Beyond gender-blind climate action: a participatory framework for inclusive climate-smart agriculture

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Abstract

Purpose – The purpose of this study aims to identify gender-differentiated climate risks and access to resources; participatory rank of CSA practices by gender and agro-ecology; and link priorities to economic indicators to be scaled to action.

Design/methodology/approach – The authors used the Climate Risk and Vulnerability (CRV) appraisal, which is a combination of participatory rural appraisal (PRA), rapid rural appraisal (RRA), focus groups and household survey, in Gulu, Uganda ($n = 50$ households) and Kilolo, Tanzania ($n = 50$ households) between March and October 2014.

Findings – This data is then subjected to extensive analysis, triangulation and validity. When applied to data from Tanzania and Uganda, the CRV shows that various social groupings (based on gender) and agricultural ecological regions exhibit varied levels of vulnerability, restrictions and CSA goals at different locations. Stakeholders may target and execute CSA while simultaneously considering biophysical, social and economic problems through the CRV.

Originality/value – Resource mapping, climate and historical calendars, cropping calendars, organization mapping, transect walks, key informant interviews, farmer interviews and a pairwise ranking matrix are all part of the CRV methodology, which integrates frequent PRA and RRA instruments into a single system that separates the gender scale.

Keywords Climate-smart agriculture, Gender scale, Participatory rural appraisal, Rapid rural appraisal

Paper type Research paper

1. Introduction

The challenge of climate change is one of the most urgent problems in sub-Saharan African agriculture. Crop yields and food security are directly endangered by the increasing temperatures, unpredictable rainfall patterns, decreasing soil fertility, deforestation and the new epidemics of pests and diseases (Sherpa, 2025). Empirical evidence indicates that maize

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yields in certain regions of East Africa have fallen to 1.6 tons per hectare in the last 20 years (compared to 6 tons per hectare), and rice yields have fallen to 4 tons per hectare (compared to 7 tons per hectare). Such shocks are not purely biophysical, and they also have social implications. The women farmers usually have a greater workload in crop management, whereas men dominate the marketing of commercial crops (Mwongera *et al.*, 2022).

According to (Sallahu *et al.*, 2024), factors such as institutional systems, resource status and financial, social, ecological and climatic circumstances might impact the adoption of CSA at land or farm size. Because CSA is context-dependent, it is necessary to provide a diversity of alternatives for the various situations across dimensions (Mkupete and Davalos, 2025). That includes interactions between demographically distinct groups (such as those defined by gender and age). This procedure includes analyzing the landscape (e.g. various agro-ecological zones, climatic governments, communities and land use) for CSA pillars, as well as for synergies and goals between various social groups. Techniques that boost production and adaptation ability may take precedence over those that enhance carbon storage and decrease emissions in low-input, small-scale agricultural systems found in developing nations (Ilesanmi, 2024). With adaptation and mitigation measures working in tandem rather than against one another and even bolstering one another at times, a win-win situation is not out of the question. Some examples of how soil organic content can increase soil adaptation ability include enhancing productivity and preserving water and carbon sequestration (Huyer *et al.*, 2024). The gender disparity in agricultural productivity between women and men is brought about by gender-related obstacles, in which women are not given the same opportunities to experience the benefits realized by CSA adoption, or there are obstacles that hinder the crop production and incomes of women (Ayuya *et al.*, 2024). These barriers are gender norms and gender biases; gender division of labor and augmentation in women workloads of climate effects; access to land and livestock; access to inputs (e.g. adapted/improved seed and fertilizer; access to information and climate services; access to credit and financial resources. Consequently, this can lead to the entrapment of women in a nonvirtuous cycle whereby the lack of incomes due to low productivity will result in them not being able to invest in CSA options and consequently their crops will be further affected by climate effects (Bayala *et al.*, 2021).

Research problems: Although significant investment has been made and the policies have been given serious consideration, a majority of approaches to CSA are ultimately flawed in three respects. To start with, they are context-blind and top-down: developed by external experts based on aggregate data, they cannot reflect local agro-ecological diversity, the institutional landscape, or households' resource limitations (Gachungi, 2023). Second, they are gender neutral or gender blind: by viewing farmers as a homogenous group, they overlook the influence of gendered division of labor, access to resources and authority on predisposition to climate change, as well as the ability to implement adaptation strategies (Tsige *et al.*, 2024). Third, they do not validate participation: the community in which the interventions have shaped the lives of its people is seldom engaged in prioritizing needs and setting ranking practices, or in determining their feasibility (Haque *et al.*, 2023). It is natural to predict the consequences: low adoption, wasted resources, and, in certain instances, greater suffering for the most vulnerable. Labor-intensive methods, such as mulching or composting, can be assigned to women without realizing that they already work 45% longer hours than men in crop management, while also preparing food at home, collecting water and taking care of kids. The extension services of institutional support mechanisms, credit schemes and farmer cooperatives are usually not available to women owing to structural barriers that CSA programs fail to address.

Research gap: Earlier research has advanced CSA investment frameworks and policy guidelines, and has tended to homogenize farmers, lack disaggregated evidence on gender and miss the micro-level realities of communities (Nigussie *et al.*, 2021). The drawbacks to these methods are that they are based on expert-driven or country-wide data and do not take into account the variety of local institutions and resources or climate exposures. The literature lacks a bottom-up, participatory tool that incorporates both qualitative and quantitative data to determine context-specific CSA practices. The CRV methodology, a combination of participatory rural appraisal (PRA) and rapid rural appraisal (RRA) approaches, is used to assess the impacts of climate change on agricultural communities in Tanzania and Uganda. The existing CSA frameworks have three major blind spots that hinder uptake: First, they are based on top-down, expert-controlled data that erode local agroecological diversity and farmer heterogeneity. Second, they consider gender a secondary consideration rather than a primary factor in climate vulnerability and adaptive capacity. Third, and most importantly, there is no systematic methodology that combines participatory community-level priorities with household-level economic analysis to determine which CSA practices actually work for whom, under what conditions, and at what cost.

1.1 Novelty and contributions

The gaps in this paper are directly addressed by proposing and implementing the Climate Risk and Vulnerability (CRV) appraisal. This new methodological framework integrates gender-disaggregated participatory instruments and household economic analysis systematically to define context-specific CSA priorities. CRV framework is a depiction of four major innovations:

(1) *Methodological innovation:* CRV is the first method to integrate PRA tools (cropping calendars, climate calendars, historical calendars, organizational mapping, resource mapping, comparative ranking) with RRA tools (transect walks, key informant interviews) and quantitative household surveys to produce both qualitative and economic data (gross margins, wealth indices, determinants of adoption). This integration facilitates triangulation, thereby justifying results across methods.

