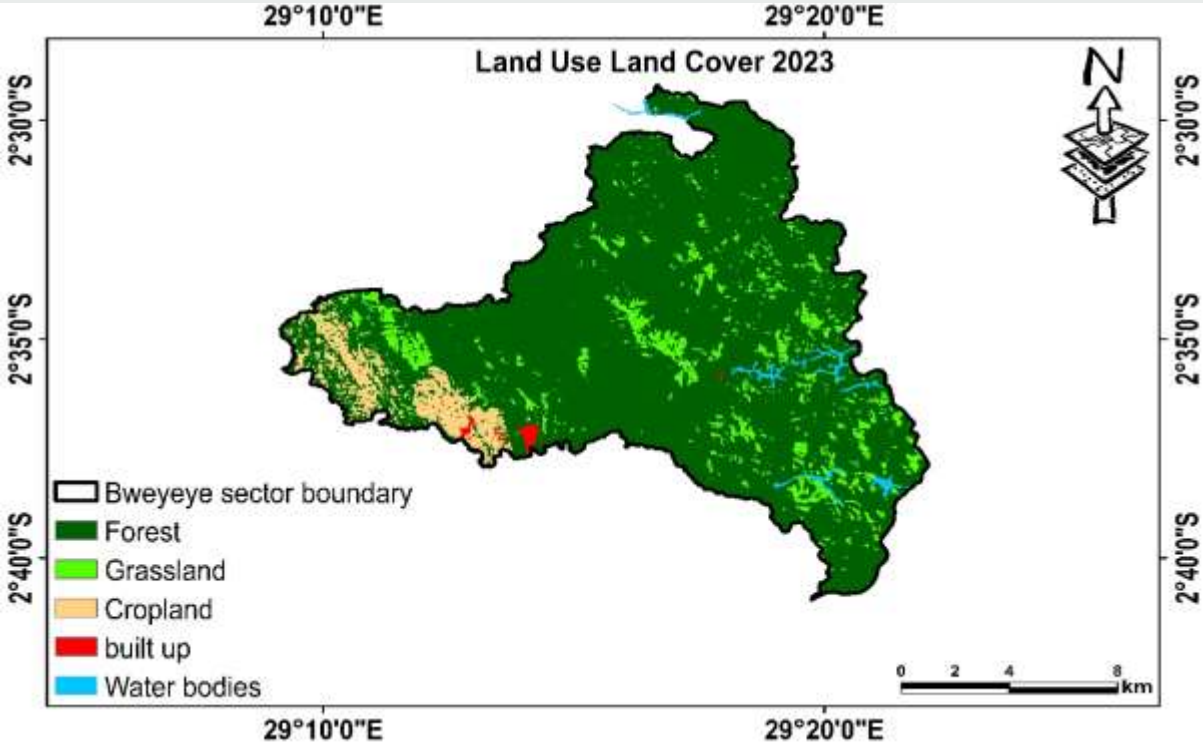
Figure 3.5: Land Use Land Cover in Bweyeye sector in 2023



Source: Primary Data, 2024

Table 3:1. Statistical analysis of LULC change in Bweyeye (2003 - 2023)

	Square km					
LULC type	**2003**	**2008**	**2013**	**2018**	**2023**	**Change (2003 - 2023)**
Forestland	220.25	205.42	192.03	189.16	174.52	-45.73
Grassland	4.77	17.47	25.22	18.33	17.15	12.38
Cropland	0.16	2.29	7.92	17.39	22.12	21.96
Built-up	0	0	0.012	0.28	8.12	8.12
Water bodies	0.004	0.0009	0.0009	0.0009	3.27	3.266

