Farmers' Knowledge, Attitude, and Motivation for Adoption of Climate-Smart Agroforestry in Two Contrasting Agroecosystems of Rwanda

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Introduction

In their report, the United Nations Development Program (UNDP, 2016) declared that the effects of climate change undermine countries' ability to achieve sustainable development. The Food and Agriculture Organization of the United Nations (FAO) inaugurated a new farming approach to conservation agriculture termed "climate-smart agriculture (CSA)"— a unified approach to improve food production with increased resilience to climate shocks (FAO et al., 2018). Climate-smart agroforestry (CSAF) is one "climate-smart agriculture (CSA)" integrated approach of combining production on one plot in the context of local land scarcity and climate change (Ntawuruhunga et al., 2023). Gradually, CSAF is receiving increasing attention from researchers as a sustainable land management option because of its ecological, climate resilience, economic, and social attributes (Ndoli et al., 2021). In poor-resource countries, agriculture is a critical, primary sector on which most of the population depends for their livelihoods. For example, in Rwanda, where agriculture contributes 25% of the country's gross domestic product (GDP) (NISR (National Institute of Statistics of Rwanda, 2023), studying mixed factors influencing CSAF uptake and promotion is essential.

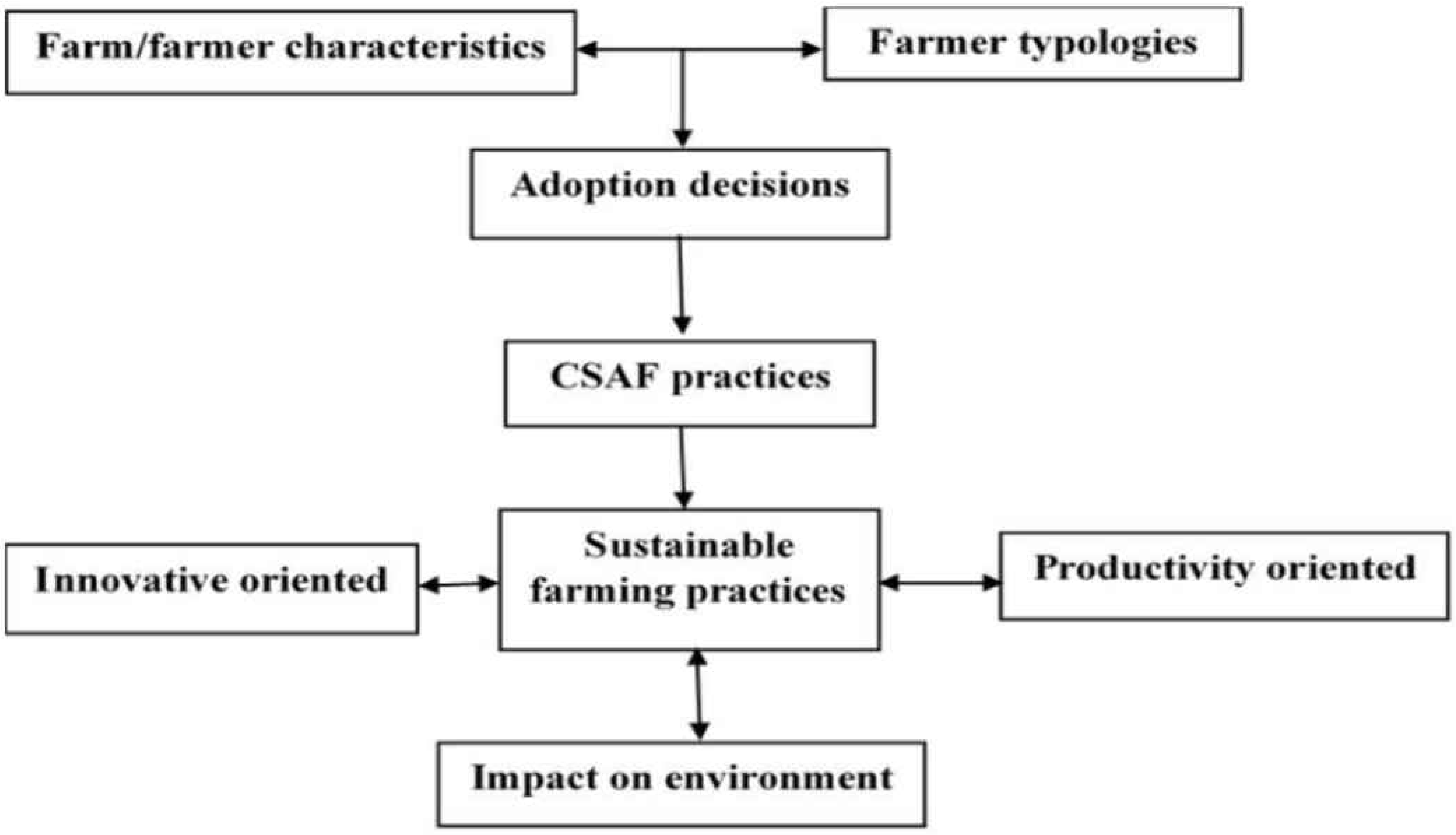
The major landscapes of Rwanda are rural, and agriculture lies in the hands of smallholder households. They work hard to ensure their families are food secure, and supplying resources is the main challenge that hinders them from practicing sustainable, productive, and climate-resilient farming. CSAF can be a pillar of effective agriculture and sustainable community livelihoods and development if adopted at scale. The role of farmers' knowledge is key in CSAF adoption. In some contexts, an emphasis on innovative farming practices that apply local and scientific knowledge can be greatly encouraged. Generally, farmers acquire practical knowledge, know-how, and skills through technology transfer, an integral part of the country's extension education process, which involves disseminating the latest technical innovations and know-how to farmers. The level of farmers' knowledge and information about CSAF will likely influence their attitudes towards these novel farming practices. The adoption decision is the 3rd and last step in the innovation adoption process (Dibra, 2015) that begins with the individual gaining knowledge about the new technology and dropping stereotypes suggesting competition with other crops. Attitudes also significantly influence farmers' adoption decisions (Kallas et al., 2010; Prokopy et al., 2008) when included in adoption studies as explanatory variables (Figure 1). Extension education is a key in knowledge and technology diffusion to the farmers, their behavior change, and its uptake. Extension education is a key driver of technology adoption, among other key determinants. Despite the increasing interest and benefits, CSAF is still considered a "novelty" in certain agroecological zones of Rwanda. This study would demonstrate the importance of extension education in modern farming techniques of combining production on one plot in the context of local land scarcity and climate change. Extension education plays a significant role in developing resilient agricultural systems (Gautam, 2015; Gautam et al., 2019).