(2) *Gender-based design:* Unlike current frameworks, which incorporate gender as an appendix, CRV incorporates gender disaggregation at all levels. All participatory activities are done in gender-separated groups. All calendars, maps and rankings take into account male and female perspectives. The quantitative analysis directly compares adopters and nonadopters by gender, showing which groups have increased workloads, who controls revenues, and who has access to institutional support.

(3) *Scaling pathways institutional mapping:* CRV involves systematic organizational mapping to understand which NGOs, government agencies, farmer cooperatives and private-sector actors are present in each location, how they are connected and which are accessible to women and men. This offers practical intelligence for formulating outscaling plans rather than general advice.

(4) *Multi-site comparative design:* This paper uses CRV in two different contexts (Gulu, Uganda, post-conflict, high organizational density and Kilolo, Tanzania, commercial agriculture zone, low institutional presence) to illustrate the impact of institutional context on CSA priorities and adoption potential. The comparative design indicates which findings can be generalized and which are specific to the site.

2. CRV experimental design

2.1 The CRV

Utilizing a variety of instruments developed for both quick and interactive rural evaluations, the CRV is a multidisciplinary strategy. For instance, we collect data on farmers' and specialists' financial assets and funding, as well as demographic details like their education level, family size and farm characteristics, using RRA approaches that aim for quick data extraction (Prajapati *et al.*, 2025). Community members are invited to participate in focus sessions as an element of the CRV's PRA efforts. There are 3 RRA tools are utilized: transect walks, major data interviews, and farmer interviews. This study used the Climate Risk and Vulnerability (CRV) methodology, which is a participatory tool used to analyze climate change impacts on smallholder farmers and identify suitable CSA strategies. The CRV uses a combination of both qualitative and quantitative methods to provide a thorough understanding of climate vulnerability. By utilizing gender-disaggregated techniques, the CRV is able to evaluate the disparities in how men and women view the current problems, as well as the possible benefits and drawbacks of every CSA option for the various demographics. There are a number of scales that the CRV covers, starting with the farm and moving to home, community, landscape preservation and regional sectors. By combining 3 CSA pillars with the three aspects of sustainable growth economic, sociable and environmental the chosen set of nine instruments may accurately measure relevant indicators. Following detail provides a summary of the methodology.

The PRA used several tools to gather information and to understand gender roles, resource management, and agricultural practices in the research sites. The cropping calendar had two major functions: defining the important crops, the order of crop harvesting and related activities; and analyzing the distribution of work and resources among men, women, and children. This was useful in evaluating the effect of gendered time use on the adoption of particular management practices. The practice of organizational mapping entailed participants developing Venn diagrams to visualize relationships between agricultural organizations and evaluating the degree of collaboration and the capacity gaps that can be used to scale up CSA. Resource mapping helped participants identify agroecological areas and visualize natural and artificial resources, including water bodies, pastures and infrastructure. Group discussions allowed participants to reflect on past resource changes to inform future action plans. The climatic calendar showed the seasonal rainfall and dry seasons, helping communities understand climatic variability and its impacts on crop production. Participants discussed vulnerabilities and coping methods, distinguishing between normal, rainy and dry years. The historical calendar was used to show the historical pattern of changes in climate, natural resources and agricultural performance by gender with a 1–5 scale. Interviews were conducted alongside transect walks, which provided on-site observations of biodiversity, land use, and farms. Finally, the interviews with farmers and key informants provided detailed information on farming systems, gender roles, market access and climate risks and comparative ranking enabled participants to compare and prioritize various agricultural practices, particularly CSA techniques, by group consensus and using frequency-based scoring. Combined, these PRA tools provided a holistic insight into gendered agricultural relations and community-based management of resources.

2.2 Engaging with stakeholders

Farmers, community leaders, investigators, agricultural specialists at the community level, extension representatives at the regional level and members of the commercial sector, donor organizations and policymakers are among the many groups and individuals across which the CRV interacts.

There are six distinct PRA and 3 RRA tools that are used throughout the full-day farmer's workshops that take place at each location. Different social categories (ethnic, gender and age) are invited to get involved in the workshops using suitable means that are taken out according to the local environment. To ensure that the participants from both Tanzania and Uganda were statistically and demographically corresponding to their respective populations, we sent requests to local farmer organizations and authorities in both countries. According to (Derenoncourt *et al.*, 2022) and (Krueger, 2014), to minimize bias, it is advised that the research location attend at least three workshop events. Including as many people as possible from all walks of life and encouraging farmers to get involved is ideal. Depending on factors such as age, gender and other demographics that might influence participant responses, the workshop will divide participants into smaller focus groups. (Mnukwa *et al.*, 2025) and (Ozor *et al.*, 2024) both agree that eight to ten people is the sweet spot for a functional focus group. People who are well-versed in the local climate and/or agriculture are contacted one-on-one to serve as key informants. Authorities at the district, ward and village levels, as well as rural groups and farmer associations, fall under this category. A farmer conducts surveys with the primary decision-makers in each family. Combining various PRA instruments and information-gathering strategies may help triangulate and validate data (Adhikari and Ghimire, 2025). The components of the CRV are illustrated in the info-graphics in Figure 1.

2.3 Collecting and analyzing quantitative data

The gross margin analysis was chosen as the main economic assessment tool because it is specifically tailored to the conditions of smallholder farming, where fixed costs are low and variable costs dominate production decisions (Wright *et al.*, 2024). GMA generally compares crop enterprises and determines how economically viable CSA practices are in the short term (by subtracting variable costs from gross revenue), unlike net profit analysis, which usually requires detailed fixed cost data (which is not always available among smallholders). The gross margin analysis (GMA) formula applied was:

2.3.1 Gross margin = gross revenue – variable costs. This methodology has been widely tested in East African smallholder research to assess agricultural profitability and to compare adopters and nonadopters of superior practices (Derenoncourt *et al.*, 2022). This study is especially suited to GMA due to:

- the fact that it incorporates the immediate cash flow implications that motivate smallholders to adopt farm equipment;
- that it does not involve complicated depreciation calculations, which smallholders may lack; and
- that it allows direct comparison of the different crop types and farming systems.

