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Influence of Farm Household Climate Change Adaptation Strategies on Food Security in Nyabihu District, Rwanda

[1]Mr. Bahufite Uwitonze Emmanuel, [2]Dr. Eugenia Nkechi Irechukwu, (PhD), [3]Mr. Masaka Eliud

[1]Author, [2,3] Co-authors

[1](School of Social Sciences, Mount Kenya University)

[2](School of Business and Economics, Mount Kigali University)

[3] (School of Social Sciences, Mount Kigali University)

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Abstract: **Climate change continues to affect food quality and increase food insecurity across Africa. This study examined the influence of climate change adaptation strategies on household food security among farm households in Nyabihu District, Rwanda. The study was guided by four objectives: identifying adaptation strategies used by farm households, determining food security outcomes following their adoption, analyzing the causal relationship between adaptation strategies and food security, and assessing socio-economic factors moderating this relationship. A total of 409 respondents participated in the study, including 397 household heads selected randomly and 12 sector authorities selected purposively through a multistage sampling technique. Secondary data were obtained from the National Institute of Statistics of Rwanda and the Ministry of Agriculture and Animal Resources. Data were analyzed using descriptive statistics and SPSS version 22. The findings revealed that crop diversity (92.7%) and improved crop varieties (92.7%) were the most widely adopted adaptation strategies, with over 90% of respondents supporting them. Traditional practices such as crop rotation and mixed farming were also endorsed by more than 90% of respondents. While over 85% favored modern approaches such as short-season crops and agricultural technologies, their adoption showed variability due to unequal access. Adoption of these strategies significantly improved food security dimensions: 82.8% reported improved access, 78.5% improved utilization, 82.1% improved stability, and 80.5% increased food availability. Correlation analysis indicated strong positive relationships between adaptation strategies and food security outcomes, with coefficients for agricultural technology ranging from $r = 0.76$ to 0.80. Multivariate regression results confirmed that all strategies had significant effects ($p < 0.05$) and explained 69% to 78% of the variation ($R^2 = 0.69–0.78$), with agricultural technology showing the strongest influence ($\beta = 0.39–0.45$). Despite these positive outcomes, challenges such as limited resources, inadequate training, and financial constraints hinder full implementation, especially in rural areas. The study concludes that integrating both traditional and modern adaptation strategies is essential for enhancing food security and climate resilience. It recommends strengthening extension services, improving access to affordable inputs, investing in climate-resilient infrastructure, and promoting farmer cooperation.**

Keywords: **Farm Household, Climate Change, Food Security, Nyabihu District, Rwanda.**

1. INTRODUCTION

Agriculture remains a critical driver of economic growth, poverty reduction, and food security in developing countries. However, climate change, manifested through rising temperatures, shifting precipitation patterns, and increased frequency of extreme weather events, poses a significant threat to agricultural productivity and food systems (FAO, 2020). Both natural climate variability and anthropogenic activities that alter atmospheric composition contribute to these changes, necessitating the adoption of innovative and climate-resilient agricultural practices.

Globally, climate change adaptation refers to efforts aimed at reducing vulnerability and enhancing resilience to climate-related impacts, particularly in developing regions. International frameworks such as the UNFCCC and the Paris Agreement promote adaptation through mechanisms like National Adaptation Plans and climate financing instruments (UNFCCC, 2015; GCF, 2024). Despite increased global attention, adaptation efforts remain uneven and underfunded, with significant implementation gaps (UNEP, 2023). The IPCC (2022) emphasizes the need for inclusive, locally driven strategies, including nature-based solutions and integration into national development planning.

Climate change directly affects the four pillars of food security, availability, access, utilization, and stability,by disrupting agricultural production systems through droughts, floods, pests, and seasonal variability (IPCC, 2017; USAID, 2018). These impacts are particularly severe in Sub-Saharan Africa, where high vulnerability, limited adaptive capacity, and dependence on rain-fed agriculture exacerbate food insecurity (FAO, 2020; IPCC, 2022). Although regional initiatives such as climate-smart agriculture, early warning systems, and ecosystem restoration have been promoted, challenges including inadequate financing, weak institutional capacity, and unequal resource access persist (UNEP, 2023; African Union, 2021; EAC, 2024).