Conceptual Framework

Extension education is based on applying knowledge and skills to spread scientific innovation among end-users (e.g., farmers) to improve farm productivity and sustainability. Farmers accept recommendations once they perceive potential increased benefits from implementing such recommendations (Chavas and Nauges, 2020). Simultaneously, this truth doesn't tell the whole story. Since farmers operate in physical, social, economic, and cultural environments, other factors may play a significant role in determining if farmers will accept and eventually adopt recommended innovations, as illustrated in Figure 1.

Figure 1

Framework of farmer adoption of CSAF for sustainable farming practices. Adopted from Osawe and Curtis (2024).



Despite the challenges of land fragmentation and scarcity due to high population pressure, rainfed smallholder farming is common in Rwanda. Farmers engage in CSAF with limited information about local contexts that influence agricultural productivity and their livelihoods, particularly scientific knowledge regarding physical and socioeconomic attributes (Amare et al., 2019; Bishaw et al., 2013; Jemal et al., 2018). Technology adoption research, through a better understanding of individual adoption decisions, can assist decision-makers in realizing this potential via better policy design and targeting (O'Shea et al., 2018). Knowledge, attitudes, and motivation of potential adopters are some of the important characteristics influencing these decisions. Therefore, the characterization of farmers' knowledge, attitudes, motivation, and demographic characteristics can inform policy to identify the untapped potential of CSAF and to promote the adoption and scaling up of CSAF practices. While existing research on technology adoption and farmers' knowledge, attitudinal, and motivational typologies is useful, they remain largely research-context-specific (Karali et al., 2013; Sulemana and James, 2014). To the best of our knowledge, the intertwined relationships between farmers' knowledge, attitude, and motivational factors and the adoption of CSAF have not been holistically explored to understand and fix challenges inherent to these practices. Moreover, while important, knowledge, attitudes, and motivational factors have received less attention, possibly because they are more difficult to measure than quantitative variables (O'Shea et al., 2018), such as farmer age and farm size, and spatial characterization, such as altitude and land use/land cover. Against this backdrop of a research gap, a study was conducted in two contrasting agroecological zones of Bugesera and Rulindo regions of Rwanda to investigate how knowledge, perceptions, and motivational factors influence the uptake of an innovation in farming. Doing so gives policymakers and stakeholders a clearer understanding of how farmers' knowledge, attitudes, and motivation can be used to better target policy incentives through extension education, to organize, stabilize, and expand CSAF practices across different farming systems.