The PCA was used to create wealth and asset indices using the standard approach developed by the Demographic and Health Surveys (DHS) program and confirmed in many studies of development economics (Barooah *et al.*, 2023). PCA is the best method of generating composite indices out of a set of household characteristics since:

- it objectively weighs the variables according to their variance across households and not arbitrary;
- it eliminates multicollinearity of correlated assets;
- it yields a continuous index that can be regressed; and
- it is accurate in determining socioeconomic status in rural African settings where income data is an invalid measure:

$$I_i = \sum_{k=1}^{m} \omega_i \left(\frac{h_k \text{-} \bar{h}_k}{s_k} \right) \quad (1)$$

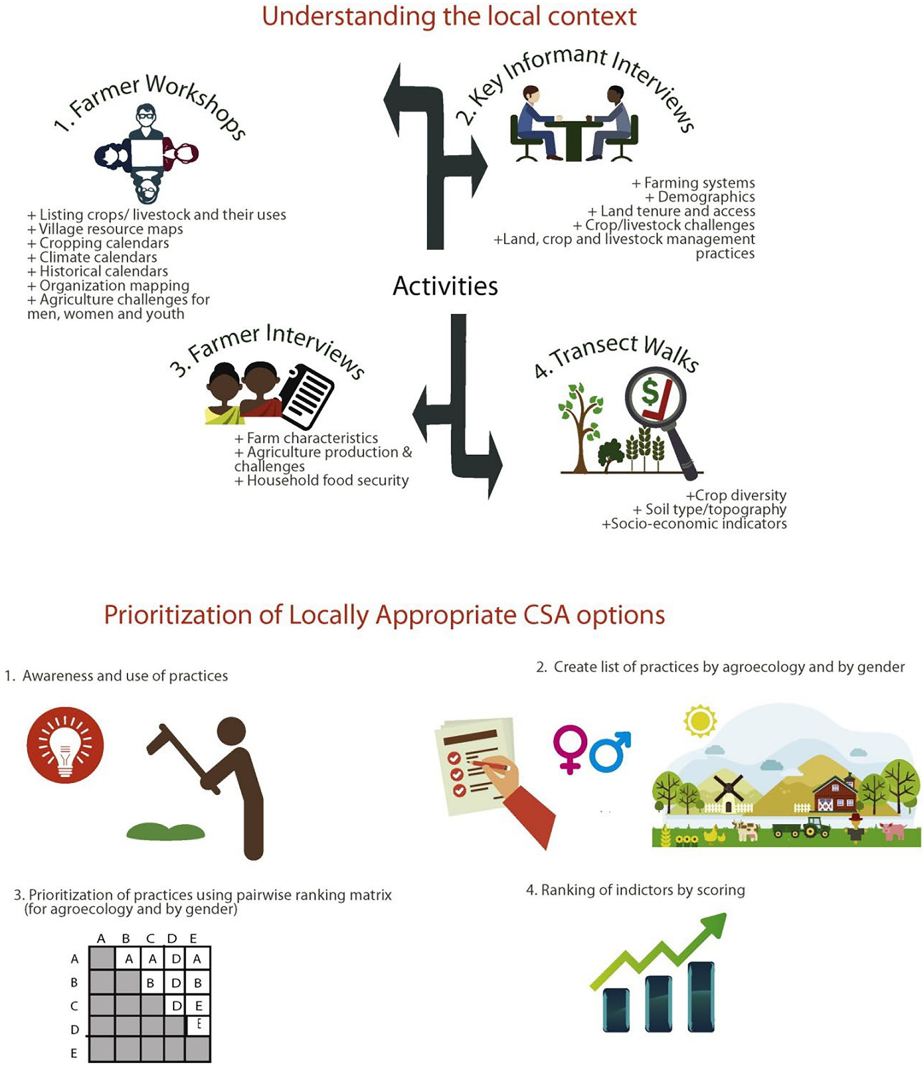

Figure 1. Diagram showing the steps used to gather data for the CRV
Source: Authors' own work

The first major component served as the basis for the calculation of well-being and resource indexes inside the PCA framework. The linear sum of the variables, as follows, is used to calculate the index for residence i: (h_k) and sk are the means and standard deviations of the resource hk, and ü is the weight for each resource or wellbeing factor that was acquired from the first main element, as stated by (Ogisi and Begho, 2023). The means were compared between adopters and nonadopters of CSA practices using independent-samples *t*-tests, as is common in works on agricultural technology adoption (Nchanji *et al.*, 2022). The reason why this parameter test should be used is that:

- it is a simple test that compares continuous variables (age, dependency Ratio, asset indices) between two independent groups;
- it is also very strong in the face of moderate violations of the normality assumption when the sample size used in both groups is above 20; and
- directly answers the research question of whether adopters and nonadopters differ significantly in key socioeconomic characteristics.

The formula used in the *t*-test was:

$$t = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \quad (2)$$

where $\overline{X}_1$ and $\overline{X}_2$ are adopters and nonadopters means, s_1^2 and s_2^2 are variances, and n_1 and n_2 are sample sizes. The level of statistical significance was evaluated as 3 (i.e. $p < 0.10$, $p < 0.05$, $p < 0.01$), which is consistent with the standards for research in agricultural economics, where field data are typically highly variable.

2.4 Justification of model selection

The selection of these models was justified by the need to cover specific sections of the data set, including the dependent variable, target population and the researcher's objective:

- *Model selection reason:* The choice of these models was supported by the fact that they would address particular parts of the data set, such as the dependent variable, the target population, and the purpose of the researcher. The GMA, PCA and *t*-tests combination was selected for the following reasons: they correspond to the data structure: GMA refers to farm-level enterprise data, PCA to several correlated household traits and *t*-tests to binary groups of adoption.
- *Validated in analogous settings:* The three methods have been widely used in East African smallholder agriculture research with demonstrated reliability (Tadesse *et al.*, 2022).
- *Have a few requirements:* These methods are sturdy and do not have complicated modeling assumptions that might be invalid in smallholder settings. Deliver actionable findings: GMA shows profitability, PCA identifies obstacles to wealth and *t*-tests predict adoption, all of which are policy design-relevant.
- *Procedures are replicable:* they enable other researchers to apply the CRV approach in other settings. Other methods (e.g., regression models, propensity score matching) were also available. Still, they were not considered, as this study was exploratory, with small sample sizes that reduced statistical power, and focused on description rather than causality. The chosen approaches yield clear, interpretable findings that could inform the participatory CSA priorities.