In Rwanda, a predominantly agrarian and densely populated country, climate variability has intensified, resulting in frequent droughts, floods, and unpredictable rainfall patterns (Rwema et al., 2025). These shocks negatively affect crop yields, household incomes, and overall food security. In response, farm households have adopted various adaptation strategies, both autonomous and policy-supported (Iyakaremye & Kabanda, 2024). However, empirical evidence on how these strategies influence different dimensions of food security remains limited. Therefore, this study seeks to examine the impact of climate change adaptation strategies on household food security outcomes in rural Rwanda.

2. METHODOLOGY

2.1 Research Design

A cross-sectional household survey was conducted to collect data on adaptation strategies, food security indicators, socio-economic characteristics, and institutional factors.

2.2. Target Population

Total households in Nyabihu district is 76,391 households from 12 sectors. Of these, there are 50,982 farm households in Nyabihu district which was considered as the target population of this study.

2.3 Sampling Technique

Throughout the assessment, the population was chosen as a sample size through methods of simple random sampling and purposive sampling.

2.4 Sample Size

This study adopted the sample size determination formula proposed by Cochran (1977), which is appropriate for large and finite populations with a specified margin of error. The formula is expressed as:

$$n_0 = \frac{N}{1 + N(e^2)}$$

Where:

- n_0= sample size
- N= target population
- e= margin of error (0.05)

Substituting the values:

$$n_0 = \frac{50{,}928}{1 + 50{,}928(0.05)^2} = \frac{50{,}928}{1 + 127.32} = \frac{50{,}928}{128.32} \approx \mathbf{397}$$

Thus, a sample of 397 heads of households was selected to participate in the questionnaire survey. In addition, 12 sector authorities were purposively selected for interviews to provide complementary qualitative insights. Accordingly, the total sample size for the study was 409 respondents.

2.5 Data Collection Instruments

Both questionnaires and interviews with respondents used by the researcher to collect data.

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3. RESULTS AND DISCUSSIONS

3.1 Demographic indicators of the Respondents

Interpreting the results requires an understanding of the gender composition since it gives context for the sample's demographic profile. These details might also provide information about possible gender related patterns in the gathered data.

Table 1: Gender of the Respondents

Gender	Frequency	Percentage
Male	229	56
Female	173	42.3
No answer	7	1.7
Total	**409**	**100**

Source: **Primary data (2025)**

According to findings of table 1, 229 respondents equal to 56% of the total respondents including the selected heads of households and local authorities in Nyabihu district are male, while 173 respondents equal to 42.3% of the total respondents are female, this indicated that the majority of the heads of the farm households and local leaders in Nyabihu district are male comparing to female. Among of the respondents indicated in this study 7 respondents (1.7%) decided to do not answer the questions of this study. As per the results in this table, those who are participating in farming activities in Nyabihu district are Male comparing to female but it looks equal as there is no big difference in their numbers. According to USAID (2019), gender-focused programs in Rwanda have begun to lessen gender differences in access to agricultural resources, cooperative participation, and training programs.

3.2 Presentation of the Findings

This study used frequency and percentage tables to present and analyze data in a methodical manner. The responses obtained from farmers about how they view different climate change adaptation strategies are arranged in these tables. The main goal is to comprehend how farmers in Nyabihu district have implemented these tactics to improve food security in the face of climate change. By highlighting the frequency and popularity of particular adaptation strategies, the data analysis makes it easier to understand which tactics are most frequently employed and thought to be successful by the local farming community. In spite of the difficulties brought on by climate variability, the conversation explores how this adaptation strategies help to maintain agricultural productivity and ensure food availability.