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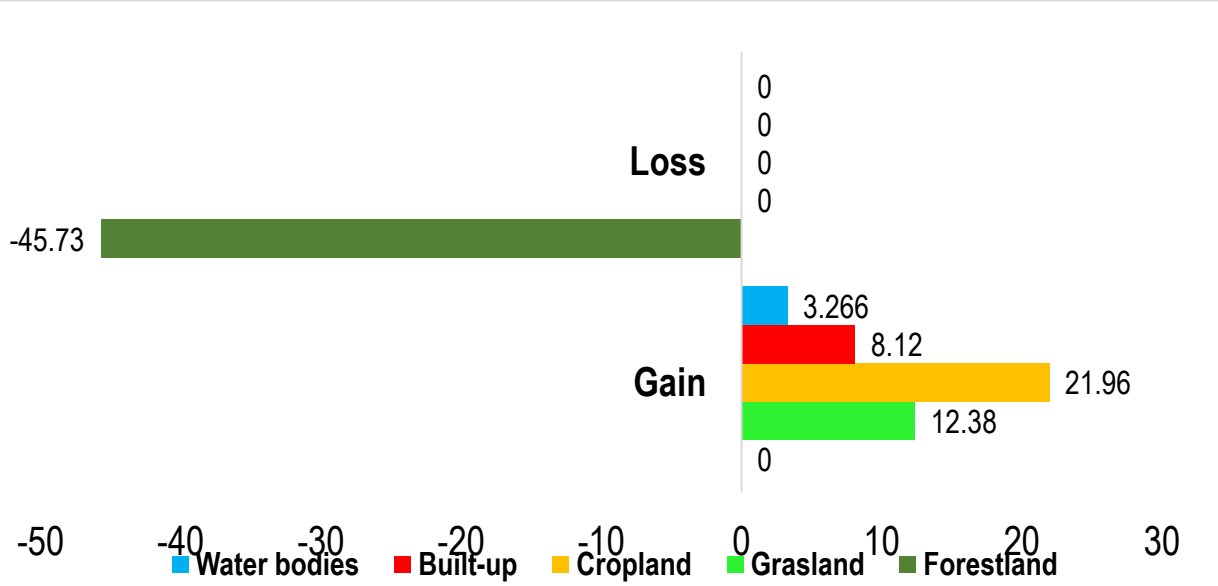
Figure 3:3. Gains and Losses (2003 - 2023)



Source: Primary Data, 2024

The baseline data analysis of Land Use and Land Cover changes in the Bweyeye sector in the year 2003 (Figure 3.1) shows that the Forestland was cover by 220.25 square kilometers (skm); Grassland 4.77skm; Cropland 0.16skm; Built-up 0skm and Water bodies 0.004skm. From this baseline the maps highlight the changes that have been taking place every five year, especially the period 2003-2023 shows the big change in the forestland cover. In this period of two decades, the forestland which is the cornerstone of ecological integrity in the sector, experienced a significant reduction, declining from 220.25skm (Figure 3.1), in 2003 to 174.52skm (Figure 3.5) in 2023. This decline of 45.73 square kilometers highlights the increasing pressures of expanding agricultural activities and infrastructural development on forest resources.

Despite the implementation of Forest Landscape Restoration initiatives, the findings underscore the challenges of balancing ecological restoration with the demands of social-economic development. Regardless the reduction in forestland but the FLR initiatives have played a great role to recover some surface areas otherwise the reduction of forestland could have been much more than 45.73 square kilometers. In contrast, cropland shows the expanding by 21.96skm over the same period. This shift reflects a prioritization of agricultural land use, likely driven by the imperative of food security and livelihoods for the local population. The rise in cropland also points to the effectiveness of soil and water conservation and agroforestry techniques in supporting sustainable farming practices.

The observed changes in forestland cover illustrate the complex interdependence of ecological restoration and socio-economic development. The decrease in forestland, despite the implementation of FLR initiatives, suggests that restoration efforts while impactful may be insufficient to fully respond to the deforestation drivers. The significant increase in cropland

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highlights the reliance of smallholder farmers on agricultural expansion for livelihoods, emphasizing the need for agroforestry as a pivotal FLR strategy. Agroforestry not only mitigates deforestation by integrating trees into agricultural systems but also enhances soil fertility and crop productivity, directly contributing to the socio-economic development.
economic benefits (Valters, 2015).

3.2 Socio-Economic Analysis

The analysis of the results provided through SPSS frequency tables is structured based on socio-economic indicators which are: Income levels, Food Security, Access to health, and Education Services. The results are examined within the context of before and after participation in Forest Landscape Restoration initiatives, focusing on the changes of socio-economic indicators of smallholder farmers.