Purpose and Objectives

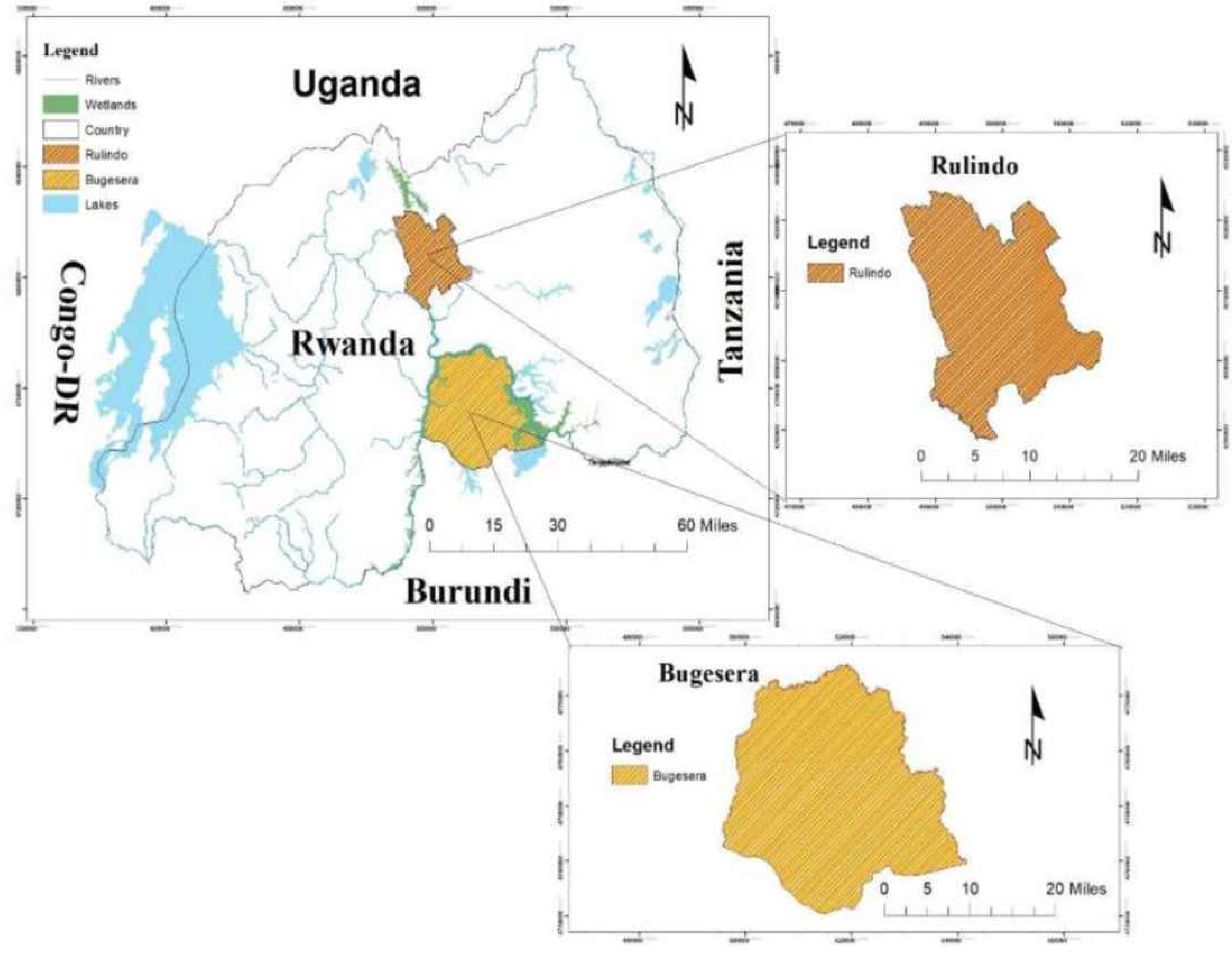
In Rwanda, as in any other tropical country, farming offers unique opportunities and challenges due to the contemporary challenge of climate change. It is characterized by rainfed subsistence farming with almost quasi-non-existent technologies and an inadequate, ineffective, and non-operational extension education system. We assume that adequate farmers' knowledge of CSAF, positive attitude towards CSAF, and motivation will enhance the uptake, adoption, promotion, and benefits. Thus, this study aimed to fill this gap by (i) assessing farmers' knowledge, attitude, and motivational factors regarding CSAF; and (ii) determining the association between farmers' knowledge, attitude, and motivational factors and the adoption of CSAF. Using the tailored survey to address the unique context of Rwandan farmers and extension services, this paper shows how tailored extension services, informed by the survey findings, can promote CSAF adoption, improve productivity, and food security.

Methodology

This study was conducted in two contrasting agroecological zones of Bugesera and Rulindo regions of Rwanda (Figure 2). Bugesera is located in the drier plains of eastern Rwanda, while Rulindo is a highland area of rolling hills and mountainous landscapes in northern Rwanda.