3.2.1 Climate change adaptation strategies adopted to enhance food security among Farm Households in Nyabihu district

The following table indicates the perception and views of heads of Farm household on different strategies adopted to enhance food security in their farming activities in Nyabihu district. Among 397 respondents, 7 respondents decided to do not respond to the question.

Table 2: Views of Farm households on Climate change adaptation strategies

Strategy	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	Std. Dev.
Improved crop varieties	3 (0.8%)	14 (3.5%)	5 (1.3%)	180 (45.3%)	188 (47.4%)	7 (1.8%)	0.75
Crop diversification	4 (1.0%)	12 (3.0%)	6 (1.5%)	172 (43.3%)	196 (49.4%)	7 (1.8%)	0.78
Changing planting dates	5 (1.3%)	11 (2.8%)	7 (1.8%)	170 (42.8%)	197 (49.6%)	7 (1.8%)	0.77
Mixed farming	2 (0.5%)	13 (3.3%)	6 (1.5%)	183 (46.1%)	179 (45.1%)	14 (3.5%)	0.72
Agroforestry	4 (1.0%)	14 (3.5%)	6 (1.5%)	168 (42.3%)	178 (44.8%)	27 (6.8%)	0.8
Crop rotation	3 (0.8%)	9 (2.3%)	4 (1.0%)	185 (46.6%)	181 (45.6%)	15 (3.8%)	0.69
Short-season crop varieties	6 (1.5%)	10 (2.5%)	5 (1.3%)	170 (42.8%)	174 (43.8%)	32 (8.1%)	0.82
Modern fertilizers	5 (1.3%)	11 (2.8%)	6 (1.5%)	175 (44.1%)	173 (43.6%)	27 (6.8%)	0.79
Selected seeds	3 (0.8%)	13 (3.3%)	5 (1.3%)	178 (44.8%)	171 (43.1%)	27 (6.8%)	0.75
Technology	4 (1.0%)	14 (3.5%)	7 (1.8%)	165 (41.6%)	176 (44.3%)	31 (7.8%)	0.82

Source: Primary data (2025)

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According to Table 2, the majority of respondents selected "Agree" or "Strongly Agree" for each of the ten climate change adaptation strategies, indicating that farm households view them all favorably overall. With 180 (45.3%) agreeing and 188 (47.4%) strongly agreeing (SD = 0.75), improved crop varieties were strongly supported. With 172 (43.3%) agreeing and 196 (49.4%) strongly agreeing (SD = 0.78), crop diversification received the most approval. Altering planting dates came in second, with 170 (42.8%) agreeing and 197 (49.6%) strongly agreeing (SD = 0.77).

Crop rotation had the lowest standard deviation, suggesting the strongest agreement among farmers, while mixed farming (A = 183, SA = 179, SD = 0.72) and crop rotation (A = 185, SA = 181, SD = 0.69), both of which received strong support. Although 168 (42.3%) and 178 (44.8%) expressed agreement with agroforestry, there was more variation (SD = 0.80) and 27 missing responses, which probably indicate that respondents were less familiar with the topic.

Conversely, tactics such as technology adoption (A = 165, SA = 176) and short-season crop varieties (A = 170, SA = 174) also had high levels of agreement (above 85%), but they also had the highest standard deviations (both 0.82) and the greatest number of missing responses (32 and 31 respectively), suggesting a wider range of viewpoints and perhaps less access or knowledge. Selected seeds (A = 178, SA = 171, SD = 0.75) and modern fertilizers (A = 175, SA = 173, SD = 0.79) were also well received, although they varied a little more than conventional methods. Higher standard deviations and missing data in strategies involving modern inputs and technologies indicate a need for greater awareness, access, and support to encourage wider adoption, whereas lower standard deviations in strategies like crop rotation, mixed farming, and improved crop varieties generally indicate that these are widely understood and accepted. The results highlight that although farmers are receptive to a variety of adaptation techniques, customized interventions are required, particularly for more recent or unfamiliar approaches.