3.2.1 Financial income before and after participation in FLR initiatives.

Table 3:1**. Financial Income before and after participation in FLR Initiatives**

Descriptive Statistics					
	N	Range	Mean	Std. Deviation	Variance
Financial income was below 100,000 Rwf	332	4	2.95	1.400	1.959
Financial income was 100,001-200,000 Rwf	332	4	3.13	1.587	2.518
Financial income was 200,001-300,000 Rwf	332	4	1.86	.777	.603
Financial income was 300,001-400,000 Rwf	332	4	1.91	.829	.687
Financial income was 400,001-500,000 Rwf	332	4	1.91	.788	.620
Financial income was above 500,000 Rwf	332	4	1.97	.887	.787
Increased from 1-100,000 in 2003-2008	332	4	2.22	1.046	1.095
Increased from 100,001-200,000 in 2003-2008	332	4	2.02	.841	.707
Increased from 200,001-300,000 In 2003-2008	332	4	1.92	.747	.558
Increased from 300,001-400,000 in 2003-2008	332	4	1.88	.680	.463
Increased from 400,001-500,000 in 2003-2008	332	4	1.89	.689	.475
Increased from 500,000 and above in 2003-2008	332	3	1.77	.617	.381
No increase in 2003-2008	332	4	1.95	.810	.656
Increased from 1-100,000 in 2008-2013	332	4	1.89	.753	.567
Increased from 100,001-200,000 in 2008-2013	332	4	2.48	1.154	1.332
Increased from 200,001-300000 in 2008-2013	332	4	3.41	1.582	2.502
Increased from 300,001-400,000 in 2008-2013	332	4	1.77	.682	.465
Increased from 400,001-500,000 in 2008-2013	332	3	1.75	.606	.368
Increased from 500,000 and above in 2008-2013	332	3	1.72	.649	.421
No increase in 2008-2013	332	4	1.81	.668	.446
Increased from 1-100,000 in 2013-2018	332	4	1.77	.673	.453
Increased from 100,001-200,000 in 2013-2018	332	4	1.92	.854	.730
Increased from 200,001-300,000 in 2013-2018	332	4	2.26	1.120	1.254

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Increased from 300,001-400,000 in 2013-2018	332	4	3.48	1.569	2.462
Increased from 400,001-500,000 in 2013-2018	332	4	1.84	.794	.630
Increased from 400,001-500,000 in 2013-2018	332	3	1.72	.639	.408
No increase in 2013-2018	332	4	1.71	.657	.431
Increased from 1-100,000 in 2018-2023.	332	4	1.72	.619	.384
Increased from 100,001-200,000 in 2018-2023	332	4	1.82	.738	.545
Increased from 200,001-300,000 in 2018-2023	332	4	1.84	.757	.574
Increased from 300,001-400,000 in 2018-2023	332	4	2.17	1.114	1.240
Increased from 400,001-500,000 in 2018-2023	332	4	3.33	1.567	2.457
Increased from 500,000 and above in 2018-2023	332	4	1.93	.998	.995
No increase in 2018-2023	332	4	1.81	.809	.654
Valid N (listwise)	332				

Source: Primary data, 2024

The progressive improvement in financial income levels among smallholder farmers in Bweyeye Sector, as demonstrated in the findings from 2003 to 2023, provides strong empirical validation of the **Theory of Change (ToC)** framework. According to the ToC, meaningful and lasting change occurs through a sequence of strategically designed interventions that address defined preconditions (Vogel, 2012). In this study, the key interventions **agroforestry, afforestation, reforestation, and soil and water conservation** acted as catalytic inputs that triggered intermediate outcomes such as increased agricultural productivity and the generation of income through timber and non-timber forest products.

The findings reflect a significant shift in income levels particularly between **2013–2018** and **2018–2023**, where mean incomes rose markedly in the **300,001–500,000 RWF** brackets (M = 3.48 and M = 3.33, respectively), suggesting that farmers reached a critical mass of benefits from their prolonged participation in FLR initiatives. This progression is consistent with (Chazdon R. L., 2020), who argue that the socio-economic outcomes of FLR manifest more significantly over longer time horizons, especially when interventions are locally adapted and consistently applied. Importantly, the relatively **low standard deviations** in early periods imply that farmers initially experienced uniform, modest income gains. Over time, **growing variability** in later periods (SD > 1.5 in higher income brackets) indicates that while many farmers capitalized effectively on FLR, disparities in benefit distribution emerged often influenced by factors such as land size, technical knowledge, and access to markets. This nuance aligns with (Valters, 2015), who critiques the ToC for not always accounting for the uneven power dynamics and structural barriers within rural development contexts.