3. CRV case studies demonstrating context-specific classification

3.1 Sites of study and strategy of sampling

The sampling strategy used in this study was a multi-stage stratified random sampling in two purposely selected districts: Gulu District, Uganda (post-conflict, high institutional density, two rainy seasons), and Kilolo District, Tanzania (commercial agriculture zone, one rainy season, low institutional presence). Villages from the highland and lowland agro-ecological zones were selected in each district, in consultation with district agricultural officers. Surveys were conducted on a random sample of 50 households per district ($n = 100$ total), selected from household lists developed in each village, and random number tables were used to select the households to be surveyed (22 in Gulu and 26 in Kilolo). Farmer participation was done with 35 farmers in Gulu (63% men, 37% women) in 4 sessions and 38 farmers in Kilolo (57% men, 43% women) in 5 sessions, where the participants were recruited through local farmer organizations to ensure representation of the farmers by gender, age and wealth groups. Purposely chosen based on their expertise on local agriculture and climate, key informants ($n = 14$ in Gulu; $n = 28$ in Kilolo), such as district officers, extension agents, village leaders and farmer cooperative leaders, were chosen. The data were collected between March and October 2014, and all participatory activities were carried out in gender-disaggregated groups; interviews were conducted in local languages (Acholi and Swahili); and the results were triangulated through various methods and site visits to ensure validity and reduce bias.

3.1.1 Research questions. The study's research methods were well aligned with its objectives and research questions, thereby reinforcing its theoretical and methodological base. *RQ1* investigated the organization of CSA adoption in Gulu and Kilolo through local agricultural organizations by applying organizational mapping, which identified networks that promoted CSA, with a specific focus on gender-based interventions and the role of local and regional organizations. *RQ2* investigated the impact of gendered understandings of climate variability on the CSA practice of recording climate change using climate calendars a collection of men's and women's recordings of seasonal changes. These calendars offered gender-sensitive insights into the effects of climate on agricultural productivity and CSA adoption. *RQ3* examined the most prioritized CSA practices and how gender roles affect their adoption using comparative ranking. This approach highlighted gender disparities in preferences for CSA and the relative significance of each practice, providing insight into how gender relations influence adoption patterns in both study areas.

3.2 Cropping calendars

The cropping calendars (Figures 2 and 3) point out the main crops and gender-based activities in the two study sites. The diet in Kilolo was mainly beans, garlic, tomatoes and maize, whereas in Gulu, men were more concerned with groundnuts and sesame, and women focused on beans. Kilolo had both genders valuing tomatoes and maize. Gender discrepancies were based on social roles: men typically handled income-related tasks, while women focused on home food production. Both men and women engaged in major agronomic activities, such as land clearing, planting, weeding and harvesting, but Gulu was more involved in farming activities with children. There was a prominent gender disparity in marketing: women were selling household crops (e.g. cassava and maize), whereas men sold cash crops (e.g. groundnuts, sesame, tomatoes and garlic). The calendars also showed that women had heavier workloads: 45% more crop management in Gulu and 20% more harvesting in Kilolo. The two regions used land preparation methods of cutting, burning and tilling with hoes or cattle, and women and children mostly did weeding, since herbicides were not common. The women and children in Gulu had to endure heavy sugarcane harvesting as many as three times a year. In both areas, animal husbandry served as a secondary source of livelihood.

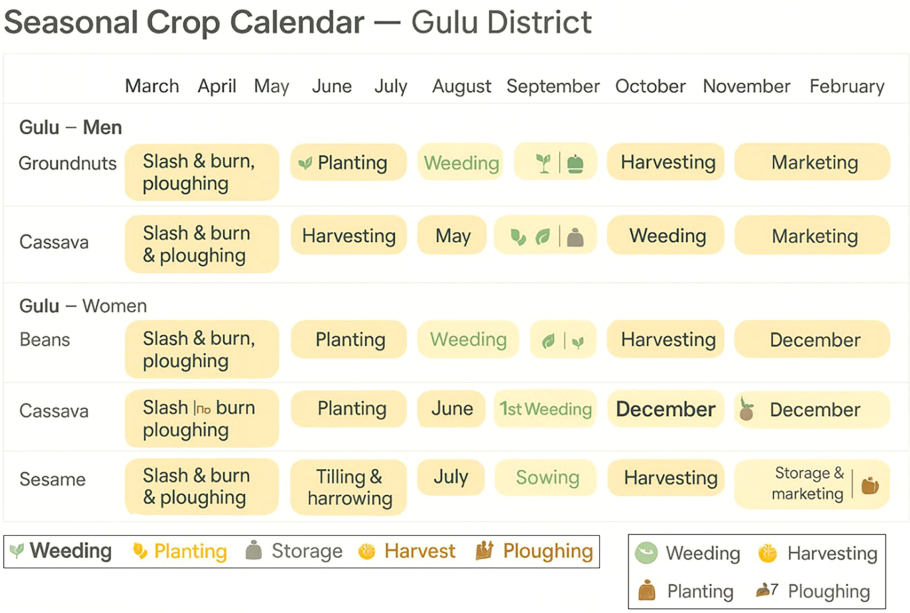

Figure 2. Monthly crop management tasks were reported by the 22 men and 13 women who attended the March 2014 farming workshop in the nation's Gulu area
Note(s): The logograms show if it's a male or female activity
Source: Authors' own work

3.3 Organizational mapping

Concerning important regional organizations, the two regions were very different from one another. Figures 4 and 5 show that there were more organizations in the Gulu district ($n = 21$) than in the Kilolo region ($n = 15$). Community-based organizations, NGOs, governments, media outlets, academic institutions, banks, and global organizations are all represented in the two research locations. The majority of organizations are nonprofits, with a small number of government entities serving as a complement. As for the gas in Tanzania, Sokoine University (SUA) and the Tanzania Social Action Fund (TASAF) were functioning, while in Uganda, the NAADS and NARO, which are now defunct, were among them.

In contrast to the Gulu district, where significant relationships between major organizations were identified in the organization mapping process (Figure 5), the Kilolo region showed very few relationships (Figure 4). Figure 4 demonstrates that in Gulu, the agricultural workers reported significantly better connections and interactions throughout the various groups. The organization mapping also shows gender disparities in the organizations of important organizations. Males in Gulu map 7 major organizations, whereas women map ten, with just three shared by both genders. In addition, in Tanzania, where there are just two gender-specific institutions (Figure 4, Figure 5), the female grouping indicates a greater number of significant organizations (six vs five) compared to the male group. Compared to women, males on this site are more likely to list connections between different organizations. Organizations addressing dietary requirements and family concerns were more common on women's listings, while organizations centered on manufacturing were more common in men's groups.