12 participants who are representatives of all the sectors in Nyabihu district were interviewed, and the results showed that soil erosion, extended dry spells, pest and disease outbreaks, and unpredictable rainfall are all major effects of climate change on agriculture in Nyabihu District. Crop diversification, the use of improved or drought-resistant seeds, agroforestry, mixed farming, and soil conservation methods like terracing are some of the adaptation strategies that farmers are implementing in response.

Although support for these strategies is frequently uneven, particularly in remote areas, it is provided by NGOs and government programs (primarily through Ministry of Agriculture and Animal Resources and Rwanda Agriculture Board). Although farmers are generally open to implementing new practices, participants pointed out that complete implementation is still hampered by their lack of access to resources, training, and regular follow-up.

These findings are consistent with other research that indicates farmers strongly support crop rotation and diversification (Mnukwa *et al.*, 2025; Rwema *et al.*, 2025). The low standard deviations of these tactics suggested that they were consistently accepted. On the other hand, responses varied more for strategies that used contemporary technologies, which is consistent with research by Ntawuruhunga *et al.* (2025) and Chitando *et al.* (2025). This variation is a reflection of knowledge, support, and access gaps. Research highlights that inputs, credit, and extension services are necessary for adoption.

3.2.2 Food security outcomes following the adoption of climate change adaptation strategies among farm households in Nyabihu district

This section explains how farmers' adoption of coping mechanisms to deal with the adverse effects of climate change has altered food security. The findings indicate that the majority of households saw improvements in their capacity to eat healthily and obtain enough food. Many respondents concurred that there was a more stable food supply all year round, better food availability, easier access to food, and improved food use.

Table 3: Views of the Respondents on food security outcomes following adoption of climate change adaptation strategies

Food Security Outcome	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	Std. Dev.
Availability	6 (1.5%)	9 (2.3%)	8 (2.1%)	53 (13.6%)	314 (80.5%)	7	0.63
Access	5 (1.3%)	10 (2.6%)	7 (1.8%)	45 (11.5%)	323 (82.8%)	7	0.61
Utilization	7 (1.8%)	8 (2.1%)	9 (2.3%)	60 (15.4%)	306 (78.5%)	7	0.65
Stability	4 (1.0%)	11 (2.8%)	6 (1.5%)	49 (12.6%)	320 (82.1%)	7	0.62

Source: Primary data (2025)

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Aspects of food security such availability, access, utilization, and stability are strongly perceived, according to the survey results. With a standard deviation of 0.63, the responses demonstrated low variability. Of the respondents, 314 (80.5%) strongly agreed and 53 (13.6%) agreed that food is sufficiently available, while only 23 (5.9%) expressed neutrality or disagreement. In a similar vein, 323 respondents (82.8%) strongly agreed and 45 (11.5%) agreed that access to food was perceived favorably, while only 22 respondents (5.7%) disagreed or were neutral, as indicated by an even lower standard deviation of 0.61.

Though there was a little more variation in this dimension (standard deviation of 0.65), 306 respondents (78.5%) strongly agreed and 60 (15.4%) agreed that food is used effectively to meet nutritional needs, while 24 respondents (6.1%) were neutral or disagreed. Finally, 320 respondents (82.1%) strongly agreed and 49 (12.6%) agreed with the rating of stability of food security over time, while only 21 respondents (5.3%) were neutral or disagreed. A standard deviation of 0.62 supports the consistency of these responses. The consistently low standard deviations and the small amount of missing data (7 responses per item) across all dimensions show a strong consensus that the surveyed population maintains food security.

Interviews with 12 respondents in Nyabihu District showed that household food security has greatly increased as a result of the implementation of climate change adaptation strategies. The majority of participants reported that small-scale irrigation, improved seed varieties, and improved farming methods had increased the availability of food. With many households' growing excess food for trade or sale, access to food has also improved. Better food storage and increased knowledge of dietary requirements has improved utilization. Even during customarily challenging seasons, respondents reported a more stable food supply all year long. Practical measures like the quantity of meals consumed, the variety of the diet, and the application of coping mechanisms like portion control are frequently used to evaluate household food security.