Yet, the **core premise of the ToC is still validated**: sustained engagement in FLR, underpinned by enabling conditions like land ownership and training, leads to observable improvements in income. These findings support (Dave, application of the Barometer in 2018.) who emphasize that restoration interventions, when guided by a clear change logic, enhance not only environmental outcomes but also household resilience and economic security. To maximize the **ToC's transformative potential**, however, greater inclusivity is required. Policies should target underperforming groups with **capacity building, equitable resource access**, and **market**

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integration to bridge income disparities and sustain impact. Without these adjustments, the risk remains that FLR will disproportionately benefit a select few, limiting its broader development objectives.

3.2.2 Data presentation, discussion, and interpretation of the results of food security before and after Participation in FLR Initiatives

Table 3.2: **Food security before and after participation in FLR Initiatives**

Descriptive Statistics					
	N	Range	Mean	Std. Deviation	Variance
Before participating in FLR initiatives, my family used to have one meal a day	332	4	2.95	1.434	2.055
Before participating in FLR initiatives, my family used to have two meals a day	332	4	3.05	1.576	2.484
Before participating in FLR initiatives, my family used to have three meals a day	332	4	1.76	.732	.535
Before participating in FLR initiatives, my family used to eat energy-providing foods only	332	4	1.92	.846	.716
Before participating in FLR initiatives, my family used to eat body-building foods only	332	4	1.80	.743	.553
Before participating in FLR initiatives, my family used to eat protective foods only	332	4	1.75	.640	.410
Before participating in FLR initiatives, my family used to eat all groups of food	332	4	1.80	.726	.527
After participating in FLR initiatives, my family used to have one meal a day	332	4	3.21	1.621	2.626
After participating in FLR initiatives, my family used to have two meals a day	332	4	3.11	1.550	2.401
After participating in FLR initiatives, my family used to have three meals a day	332	4	3.82	1.176	1.383
After participating in FLR initiatives, my family used to eat energy-providing foods only	332	4	3.04	1.476	2.180
After participating in FLR initiatives, my family used to eat body-building foods only	332	4	3.08	1.511	2.283
After participating in FLR initiatives, my family used to eat protective foods only	332	4	3.10	1.518	2.305
After participating in FLR initiatives, my family used to eat all groups of food	332	4	4.46	.739	.546
Valid N (listwise)	332				

The analysis of food security before and after participation in Forest Landscape Restoration (FLR) initiatives presents compelling evidence of improved dietary intake and meal frequency among smallholder farmers in the Bweyeye sector. Prior to engagement in FLR programs, most households exhibited signs of food insecurity indicated by low mean values for consuming three

meals per day (M = 1.76, SD = 0.732) and limited dietary diversity. For instance, families reported low mean scores for consuming body-building foods (M = 1.80), protective foods (M = 1.75), and energy-rich staples (M = 1.92). These findings are consistent with food insecurity patterns in rural agricultural communities where subsistence farming is affected by poor soil health, land degradation, and climate stressors (FAO I. U., 2021).

Following participation in FLR initiatives, the data show a marked transformation. The mean for households consuming three meals per day rose sharply to 3.82 (SD = 1.176), and most notably, the mean for families consuming all food groups increased to 4.46 (SD = 0.739). These results suggest that reforestation, agroforestry, and soil conservation practices contributed to both food availability and nutritional adequacy. Agroforestry systems, in particular, are known to diversify household diets by integrating fruit-bearing trees, legumes, and shade-tolerant crops, thus enhancing nutritional outcomes.

These findings validate the Theory of Change (ToC) framework, which posits that when strategic interventions are linked to well-defined preconditions such as sustained land restoration and farmer participation, they catalyze long-term improvements in socio-economic and ecological conditions (Vogel, 2012). The progression from mono-dietary patterns and meal scarcity to diversified diets and stable food access in Bweyeye exemplifies the causal logic central to ToC. It confirms that sustained engagement in FLR initiatives not only enhances agricultural productivity but also strengthens community resilience to food insecurity, aligning with prior research that connects land restoration with enhanced food systems (Chazdon R. L., 2020).