Figure 2

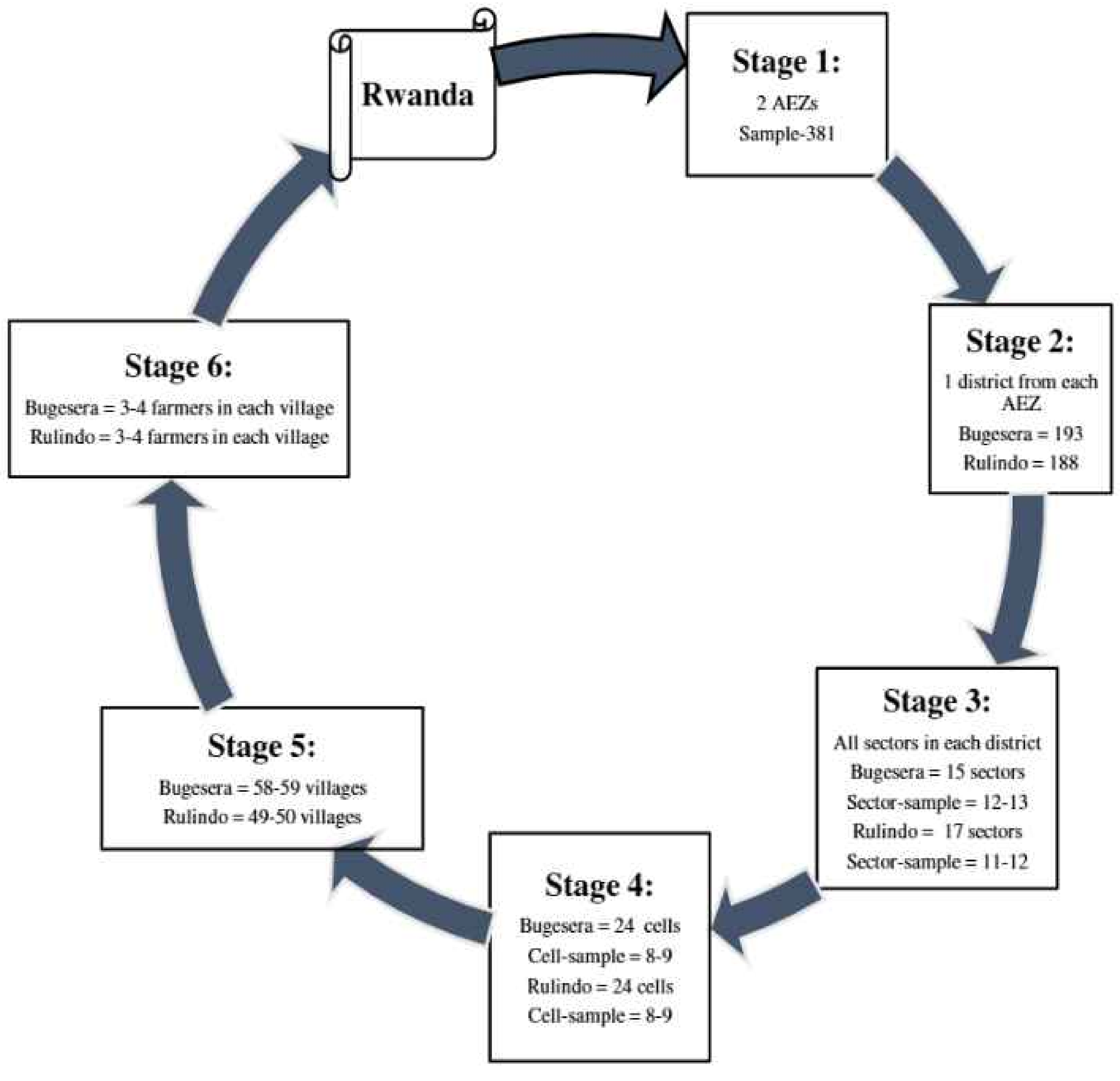
Map of Rwanda with study areas (Bugesera and Rulindo) (adapted after CGIS)



This study employed a multi-stage stratified random sampling method to select the study zones, from which 381 (193 from Bugesera and 188 from Rulindo) farm households were sampled (Figure 2). We used the agroecological map of Rwanda divided into four major agroecological zones: the eastern plains, central plateau, highlands, and the area surrounding Lake Kivu (Iiyama et al., 2018). In the second stage, two districts were selected from the two agroecological zones, one from each, considering both heterogeneity and homogeneity in certain characteristics such as biophysical and climatic conditions, cropping patterns, water resources, and irrigation systems. In the third stage, all the sectors (sub-administrative entities) were selected from each district. In the fourth stage, we randomly selected 24 cells from each sector using stratified sampling. In the fifth stage, fifty-eight to fifty-nine villages and forty-nine to fifty villages were randomly selected from each cell in Bugesera and Rulindo, respectively, using the Rwanda village statistics (NISR, 2023). In the sixth and last stage, about three to four farm households were randomly selected from each village in both study areas, irrespective of the size of their land holdings or farm (Figure 3).