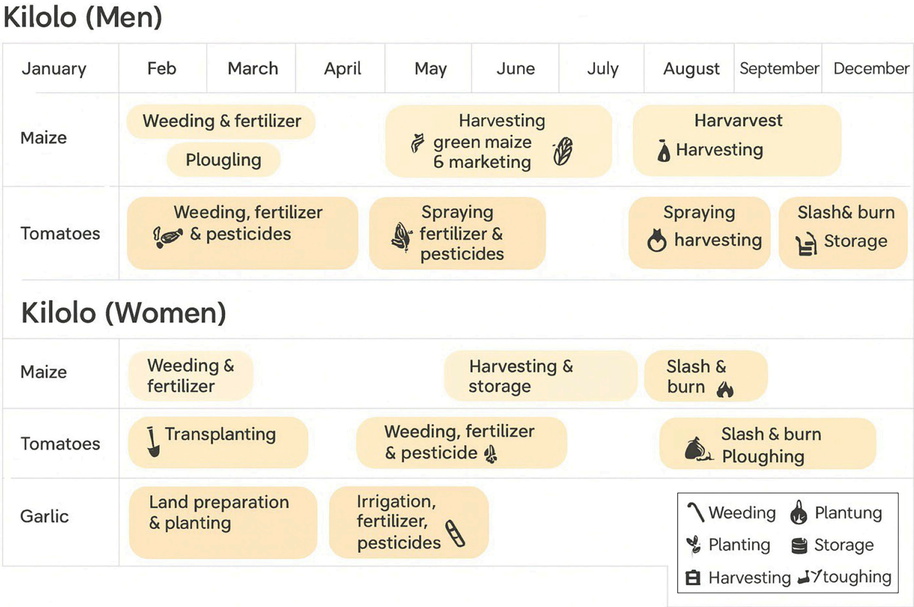

Figure 3. Crop management tasks are broken down by month, as reported by the 22 men and 16 women who attended a farming workshop in the Kilolo area of Tanzania in October
Note(s): The logograms show the gender of those who took part

A major goal of organizational mapping is to find out which organizations are best suited for reaching women and men and how many people they can reach overall. Men and women farming in Gulu agreed, for instance, that NAADS has excellent connections (Figure 4). Therefore, focusing on this type of organization can facilitate collaboration among several stakeholders.

3.4 Calendars of climate

Figure 6 presents a 20-year simulation of a historical calendar in the Kilolo region, indicating reduced rainfall, higher temperatures, less tree cover and lower crop productivity. However, the livestock population did not decline. Such results need to be triangulated with local or national data (FAO, 2017). The farmers complained of reduced soil fertility and a decrease in crop yields (rice and maize) by more than 50% (from 7 to 4 tonnes per hectare and from 6 to 1.6 tonnes per hectare, respectively). Climate data validated changes in precipitation and temperature, indicating greater climate variability. Gender differences in perceptions were also observed in the exercise, with males reporting a gradual increase in livestock numbers, whereas females reported a rise that persisted even in 2014. As shown in Figure 7, men and women perceive normal, wet and dry years differently, with women identifying more "good periods" during wet years and men emphasizing difficult periods during dry years. The respondents blamed deforestation and poor agricultural practices for the loss of rainfall, increase in temperatures, and low yields. The farmers stressed the need to focus on improving soil quality and crop production through more efficient agricultural practices.

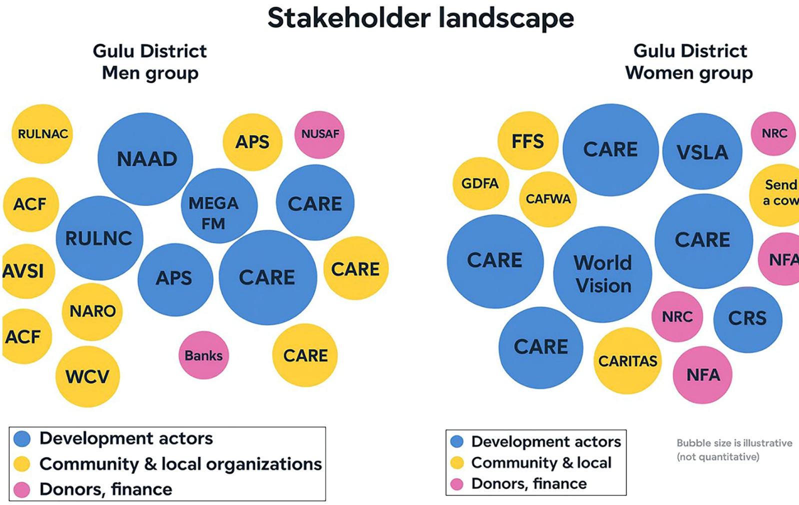

Figure 4. Participant organization mapping and links were described by the 22 males and 13 females who attended a farming workshop in the Gulu area of Uganda in March

Note(s): The significance of the things shown by the different colored circles is as follows: blue for highly important, yellow for medium important, and pink for a low value. The organization is represented with acronyms

Source: Authors' own work

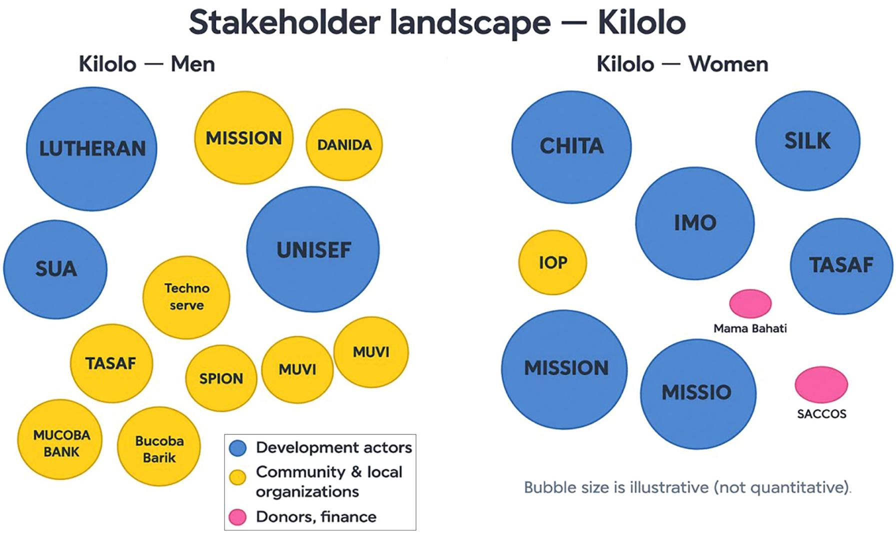

Figure 5. Organizational maps and links were described by the women ($n = 16$) and men ($n = 22$) who attended a farming workshop in Tanzania's Kilolo area in September 2014