However, it is also important to acknowledge that the variability in improvement across households, as reflected in the standard deviations, highlights disparities in the extent of benefits. This implies that while the ToC framework is validated, its implementation must be inclusive and adaptive, addressing structural inequalities such as land access, gender disparities, and household size, to ensure equitable outcomes (Valters, 2015).

3.2.3 Analysis, discussion, and the interpretation of the results of access to health services before and after Participation in FLR Initiatives

Table 3.3**: Statistics of access to the health services before and after participation in FLR initiatives.**

Descriptive Statistics					
	N	Range	Mean	Std. Deviation	Variance
Before participating in the FLR initiatives, I was not able to pay mutual health insurance.	332	4	4.13	.609	.371
After participating in FLR initiatives, I was able to pay mutual health insurance.	332	1	4.47	.500	.250
Valid N (listwise)	332				

Source: Primary data, 2024

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The findings on access to health services among smallholder farmers before and after participation in FLR initiatives reveal a substantial improvement in the ability to pay for mutual health insurance. Prior to participation, the majority of respondents reported challenges in affording annual health insurance contributions, as indicated by the high mean value of M = 4.13 (SD = 0.609). This result underscores the pre-existing financial vulnerability among rural farming communities in Bweyeye, where limited income opportunities and degraded agricultural systems constrained access to essential social services, including healthcare. The relatively low standard deviation reflects consistency in responses, suggesting that this challenge was widespread and systemic.

Following engagement in FLR initiatives, however, the data show a significant increase in the ability to pay for mutual health insurance (M = 4.47, SD = 0.500). This shift indicates improved financial resilience, likely driven by the economic benefits of FLR interventions such as increased agricultural yields, timber and non-timber forest products, and enhanced ecosystem services from reforestation, afforestation, and agroforestry. These improvements are consistent with the Theory of Change (ToC), which posits that when long-term strategies are implemented with clear preconditions such as capacity-building, sustained participation, and community-based ecosystem restoration transformative socio-economic outcomes follow (Vogel, 2012).

Moreover, the decrease in standard deviation suggests a narrowing gap in healthcare access among the surveyed population, highlighting more equitable benefits. This supports evidence from recent studies, such as Chazdon et al. (2020), which assert that FLR initiatives can positively influence livelihoods by increasing income and access to social services when local communities are actively involved. These findings affirm the ToC's causal logic, demonstrating that strategic restoration efforts lead to enhanced well-being through improved financial capabilities. Nevertheless, the relatively high baseline challenges indicate the importance of sustained investment in FLR and complementary policies such as financial literacy, access to credit, and cooperative health schemes to ensure these gains are both inclusive and sustainable.

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3.2.4 Analysis, discussion, and interpretation of the result on the access to education services before and after participation in FLR initiatives

Table 3.4**: Statistics of Access to education Services before and after participation in FLR.**

Descriptive Statistics					
	N	Range	Mean	Std. Deviation	Variance
Before participating in the FLR initiatives, I had dropped out my education due to lack of funds.	332	4	4.28	.647	.418
Before participating in forest landscape restoration initiatives, my spouse had dropped out the education due to lack of funds.	332	4	4.23	.629	.396
Before participating in FLR initiatives, my spouse and I dropped out education.	332	4	4.23	.693	.481
Before participating in FLR initiatives, my children dropped out the education due to lack of funds.	332	4	3.92	1.117	1.248
After participating in forest landscape restoration initiatives, I was able to generate fund of my education.	332	4	1.84	.785	.616
After participating in FLR initiatives, I was able to generate fund of the education of my spouse.	332	4	1.90	.688	.473
After participating in FLR initiatives, I was able to generate fund of my education and of my spouse.	332	4	1.79	.573	.328
After participating in FLR initiatives, I was able to fund the education of my children.	332	4	4.62	.730	.532
Valid N (listwise)	332				

Source: Primary Data, 2024

The results from Table 3:11 reveal a significant shift in the financial ability of smallholder farmers to access education services before and after participation in Forest Landscape Restoration (FLR) initiatives. Prior to FLR engagement, a considerable number of respondents faced economic barriers to education, with high mean scores indicating agreement that both they (M = 4.28, SD = 0.647) and their spouses (M = 4.23, SD = 0.629) dropped out due to lack of funds. Similarly, children's dropout rates were concerning (M = 3.92, SD = 1.117), showing financial instability and educational vulnerability among households.