Community knowledge is in line with indicators of global food security, despite the lack of formal assessment instruments. The sustainability of the strategies and the affordability of the inputs were questioned. In general, Adaptation strategies adopted by Farmers in Nyabihu district are seen as successful and crucial for boosting climate change resilience and guaranteeing local food security over the long run.

Ndiritu & Muricho (2021) and Wakweya (2025) found that adaptation enhances food availability, access, and stability in vulnerable regions. Afiani & Bozoğlu (2024) highlight that support services and information access are key to success. Nsabagwa et al. (2021) noted variation in benefits due to local vulnerabilities. Muluneh (2021) emphasizes integrating biodiversity to sustain food utilization and stability.

3.2.3 Causal relationship between climate change adaptation strategies and food security outcomes in Nyabihu district

This section investigates the causal relationship between climate change adaptation strategies and food security outcomes. It specifically seeks to determine the kinds of adaptation tactics households employ in response to climate change and investigate how these tactics impact various facets of food security, such as food stability, availability, and accessibility. The section also examines which of these tactics have the biggest effects and whether they are successful in enhancing food security.

Table 4: Views of the respondents on the relationship between climate change adaptation strategies on food security outcomes in Nyabihu district

Effect	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	Std. Dev.
Increase crop output	3 (0.8%)	4 (1.0%)	5 (1.3%)	90 (23.1%)	288 (73.8%)	7	0.54
Increase of income	4 (1.0%)	6 (1.5%)	8 (2.0%)	85 (21.8%)	287 (73.6%)	7	0.56
They contribute to availability of food	2 (0.5%)	3 (0.8%)	7 (1.8%)	95 (24.4%)	283 (72.6%)	7	0.53
They contribute to accessibility of food	3 (0.8%)	5 (1.3%)	6 (1.5%)	87 (22.3%)	289 (74.1%)	7	0.55
They contribute to utilization of food	3 (0.8%)	4 (1.0%)	9 (2.3%)	80 (20.5%)	294 (75.4%)	7	0.56
They contribute to stability of food	4 (1.0%)	5 (1.3%)	5 (1.3%)	92 (23.6%)	284 (72.8%)	7	0.55

Source: Primary data (2025)

According to the findings in Table 4, respondents had a very favorable opinion of how climate change adaptation measures affected Nyabihu District's food security outcomes. Where, 90 respondents (23.1%) agreed and 288 respondents (73.8%) strongly agreed that these strategies increase crop output, while only 12 respondents (3.1%) disagreed or were neutral. In a similar vein, 287 respondents (73.6%) strongly agreed and 85 respondents (21.8%) agreed that adaptation strategies have increased income, whereas only 18 respondents (4.5%) disagreed or were neutral. These numbers demonstrate a high degree of confidence in the ability of adaptation measures to raise household incomes and agricultural productivity. A high degree of agreement among respondents was indicated by the low standard deviation of these responses (0.54 for crop output and 0.56 for income).When evaluating the four main pillars of food security, the same pattern holds true. Just 12 (3.1%) respondents had neutral or opposing opinions regarding food availability, compared to 283 (72.6%) who strongly agreed and 95 (24.4%) who agreed that adaptation strategies have a positive impact. Again, there was overwhelming support for food accessibility, with 289 respondents (74.1%) strongly agreeing and 87 (22.3%) agreeing. Of the respondents, 294 (75.4%) strongly agreed and 80 (20.5%) agreed that food utilization had a positive impact. Similarly, 92 respondents (23.6%) agreed and 284 respondents (72.8%) strongly agreed that adaptation helps ensure food stability.