Figure 3

Stages of sampling to select farm households in the study areas



To determine the sample size (Table 1), this study used data published from the Rwanda Agricultural Household Survey Report 2020 (National Institute of Statistics of Rwanda, 2021). These data show that about 166,000 (45.60%) of 364,000 (N) rural households in Bugesera and Rulindo are farmers. So, 381 (n) farmers were selected to form the total sample (Wonnacott & Wonnacott, 1969). Sampling intensity was proportionally allocated to each subsample based on farming population size. Increasingly, using the list of farmers selected for interview, a simple random sampling was used to select the sample units.

Lists of farmers from the selected villages were prepared with the assistance of village leaders, and 381 farmers were randomly picked for interviews, of which 193 were from Bugesera and 188 from Rulindo.

Table 1.

Sampled sites and size

Sites	Households	Farmer households	Sample size (*n*)	% sample
Bugesera	204,000	84,000	193	50.66
Rulindo	160,000	82,000	188	49.34
Total	364,000	166,000	381	100.00

Before surveying the selected regions, the questionnaires were pre-tested on 11 random farmers from the two separate study areas (Bugesera (6 farmers) and Rulindo (5 farmers) and later revised to fit into the context of the local biophysical, climatic, and socio-economic situations. Face-to-face interviews with farmers were conducted on the farms. Informal agreements were made before the start of any session with the farm household heads by explaining the purpose and objectives of the study. Data were collected from farmers from April to September 2023.

The original questionnaire was built on an Open Data Kit (ODK) software uploaded on an Android mobile device (tablet) under the ODK Collect application. The built form on ODK included the Global Positioning System (GPS) capturing the farm coordinates, socio-economic information, bio-physical information, etc. Research variables included agroecological zone, altitude, gender, age, civil status, education, household size, *ubudehe* (household poverty level), farm size, farming experience in CSAF, owning a radio, owning a mobile phone, livestock size, farm-river distance, training, extension visits, farmer knowledge, attitude, and motivation in CSAF adoption. In addition, we conducted three focus group discussions (FGDs), with 8-12 participants. The discussion sessions focused on the knowledge, attitude, and motivational factors that drive farmers to adopt CSAF practices. We also interviewed the local government (districts), the Albertine Rift Conservation Society (ARCOS), and the model farmers to complement our findings. Two interviews were conducted with local officials (districts), one interview with an ARCOS staff member, and two model farmers. These officials were contacted to acquire an overview of CSAF practices in the study areas. We also conducted a literature review to complete the findings of this research.

The data were analyzed using descriptive and inferential statistics in Microsoft Excel, Stata, and R software (Tokede et al., 2020). Descriptive statistics, correlation, and regression analyses were applied. Descriptive statistics were used to calculate the frequency distribution, mean, percentage, and standard deviation, describing the respondents' demographics and CSAF practice status, as well as to assess the farmers' knowledge, attitudes, and motivational factors in the study areas. The outcome variables were investigated using the Frequency and Percentage Method (FPM) with the Rank Order of tested responses. A logistic regression model (Kabirigi et al., 2023), termed "logit", was utilized to test how the farmers' knowledge, attitude, and motivation (predictor variables) influence the adoption of CSAF (outcome variable). According to Sperandei (2014), the logit regression analysis is performed to compute a statistic (odds ratio) that estimates how changes observed in the dependent variables (binary outcomes) are associated with changes in predictor variables. In this study, the outcome variable was the adoption of CSAF (1 = adopting or 0 = not adopting). Input variables were farmers' knowledge, attitude, and motivational factors to adopt CSAF. The outcome variable — the adoption of CSAF — depicts heterogeneity in adoption among CSAF farmers (Kabirigi et al., 2023). The nature of the outcome variable imposed the kind of regression we had to perform. The data dictated the use of logistic regression. A logit regression can be binomial, ordinal, or multinomial (Kabirigi et al., 2023). As described in Table 1, the data show that the adoption of