Note(s): The significance of the things shown by the different colored circles is as follows: blue for highly important, yellow for medium important, and pink for low value. Acronyms stand in for groups

Source: Authors' own work

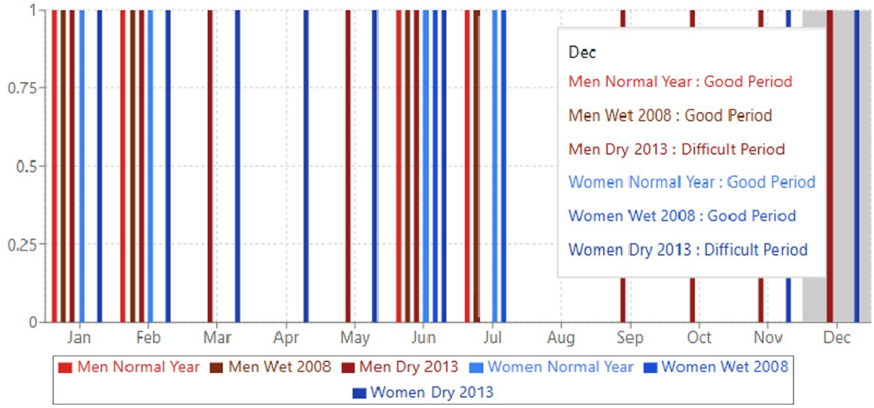

Figure 6. In February, participating farmers in the Gulu area of Uganda's farmers programs reported three types of years: usual, wet (2008) and drier (2012)

Note(s): The male respondents numbered 22, and the female respondents numbered 13

Source: Authors' own work

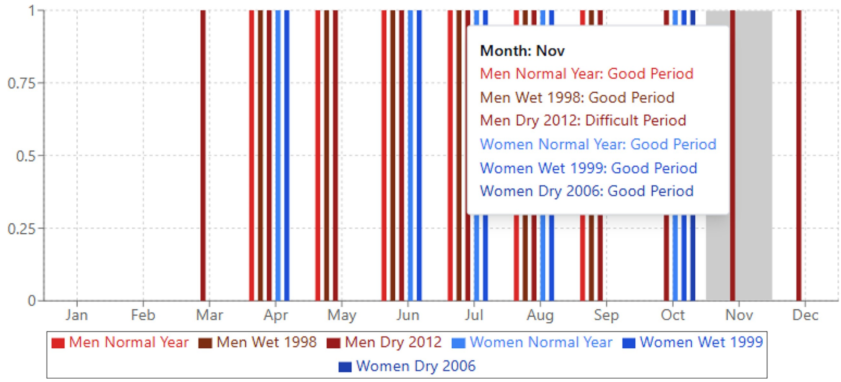

Figure 7. Represents a time series comparing various periods among men and women throughout the year

Note(s): Its own color indicates this: Red Men Normal Year, Brown Men Wet 1998, Orange Men Dry 2012, Blue Women Wet 1999, Light Blue Women Dry 2006, and Gray Women Normal Year. In the pop-up annotation for November, it is noted that both men's and women's normal years are in a reasonable period. However, in Men Dry 2012, it is stated that the stage is a Difficult Period, whereas in Women Wet 1999 and Women Dry 2006, it is in a Good Period

Source: Authors' own work

3.5 Historical calendar

Figure 8 presents a 20-year historical calendar exercise in the Kilolo region that indicated declines in rainfall and tree cover, increased temperatures and crop productivity, but no change in the number of livestock. Such results have to be triangulated with local or national data (Antwi and Antwi-Agyei, 2023). According to farmers, soil fertility declined, and crop

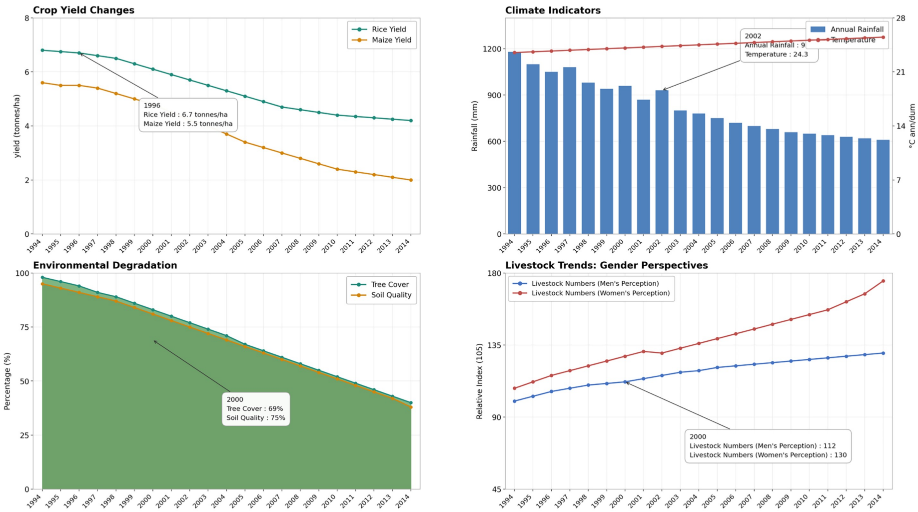

Figure 8. Rating one (extremely low) to five (extremely high) on a scale from 1 to 5
Source: Authors' own work

yields reduced significantly by more than half from 7 to 4 tonnes per hectare in rice and from 6 to 1.6 tonnes per hectare in maize. The evidence from climate data included precipitation and temperature changes, indicating climate variability. Gender differences in perception were also found in the exercise: more men said they were slowly rising with livestock, whereas more women said they were still rising until 2014. Respondents cited decreases in rainfall, increases in temperature and low yields as a result of deforestation and poor farming methods. Farmers stressed that the priority should be on improving soil quality and crop production through superior farming techniques.

3.6 Interviews with key informants and farmers

A triangulation of results was conducted to ensure validity and consistency, with a special focus on gender-based differences in perception and practice. Table 1 provides a summary of the five most important development-limiting factors for every region. Both Gulu and Kilolo faced challenges related to inadequate roadways and marketplaces; however, for Kilolo, the issue was following the harvest and bad markets. Market knowledge gaps, lacking facilities, unstandardized scales and measurements, farm-level dealer exploitation, and costly transport expenses were listed as major advertising obstacles by participants in both nations. Reasons for the underwhelming growth of the market include the costly components in Kilolo and the subpar seed accessible in Gulu. Since Gulu farmers were the only group to mention climatic variability as a restriction, the Kilolo farmers inferred that rising illnesses and pests were caused by climate change.