Responses varied little in each of these categories, with standard deviations ranging narrowly between 0.53 and 0.56 and disagreement and neutrality staying below 4%. These results unequivocally show that community members generally and consistently recognize the importance of climate change adaptation strategies in improving all facets of food security in Nyabihu District.

The results of this study are consistent with those of other recent authors, such as Knudsen & Ujeneza (2020), who discovered that Rwandan crop productivity increases as a result of climate change adaptation.

In a similar vein, Mogess & Ayen (2023) demonstrated that adaptation measures greatly improve food security and rural household welfare in Ethiopia. In East Africa, Otieno *et al.* (2022) also documented improved access to food and income as a result of seed system interventions. This evidence is supported by the high level of agreement among Nyabihu respondents, which demonstrates the beneficial relationship between adaptation and food security. Responses with low standard deviations also point to a common community experience of these advantages.

Table 5: Pearson Correlation between Variables

Adaptation Strategy	Food Availability	Food Access	Food Utilization	Food Stability
Improved crop varieties	0.75	0.72	0.7	0.68
Crop diversification	0.78	0.76	0.74	0.73
Changing planting dates	0.65	0.63	0.61	0.62
Mixed farming	0.7	0.67	0.66	0.64
Agroforestry	0.74	0.7	0.69	0.71
Crop rotation	0.72	0.73	0.7	0.69
Short-season crop varieties	0.68	0.65	0.66	0.64
Modern fertilizers	0.76	0.75	0.73	0.72
Selected seeds	0.77	0.74	0.7	0.71
Use of agricultural technology	0.8	0.78	0.76	0.79

Source: Primary data (2025)

All four aspects of food security availability, access, utilization, and stability have a consistently high positive correlation with climate change adaptation strategies, according to the Pearson correlation table. Interestingly, with coefficients ranging from 0.76 to 0.80, the use of agricultural technology exhibits the highest correlation among all outcomes, indicating that it is a particularly effective tactic. With correlation values typically above 0.70, other tactics like crop diversification, improved crop varieties, and the use of specific seeds also exhibit strong associations. The fact that even the weakest correlations found for short-season crop varieties and shifting planting dates remain comparatively high (all ≥ 0.61), suggests that every adaptation strategy enhances food security. All things considered, these findings demonstrate how implementing climate-resilient farming methods can greatly improve the food security of households.

In line with the above results, Crop diversification and improved seeds greatly increase food availability and access in Ethiopia, according to Admasu *et al.* (2021). In a similar vein, Twinomugisha and Mushy (2020) found that Malawi's food stability and utilization were enhanced by the use of contemporary technologies and fertilizers. Agroforestry and mixed farming are essential for enhancing aspects of food security, according to a study by Gebre *et al.* (2023). These findings support the widely held belief that household food security is significantly supported by integrated adaptation strategies (Elias *et al.*, 2022; Mekonnen & Tesfaye, 2024).

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Table 6: Multivariate Regression Model

	Food Availability		Food Access		Food Utilization		Food Stability	
Adaptation Strategy	**(β)**	**p-value**	**(β)**	**p-value**	**(β)**	**p-value**	**(β)**	**p-value**
Improved crop varieties	0.42	0.0015	0.4	0.001	0.38	0.016	0.35	0.0042
Crop diversification	0.37	0.0015	0.35	0.001	0.33	0.011	0.31	0.007
Changing planting dates	0.19	0.007	0.17	0.012	0.16	0.015	0.15	0.018
Mixed farming	0.25	0.001	0.23	0.031	0.22	0.0018	0.2	0.003
Agroforestry	0.33	0.024	0.3	0.001	0.29	0.021	0.28	0.004
Crop rotation	0.29	0.041	0.27	0.001	0.25	0.021	0.24	0.001
Short-season crop varieties	0.21	0.004	0.19	0.006	0.18	0.008	0.17	0.009
Modern fertilizers	0.4	0.031	0.38	0.005	0.36	0.009	0.34	0.005
Selected seeds	0.36	0.0021	0.34	0.021	0.32	0.007	0.3	0.0034
Use of agricultural technology	0.45	0.0001	0.43	0.011	0.4	0.021	0.39	0.002
Constant (Intercept)	1.2	0.003	1.15	0.001	1.1	0.006	1.05	0.004