CSAF is a binary outcome. We therefore analyzed the data by performing a binomial logistic regression analysis. In this respect, we coded the outcome variables as "1" and "0" (1 = adopting, 0 = not adopting). This coding was chosen as it leads to the most straightforward interpretation of results. It is worth noting that this approach enables the quantification of the model parameter perturbations affecting the probability of occurrence of a certain binary outcome (Morotti & Grandi, 2017). Employing the response variable "adopt CSAF", the regression model is depicted as follows:

$$p_k(adopt\ CSAF) = \begin{cases} \left(\frac{1}{1+e^{-Z_k}}\right) & for\ adopt\ CSAF_k = 1 \\ \left(1 - \frac{1}{1+e^{-Z_k}}\right) & for\ adopt\ CSAF_k = 0 \end{cases} \quad (1)$$

With:

$$Z_k = \beta_0 + \beta_1 \times Knowledge + \beta_2 \times Attitude + \beta_3 \times Motivation \quad (2)$$

Ceteris paribus, the parameter β_i represents the expected average change in the response variable for a one-unit change in the explanatory variable. Therefore, we are modelling the response variable "adopt CSAF" as explained by knowledge, attitude, and motivational factors.

Odds ratios are computed to report the strength of association between an event (response variable) and one or more input variables (predictor variables) (Kabirigi et al., 2023). The formula (Muhamadi & Boz, 2021) was used to compute the odds ratios for all predictor variables:

$$Exp\beta\ or\ odds = \frac{P}{1-P} \quad (3)$$

We transformed results into odds ratios (OR) reflecting the increase or decrease in odds associated — ceteris paribus — with the influence change in the explanatory variable (Norton et al., 2018). Its interpretation is that — all other predictor variables being held constant — how many times the likelihood for the farmer with a high level of CSAF adoption increases for a single predictor when the predictor is increased by one unit. Importantly, odds ratios measure how strongly an outcome is associated with its predictor. These measures have been extensively used in research to analyze and interpret results from logistic regression models (Sprince et al., 2003; Ohlmacher & Davis, 2003; Jasinski et al., 2005; Rautiainen et al., 2009; McDonald, 2014).

Three regression explanatory variables, notably knowledge, attitude, and motivation, were used in this study for the binary logistic regression model. Various techniques are used to select variables that fit the model. They include the stepwise approach that combines the forward collection and backward elimination of predictor variables, to be added or removed statistically, without disturbing the model prediction accuracy (Hosmer & Lemeshow, 2000). Reference groups were farmers without knowledge of CSAF farming, farmers with negative attitudes towards CSAF, and unmotivated farmers regarding CSAF practices. Our regression model reached a higher significance level by excluding the attitude variable, which did not satisfy the condition of model goodness-of-fit (Muhamadi & Boz, 2021).

Main Results

Table 2 highlights different aspects regarding the knowledge of farmers about CSAF that were deemed important to advance the investigation in this study. The majority (65.88%) of farmers in study areas know that CSAF systems contribute to soil fertility and erosion control, 65.35% know that tree cultivars used for CSAF include fruits and fodder, 64.57% know that CSAF maximizes land usage, 63.25% know that CSAF contributes to improved income and food security, whereas 62.20% know that CSAF involves crop-tree integration, as portrayed by rank order of tested responses. These results imply that farmers had good knowledge about CSAF, with an average of 64.25% in the study areas. It may be inferred that more than half (50%) of survey participants have adequate knowledge of CSAF. Therefore, more exposure needs to be given to the farmers to increase the uptake and adoption levels of CSAF.

Table 2.

Farmers' knowledge of CSAF in surveyed areas (n = 381)

	True (%)	**False (%)**	**Rank order**
CSAF involves crop-tree integration	62.20	37.80	**5**
Tree cultivars used for CSAF include fruit, fodder	65.35	34.65	**2**
CSAF systems contribute to soil fertility and erosion control	65.88	34.12	**1**
CSAF maximizes land usage	64.57	35.43	**3**
CSAF contributes to improved income and food security	63.25	36.75	**4**
Average	**64.25**	**35.75**	

Results from farmers' attitudes towards CSAF (Table 3) showed that 66.93% of respondents concurred with the statement that the overall income/benefits from CSAF are more than pure agriculture and forestry, 66.14% agreed to the statement that CSAF improves the agroecosystem's micro-climate, 65.62% agreed to the statement that every farmer should practice CSAF, 65.35% agreed to the statement that CSAF reduces the incidence of total crop failure, whereas 64.57% of respondents endorsed the statement that CSAF helps farmers to become self-reliant in timber, fuel, fruits, and fodder as portrayed by per rank order of tested responses. On average, farmers had a positive attitude towards CSAF (65.72%) in the study areas.

Table 3.