After participation in FLR initiatives, the most notable positive change was in the ability to fund children's education (M = 4.62, SD = 0.730), suggesting a substantial improvement in household financial resilience. These findings imply that income generated from FLR-related activities—such as agroforestry, afforestation, reforestation, and soil and water conservation played a pivotal

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role in reducing economic constraints and enabling access to education, particularly for children.

These outcomes align strongly with the Theory of Change (ToC), which posits that well-planned, sustained interventions can yield measurable long-term socio-economic benefits if foundational conditions (e.g., financial security and institutional support) are met (Vogel, 2012). In the context of this study, FLR activities served as strategic levers to trigger those conditions. By improving livelihoods, they empowered households to prioritize educational expenditures.

Furthermore, according to (Gregorio, 2020), Forest Landscape Restoration initiatives that integrate income-generating practices can indirectly support education access by stabilizing household economies. Similarly, (Bloomfield, 2018) observed that FLR can lead to better education outcomes through scholarships and improved household capacity to finance learning.

However, the data also show lower mean values for respondents funding their own (M = 1.84) or their spouse's education (M = 1.90), reflecting a gap in adult education engagement. While children's schooling has clearly improved, adult learners remain underserved. This highlights a critical gap in the sustainability loop of FLR-linked socio-economic development. For the ToC to be fully realized, complementary investments in adult literacy and vocational training must accompany environmental initiatives (Valters, 2015).

The findings validate the ToC's assertion that strategically implemented environmental interventions can drive socio-economic transformation (Valters, 2015). In Bweyeye sector, improved access to children's education was a direct outcome of financial stability achieved through FLR initiatives. This supports the causal pathway of the ToC: interventions enabling conditions, intermediate outcomes and long-term change. Nonetheless, the limited adult educational gains reveal the need for multi-sectoral approaches, combining FLR with inclusive educational policies.

Table 3.5: Correlation Analysis

		Soil and water conservation	Financial Income	Food security	Health services	Education services
Reforestation	Pearson Correlation	.352**	.220**	.385**	.339**	.353**
	Sig. (2-tailed)	.000	.000	.000	.000	.000
	N	332	332	332	332	332
Afforestation	Pearson Correlation	.358**	.248**	.171**	.212**	.252**
	Sig. (2-tailed)	.000	.000	.002	.000	.000
	N	332	332	332	332	332
Agroforestry	Pearson Correlation	.518**	.257**	.242**	.280**	.177**
	Sig. (2-tailed)	.000	.000	.000	.000	.001
	N	332	332	332	332	332

Source: Primary Data, 2024

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The correlation analysis presents significant relationships between different FLR initiatives (reforestation, agroforestry, and soil and water conservation) and the socio-economic indicators (Financial Income, Food Security, Access to Health Services, and Access to Education Services). The results indicate that all FLR initiatives positively correlate with socio-economic improvement, suggesting that participation in these interventions enhances livelihoods and overall well-being in the Bweyeye sector. Among the FLR initiatives, agroforestry exhibits the highest correlation with other variables, particularly soil and water conservation ($r = .518$, $p < .01$) and reforestation ($r = .464$, $p < .01$**).** This strong association suggests that agroforestry practices often complement other restoration efforts, contributing to improved soil stability, increased agricultural yields, and diversified income sources. Notably, agroforestry also shows a significant correlation with financial income ($r = .257$, $p < .01$)**,** indicating that farmers engaging in agroforestry benefit from more from it. Additionally, agroforestry positively correlates with food security **(**$r = .242$, $p < .01$**).**

Reforestation, another key FLR initiative, exhibits moderate to strong correlations with food security ($r = .385$, $p < .01$) and access to health services ($r = .339$, $p < .01$**)**, highlighting its role in improving environmental conditions that support agricultural productivity and rural health. The correlation between soil and water conservation and financial income ($r = .313$, $p < .01$) suggests that improved soil management contributes to increased agricultural yields, ultimately boosting household earnings. Furthermore, the correlation between FLR activities and access to education services, though weaker compared to other socio-economic factors, remains statistically significant **(**$r = .353$ for reforestation, $r = .252$ for afforestation, and $r = .177$ for agroforestry, $p < .01$**)**. This finding implies that the economic benefits derived from FLR programs to support educational access, likely through increased household incomes that enable families to afford school fees. In addition, the financial income correlates most strongly with access to health services ($r = .365$, $p < .01$) and food security ($r = .342$, $p < .01$), reinforcing the idea that economic improvements from FLR initiatives translate into better access to essential services.