Food security outcomes, such as food availability, access, utilization, and stability, are positively and statistically significantly impacted by all of the climate change adaptation strategies that were included in the analysis, according to the results of the multivariate regression. With β-values ranging from 0.39 to 0.45 and p-values well below 0.05, it is noteworthy that the use of agricultural technology emerged as the most influential strategy across all four outcomes. This implies that households are more likely to experience greater food security if they use cutting-edge technologies like digital farming systems, mechanized tools, or better irrigation. Similar to this, methods such as modern fertilizers, improved crop varieties, and specific seeds demonstrated significant positive effects (β = 0.32–0.42), demonstrating their vital role in raising agricultural productivity, which in turn improves food availability and accessibility.

Crop rotation, agroforestry, mixed farming, and crop diversification were among the other adaptation strategies that demonstrated statistically significant impacts and were especially linked to increases in food stability and utilization. By maintaining ecological balance and a variety of revenue streams, these tactics assist households in managing climate risks and ensuring steady food supplies.

All aspects of food security were significantly impacted by shifting planting dates and using short-season crop varieties, despite their comparatively lower β-values (0.15–0.21), underscoring their importance in adapting to seasonal climate variability. Overall, these adaptation strategies explain a significant amount of the variation in food security outcomes, as indicated by the high R-squared values (0.69 to 0.78 across all models), highlighting their collective significance in creating resilient and food-secure households under climate change.

The multivariate results are consistent with those of Admasu et al. (2021), who discovered that better crop varieties and fertilizers greatly increase Ethiopia's food supply. In a similar vein, Elias et al. (2022) highlighted how agricultural technology can enhance food stability and accessibility. According to Twinomugisha and Mushy (2020), agroforestry and crop diversification have a positive impact on East African food consumption.

Table 7: Socio-economic factors moderating the Relationship between Adaptation to Climate Change and food Security

Socio-Economic Factor	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Missing	Std. Dev.
Gender of household head	2 (0.5%)	3 (0.8%)	3 (0.8%)	45 (11.5%)	337 (86.4%)	7	0.47
Age of household head	3 (0.8%)	5 (1.3%)	2 (0.5%)	50 (12.8%)	330 (84.6%)	7	0.52
Education level of household head	1 (0.3%)	4 (1.0%)	2 (0.5%)	56 (14.4%)	327 (83.8%)	7	0.5
Household size	3 (0.8%)	2 (0.5%)	1 (0.3%)	55 (14.1%)	329 (84.4%)	7	0.49
Household income	2 (0.5%)	5 (1.3%)	3 (0.8%)	50 (12.8%)	330 (84.6%)	7	0.52
Farm size	1 (0.3%)	2 (0.5%)	3 (0.8%)	53 (13.6%)	331 (84.9%)	7	0.48
Membership in a cooperative	3 (0.8%)	4 (1.0%)	2 (0.5%)	58 (14.9%)	323 (82.8%)	7	0.55
Availability of credit	2 (0.5%)	3 (0.8%)	1 (0.3%)	57 (14.6%)	327 (83.8%)	7	0.5
Availability of extension services	3 (0.8%)	5 (1.3%)	3 (0.8%)	51 (13.1%)	328 (84.1%)	7	0.53
Relatives in the village	1 (0.3%)	2 (0.5%)	2 (0.5%)	48 (12.3%)	337 (86.4%)	7	0.47
Market accessibility	2 (0.5%)	3 (0.8%)	3 (0.8%)	55 (14.1%)	327 (83.8%)	7	0.5
Off-farm income	3 (0.8%)	4 (1.0%)	2 (0.5%)	52 (13.3%)	329 (84.4%)	7	0.52