3.7 Comparative ranking

Results showed that responder gender and agriculture zone (highland vs lowland) affected answers when comparing the two regions' pairing rankings of activities (Table 2). One prevalent technique among members at the Gulu highland area was seedling selection. In the

Table 1. Examine the top five main challenges to general expansion, ranked by importance as noted by members in workplaces held in Oct 2015 in Gulu district, Uganda (35 people) and Kilolo district, Tanzania (38 people)

Gulu, Uganda	Kilolo, Tanzania
1. Inadequate road infrastructure	1. Unstable market conditions
2. Unstable market conditions	2. Deficient storage systems
3. Insects and pathogens	3. Insect infestations and pathogens
4. Poor seed features and availability	4. Costly resources
5. Variations in climate conditions	5. Inadequate extension services

Source(s): Authors' own work

Table 2. Using a paired scoring matrix, we were able to collect the following information from 35 farmers in Tanzania and 38 farmers in Uganda: their preferred techniques

Rank	Male	Female	Male	Female
Gulu, Uganda				
Elevated lands			*Lowlands*	
1	Superior animal varieties	Seed choice	Seeding process	Perfect timing
2	Crop production	Proper timing of harvest	Perfect timing	Rotational cropping
3	Pesticides application	Write space	Proper planting timing	Selecting the right seeds
4	Mini tillage	Proper timing	Mulching	Intercropping
5	Seed selection	Row planting	Polyculture	Row planting
Kilolo, Tanzania				
Highlands			*Lowlands*	
1	Enhanced variety	Improved animal breeds	Enhanced variety	Enhanced variety
2	Planting process	Enhanced variety	Irrigation	Irrigation
3	Mulching	Fallowing	Early planting	Fertilizers
4	Rotational cropping	Contour ploughing	Planting process	Planting process
5	Fertilizer	Farming	Correct spacing	Herbicides

Source(s): Authors' own work

valleys, there was no difference between the men and women when it came to row the planting process, growing at the right time and cross-cropping. The Men farmers in the Kilolo mountains prioritized using fertilizer, rotating crops, mulching, enhanced variety and insecticides. Table 3 shows that farming; better types and breeds of animals, giving up and contoured plowing were the most popular among the women in this area. The adoption of superior types was the sole concurrent activity. There were more shared practices between men and females in the lowland zone of Kilolo when it came to water supply, insecticides, and enhanced variety selection.

3.8 Farmers interviews

The disparities in the CRV methodology showed the gender differences in agricultural practices and climate vulnerability. Resource mapping of Gulu and Kilolo revealed that women in Gulu faced more challenges with water for both household and farming use, whilst men in Kilolo faced arable land accessibility as a significant production constraint. The interviews with farmers (Figures 9 and 10) showed that prioritized agricultural practices

Table 3. United States Dollars (USD) gross profit assessment derived from 2014 family surveys with 24 farmers in the Gulu district of Uganda and 28 farmers in the Kilolo district of Tanzania

Economic indicators	Gulu, Uganda	Kilolo, Tanzania
Crop expenses	209	674
Variable expenses		
Input expenses: fertilizer, herbicides and pesticides	0	30
Labor cost	84	18
Cost of renting land	0	41
Overall variable expenses	84	85
Gross margins	127	591

Source(s): Authors' own work

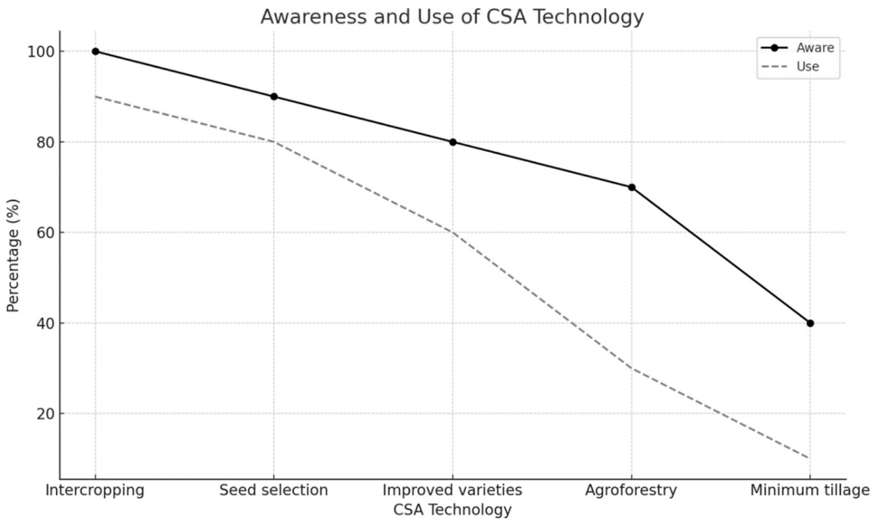

Figure 9. The sample size ($n = 22$) is from the Gulu region in Uganda and it shows a number of farmers who are aware of and use the prioritized climate-wise agricultural methods

were not implemented despite the presence of a knowledge and adoption gap. In Kilolo, the adoption rate was 4–34, and in Gulu, it was 7–90. The most widespread practice became agroforestry, which could be explained by vegetation deterioration in Kilolo. Nevertheless, various obstacles to the adoption of climate-smart agriculture (CSA) methods included climate variability, a shortage of skilled workers, excessive costs and resource constraints. Also, there was a weak link between the prioritized practices and the observed changes in resource utilization and productivity.

3.9 Economic analysis

The primary crops grown and traded in a specific area are the subject of the economic research study. Remember that we are not claiming a cause-and-effect connection in this evaluation. The findings indicate that farming activities in both Gulu and Kilolo had