The correlation analysis findings align well with the Theory of Change (ToC) by demonstrating the interconnected pathways through which FLR initiatives contribute to socio-economic improvements. The significant positive correlations between FLR activities (Reforestation, Afforestation, Agroforestry, and Soil and Water Conservation) and socio-economic indicators (Financial Income, Food Security, Access to Health Services, and Access to Education Services) validate the assumption that environmental restoration leads to improved livelihoods. Agroforestry stands out as the most impactful FLR initiative, showing the highest correlation with soil and water conservation ($r = .518$, $p < .01$) and reforestation ($r = .464$, $p < .01$). This aligns with the previous dataset findings on financial stability improvements, where FLR participation resulted in a significant increase in farmers' ability to pay for health insurance ($M = 4.47$, $SD = 0.500$) and support children's education ($M = 4.62$, $SD = 0.730$). The correlation between agroforestry and financial income ($r = .257$, $p < .01$) reinforces this trend, indicating that income-generating activities under FLR have tangible financial benefits.

Reforestation's moderate to strong correlations with food security ($r = .385$, $p < .01$) and access to health services ($r = .339$, $p < .01$) support earlier findings that FLR participation enhances economic resilience, enabling better access to essential services. Similarly, soil and water conservation's positive association with financial income ($r = .313$, $p < .01$) mirrors the

improvements in financial stability observed in previous datasets. These relationships confirm that enhanced land productivity leads to increased earnings, which in turn facilitate access to healthcare and education.

While the correlation between FLR activities and access to education services is weaker ($r = .353$ for reforestation, $r = .252$ for afforestation, and $r = .177$ for agroforestry, $p < .01$), it remains statistically significant. This aligns with earlier findings showing that FLR initiatives significantly improved children's education financing but had limited impact on adult education ($M = 1.84$ for personal education, $M = 1.90$ for spouses). The relatively lower correlation suggests that while FLR initiatives generate financial resources for education, other structural barriers—such as adult responsibilities or lack of accessible schooling—may limit full participation in formal education.

Overall, these findings reinforce the ToC by confirming that FLR programs create a positive ripple effect across multiple socio-economic dimensions. The data highlight the importance of continued investment in FLR initiatives, particularly agroforestry, to maximize income generation and further improve access to essential services like health and education. Additionally, targeted interventions such as adult education and skill-based training could complement FLR benefits and ensure broader socio-economic transformation.

4. Conclusion

In conclusion, this research was conducted with three specific objectives including the first one to evaluate FLR by mapping forestland cover change in Bweyeye sector from 2003 to 2023; second one was to assess the effects of FLR in Bweyeye sector in the period 2003 to 2023 and the third one to analyze the relationship between FLR and the socio-economic development. The findings indicate that despite efforts to restore degraded landscapes through reforestation, afforestation, agroforestry, and soil and water conservation, forest cover experienced a decline of 45.73 square kilometers between 2003 and 2023 due to agricultural expansion and infrastructural development.

Nevertheless, FLR initiatives played a crucial role in mitigating environmental degradation and enhancing agricultural productivity. The findings have also shown the FLR initiatives plays a pivotal role in supporting income generation, food security, access to health and education services. In addition to that, the study confirmed a positive correlation between FLR initiatives and improvements in income levels, food security, and access to health and education services. Specifically, smallholder farmers who actively participated in FLR initiatives experienced a notable increase in their annual financial income, with many transitioning from the lower-income levels (below 200,000 RWF annually) to higher income groups (above 400,000 RWF annually). Additionally, food security significantly improved, with more households reporting an increase from one or two meals per day to three meals daily, and a diversified food diet incorporating energy-providing, body-building, and protective foods.

Furthermore, the study established that participation in FLR initiatives directly influenced access to essential social services. The income generated from FLR-related activities enabled many smallholder farmers to afford mutual health insurance and invest in their children's education, reducing school dropout rates that were previously high due to financial constraints. Regression analysis revealed that reforestation had the strongest positive effect on financial income, food

security and access to health, whereas agroforestry significantly contributed to education financing. These findings underscore the multifaceted role of FLR in promoting socio-economic resilience among rural farming communities.

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