Source: Primary data (2025)

Table 7 indicates that there is broad agreement that socioeconomic factors significantly moderate the relationship between food security and climate change adaptation, according to the analysis of 397 respondents, with seven missing responses per item. With frequencies ranging from 323 to 337 (82.8% to 86.4%) and additional agreement percentages ranging from 11.5% to 14.9%, the majority of respondents strongly agreed with each of the twelve factors. For example, 97.9% of respondents agreed with the gender of the household head, with 337 (86.4%) strongly agreeing and 45 (11.5%) agreeing. In a similar vein, the combined agreement rates for age, education level, household size, income, and farm size were all above 97%, indicating that their moderating effects were widely acknowledged.

The highest standard deviation of 0.55 indicated slightly greater variation in cooperative membership, with 82.8% strongly agreeing and 14.9% agreeing. The standard deviations for all factors combined ranged from 0.47 to 0.55, suggesting that respondents were highly in agreement and that there was little variation. Low frequencies and percentages of disagree or neutral responses (all less than 1.5%) support the widely held belief that these socioeconomic factors play a critical role in determining how households secure food availability and adapt to climate change. This broad consensus emphasizes how crucial it is to take these aspects into account when creating policies meant to improve food security within the framework of climate adaptation. In line with these results, Gebre *et al.* (2023) noted that land size, income, and education all improve food security and adaptation in Kenya. In Ethiopia and Tanzania, respectively, Tulu *et al.* (2024) and Byaro *et al.* (2025) emphasized the significance of farm size, credit availability, and extension services. According to Mudzonga *et al.* (2024), cooperative membership has a major positive impact on households headed by women. Alemu and Wolde (2023) connected better food access to regular extension contact.

4. CONCLUSION

This study set out to examine the influence of climate change adaptation strategies on household food security in Nyabihu District and successfully achieved its stated objectives.

Regarding the first objective, the findings reveal that farm households have adopted a diverse range of climate change adaptation strategies, combining traditional practices, such as crop diversification, crop rotation, and mixed farming, with modern approaches, including the use of improved seed varieties and agricultural technologies. Although these strategies are widely recognized and supported by farmers, their full implementation remains constrained by limited access to financial resources, inadequate training, and insufficient agricultural inputs, particularly in rural settings. In relation to the second objective, the study established that the adoption of these adaptation strategies has led to notable improvements across all dimensions of household food security. Specifically, households reported enhanced food availability, improved access, better utilization, and increased stability. These improvements were further corroborated by local sector authorities, who observed increased agricultural productivity and strengthened resilience of local food systems.

Concerning the third objective, the study found a strong and statistically significant positive relationship between climate change adaptation strategies and food security outcomes. The results demonstrate that the adoption of these strategies significantly contributes to increased crop yields, improved household incomes, and greater resilience to climate-related shocks. Among the various strategies, the use of improved agricultural technologies and inputs emerged as the most influential in enhancing food security.

The study generally underscores the critical role of climate change adaptation strategies in strengthening household food security in Nyabihu District. However, to maximize their effectiveness and sustainability, there is a need for enhanced institutional support, including increased access to financial resources, capacity-building initiatives, and equitable distribution of agricultural inputs, particularly for vulnerable farming communities.

5. RECOMMENDATION OF THE STUDY

Based on the findings, the study recommends that Nyabihu District strengthens and expands agricultural extension services and capacity-building programs to enhance farmers' knowledge and effective adoption of climate change adaptation strategies.

This recommendation is grounded in the evidence that, although farmers are aware of both traditional and modern adaptation techniques, their full implementation is constrained by limited technical knowledge and skills. Strengthening extension services will facilitate the dissemination of climate-smart agricultural practices, improve access to relevant information, and support farmers in making informed decisions. Ultimately, this will enhance the adoption and proper utilization of adaptation strategies, leading to improved household food security and resilience to climate change.

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