Farmers' attitude towards CSAF and its benefits in surveyed areas (n = 381)

	Agree (%)	**Disagree (%)**	**Rank order**
CSAF helps farmers to become self-reliant on fuel, fodder, timber, and fruits	64.57	35.43	**5**
Overall income/benefits from CSAF is more than pure agriculture and forestry	66.93	33.07	**1**
CSAF reduces the incidence of total crop failure	65.35	34.65	**4**
CSAF improves the microclimate of the area	66.14	33.86	**2**
Every farmer should practice CSAF	65.62	34.38	**3**
Average	**65.72**	**34.28**	

Regarding factors of motivation for CSAF adoption, results indicated that 46.72%, 45.93%, 45.41%, 45.14%, and 35.96% of surveyed farmers expressed that high financial returns, utilization of unproductive lands, environmental amelioration, availability of incentives (seedlings and other inputs), and cottage industry development were, respectively, the highly motivating factors in influencing adoption of CSAF practices as per rank order of test responses (Table 4). The 'high financial returns' factor is top-ranked and highly motivating for adopting CSAF in the farmlands. The 'Utilization of unproductive lands' factor is ranked second in the same ranking order. The other motivational factors like 'environmental amelioration', 'availability of incentives (seedlings and other inputs)', and 'cottage industry development' were in order of 3rd, 4th, and 5th, respectively.

Table 4.

Motivational factors for CSAF uptake in surveyed areas (n = 381)

Factors of farmers' motivation	**Highly motivating (%)**	**Moderately motivating (%)**	**Least motivating (%)**	**Rank order**
High financial returns	46.72	27.56	25.72	**1**
Utilization of unproductive lands	45.93	29.40	24.67	**2**
Availability of incentives (seedlings & other inputs)	45.14	28.61	26.25	**4**
Cottage industry development	35.96	25.46	38.58	**5**
Environmental amelioration	45.41	29.13	25.46	**3**
Average	**43.83**	**28.03**	**28.14**	

We used a binary logistic regression model to establish the effects of knowledge, attitude, and motivational factors on the adoption of CSAF (Table 5). Using a 5% statistical significance level, results showed that both knowledge and motivational factors significantly influenced CSAF adoption. The effect of farmers' knowledge on CSAF adoption was statistically significant (Table 5). The odds ratio for knowing CSAF (resulting from training in CSAF farming) shows that — ceteris paribus — farmers knowledgeable of CSAF were 2.5 times more likely to adopt CSAF than farmers without knowledge of CSAF farming. Similarly, the impact of farmers' motivating factors on CSAF adoption was statistically significant (Table 5). Holding all other variables constant, the odds ratio for being motivated by CSAF benefits was 0.6 times more likely to practice CSAF than unmotivated farmers for CSAF uptake.

Table 5.

Summarized logistic regression analysis results

Significant predictors	**OR**	**SE**	**Z**	**P>|z|**	**95% CI of OR**
Average knowledge	2.573	0. 483	5.03	0.000*	1.780-3.720
Average motivation	0.631	0. 049	-5.81	0.000*	0.540-0. 737
OR = odd ratio, SE = standard error, CI = confidence interval					
Wald chi2(2) = 35.53	Number of respondents = 381				
Prob > chi2 = 0.0000	Log likelihood = -243.51257				

*significant at 0.01

Note: The attitude variable was dropped from the regression model.

Discussion and Conclusion

This study's findings point to three key conclusions to understand how knowledge, attitudes, and motivation factors can influence farmers to adopt CSAF practices on farms. First, descriptive results indicate that most participating farmers are knowledgeable of CSAF practices, have positive attitudes towards CSAF practices, and are motivated to adopt them. The positive knowledge, attitudes, and motivation reflected in respondents may result from the sensitization and extension programs imparted to farmers. Farmers' knowledge, positive attitudes, and motivation to embrace an innovation align with previous studies that extension exposure is paramount to disseminating innovation among farmers (Dolisca et al., 2006; Islam et al., 2017; Lee et al., 2009; Marcus, 2001; Mathijs, 2003; Munthali et al., 2019; Tega and Bojago, 2023; Uppal and Pathania, 2008; Weir and Knight, 2004). Second, significant correlations underscore the influence of demographic factors such as gender, age, civil status, education, household size, *ubudehe* (social category), farm size, CSAF farming experience, communication technologies (owning a radio and a mobile phone), livestock herd size, farm-river distance, training, and extension visits on farmers' knowledge and attitudes towards CSAF adoption. These results concur with the literature that farmers' knowledge, attitude, and motivation are affected by socioeconomic factors (Dalmiyatun et al., 2017; Das et al., 2021; Kameswari et al., 2011; Maake and Antwi, 2022; Meijer et al., 2015; Oladele, 2004; Reddy et al., 2017; Sebeho and Stevens, 2019; Shankaraiah and Narayanaswamy, 2012). Thirdly, results highlight that farmers with greater knowledge of CSAF practices are likely to adopt them, while those perceiving CSAF as profitable farming systems (or motivated by expected comparative high profit returns) show higher adoption rates (Ahmad et al., 2023; Dalmiyatun et al., 2017; Fischer and Vasseur, 2002; McGinty et al., 2008; Mekoya et al., 2008; Milne, 2006; Sileshi et al., 2008; Sood and Mitchell, 2004; Tokede et al., 2020; Zaca et al., 2023; Zubair and Garforth, 2006). This finding could inform the importance of extension education for technology dissemination among farmers using hands-on experience, especially in resource-poor countries with low literacy rates.

Recommendations

In Rwanda, CSAF is gaining traction as a promising strategy for enhancing farm resilience and productivity in the face of climate change. Research suggests that CSAF practices can significantly improve farmers' yields, incomes, and food security. CSAF practices can also effectively adapt to the sloped terrain of northern Rwanda and the low semi-arid regions of eastern Rwanda. While challenges remain regarding widespread adoption, the growing awareness and positive farmer attitudes, with government support, offer a positive outlook for the future of CSAF in Rwanda. We recommend that policymakers and stakeholders concentrate on investing in extension services for farmers. Knowledge transfer through farmer field schools (FFSs) and mobile communication technologies can upscale the adoption of CSAF. Moreover, capacity-building initiatives for farmers, led by extension services, should organize a training of trainers (ToT) program among farmers to establish role model farmers, facilitating the transmission of knowledge and skills to build motivation. Initiating ToT education programs and role model farms may serve as experiential techniques to promote learning, foster positive attitudes, instill motivation, and showcase the benefits of combining production on a single plot in the context of local land scarcity and climate change. This approach could set positive trends for role model farmers, encourage information exchange, behavior change, and foster motivation for CSAF upscaling (Degrande et al., 2015; Simpson et al., 2015).

Ultimately, the structure of this analysis reflects calls from Bernard et al. (2019) and others to consider that CSAF does not typically have its own policy space. It belongs to many sectors, and its various aspects span across agriculture, forestry, natural resources, and climate change policies and strategies. This analysis suggests that countries across Sub-Saharan Africa (SSA) and the global south, in general, should increase investments in rural advisory services, research, and monitoring systems to increase the capacity for CSAF, as a critical way to support farmers (Bernard et al., 2019) and tackle climate change. The support for farmers should be done with intentional and strong linkages to the institutions providing research and training, as well as implementing agents such as farmer group leaders, government extension and non-government actors such as NGOs, that would include working across sectors and stakeholders so that expertise, often held in research and education experimentation centers, and in environment ministries, is used to train advisory staff or tree nursery operators, typically within civil society organizations (CSOs) operating in rural settings. CSOs support governments in poverty alleviation in the Global South, provide analysis and expertise, and help in the implementation of international agreements, including Agenda 2030 and the SDGs. They can typically be ideal partners in facilitating technology transfer to the farmers. These results echo and confirm Jama & Zeila (2005) and Sheppard et al. (2020) who reported that extension education has supported farmer learning in the southern African region and optimistically assert that CSAF has the potential to achieve the global goals of poverty alleviation and increased food security while facilitating global environmental protection in the face of climate change in various regions of the globe.

Future research and implementation related to CSAF should continue adopting a systems-oriented approach to designing projects that simultaneously analyze, assess, and balance local knowledge among farmers. National and regional policies aimed at promoting CSAF must be tailored to local contexts to reduce trade-offs regarding desired outcomes and impacts, especially since most farmers in least-developed and developing countries are illiterate. Our contextual findings offer a more nuanced understanding of farming situations in both the Global South and North. The local conditions and research focus on farmer knowledge differ significantly between these regions. In the north, where literacy levels are high, research often employs quantitative methods. Conversely, southern contexts favor qualitative, participatory approaches to understand farmers' accumulated experience and adaptive capacity to environmental challenges, including rapid agricultural changes and climate change. As shown in our study, in the Global South, farmers' local, accumulated knowledge is crucial for sustainable agriculture and resilience, often requiring integrated, context-specific methods to incorporate their expertise meaningfully into research and extension. Introducing new farming technologies may encounter resistance, especially if they lack immediate value, while traditional farming methods may be maintained without added benefits. On the other hand, in the Global North, the utilization of advanced literacy skills in research often focuses on specific technical knowledge, such as the application of agrochemicals and planting techniques, which frequently relies on traditional scientific validation.

One limitation of this study is that the data are cross-sectional and may not fully capture the dynamic process of CSAF adoption and unfolding over time, which would require longitudinal studies that track farmers over a period in a cross-site comparative study.

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