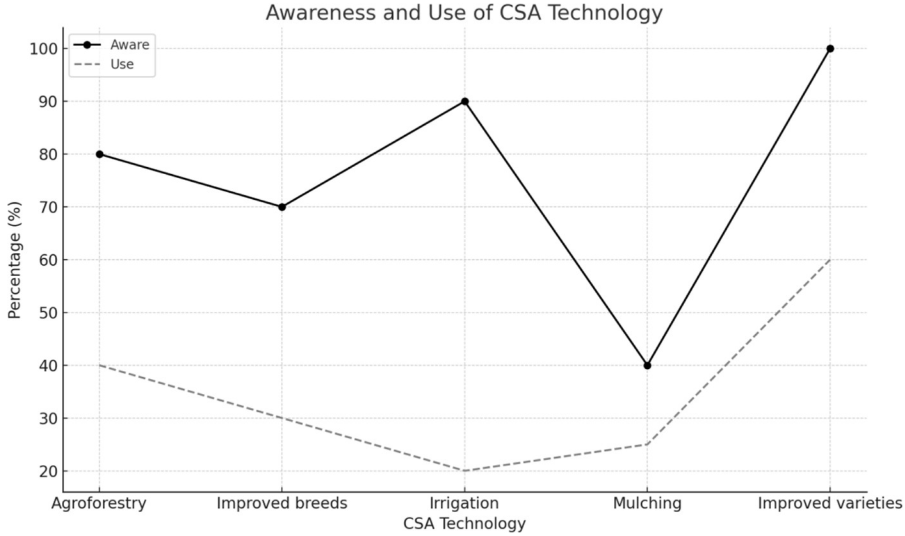

Figure 10. The number of households examined in the Kilolo region, Tanzania and the number of farmers who are conscious of and practice the prioritized climate-wise agricultural techniques are 26
Source: Authors' own work

substantial net benefits (Table 3). The main expense in Gulu was workforce, which was far more than in Kilolo since pests and illnesses were the biggest problem for farmers there. Workers' wages were the sole factor expense in Uganda. It is recognized that variable production expenses may be understated if additional manufacturing elements are not included. The key agricultural businesses in the area, nevertheless, will see our results mirrored in their operational realities. Crops grown for horticulture purposes, as opposed to conventional subsistence crops, tend to yield greater financial rewards in Kilolo.

There was an increase in the reliance ratio among farm households that embraced enhanced varieties (Table 4). More data on agricultural output was available to those who embraced enhanced cultivars compared to those who did not. The group that adopted practiced low tillage and had easier availability of resources for postharvest processing and short-term weather forecasts. In addition, adoptees possessed a greater quantity of nonfarming resources. Older homeowners characterized the groups with characterized agroforestry, more accurate literacy and a greater abundance of nonagricultural resources when contrasted with the others. Those who embraced seed choice had improved accessibility to data on postharvest management than those who did not.

We compared those who did not participate in farmer-priority CSA practices in Kilolo, those who did have different social and economic backgrounds levels of knowledge accessibility levels of health and resource indexes (Table 5). In terms of education, wealth and knowledge, those who embraced new kinds varied from those who did not. In particular, the percentage of family farms with individuals with a degree beyond basic school was greater among those that embraced upgraded variety. Compared to nonadopters, those who embraced them had easier access to data on postharvest handling, agricultural and animal productivity, and more. Farmers and nonfarmers alike possessed additional resources among the adopters.

Table 4. A comparison of 24 farmers in Gulu, Uganda, who prioritized climate wise agricultural methods with those who did not, with respect to their social and economic financial prosperity, and accessibility to data

	Mean values				
Factor	Improved varieties	Mini tillage	Polyculture	Agroforestry	Selecting the right seeds
Age of the household head	40.79 (39.97)	39.63 (0.48)	40.19 (40.19)	46.09*** (40.09)	41.80 (40.23)
Literacy	0.14 (0.12)	0.15 (0.13)	0.13 (0.13)	0.24*** (0.12)	0.13 (0.13)
Dependency ratios	0.57* (0.55)	0.57 (0.56)	0.56 (0.55)	0.48 (0.57)	0.56 (0.55)
Crop production data	0.85** (0.79)	0.87 (0.81)	0.82 (0.80)	0.82 (0.82)	0.83 (0.70)
Postharvest data	0.82 (0.77)	0.96*** (0.78)	0.80 (0.74)	0.82 (0.80)	0.82*** (0.63)
Mini forecast data	0.80 (0.75)	0.94*** (0.76)	0.76 (0.82)	0.80 (0.77)	0.78 (0.74)
Wellbeing indexes	− 1.33*** (− 1.26)	− 1.25 (− 1.30)	− 1.31*** (− 1.15)	− 1.08 (− 1.31)	− 1.31 (− 1.18)
Non-agro assets indexes	0.46 (0.43)	0.57** (0.44)	0.45 (0.45)	0.70*** (0.43)	0.44 (0.48)
Agro assets indexes	0.09 (0.09)	0.11 (0.09)	0.08*** (0.17)	0.39*** (0.07)	0.09 (0.13)

Source(s): Authors' own work

Table 5. This study compares 28 farmers in Kilolo, Tanzania, who prioritized climate-wise agriculture methods with those who did not, with regard to their social and economic prosperity and accessibility to data

	Average values				
Variable	Improved varieties	Mulching	Irrigation	Agroforestry	Enhanced breeds
Age (household owner)	46.66 (47.75)	42.01* (47.60)	46.23 (47.64)	50.02 (47.32)	47.27 (47.40)
Literacy	0.15*** (0.11)	0.17*(0.10)	0.12 (0.0.13)	0.15 (0.12)	0.14 (0.12)
Dependency ratio	0.50 (0.52)	0.41**(0.50)	0.49 (0.52)	0.53 (0.52)	0.64 (0.52)
Crop production data	0.62*** (0.46)	0.55 (0.49)	0.72*** (0.47)	0.81** (0.50)	0.65 (0.51)
Animal production data	0.28*** (0.16)	0.25 (0.18)	0.22 (0.20)	0.31 (0.20)	0.65*** (0.19)
Postharvest data	0.61*** (0.44)	0.45 (0.47)	0.76*** (0.44)	0.81** (0.48)	0.52 (0.49)
Poor forecast data	0.67 (0.61)	0.65 (0.60)	0.72** (0.60)	0.81 (0.62)	0.77 (0.62)
Wellbeing indexes	− 1.50*** (0.88)	− 0.38*** (0.75)	− 0.78** (− 0.75)	− 0.78 (− 0.76)	− 0.47 (− 0.76)
Non-agro assets indexes	1.57*** (0.90)	1.62*** (1.07)	1.11 (1.12)	1.36 (1.11)	1.36 (1.11)
Agro assets indexes	0.77*** (0.38)	0.92*** (0.47)	0.52 (0.44)	0.76 (0.50)	0.72 (0.50)

Source(s): Authors' own work

But in contrast to those who didn't adopt better forms, those who did had a poorer happiness index. Farmers who started mulching their yards tended to have younger heads of home, more educated members overall, and shorter dependability ratios. People who mulched their crops had less beneficial indices but stronger farming and nonfarming resources, just like people who planted enhanced variations.

Table 6 presents the results using the methodological tool to provide an effective connection between the data collection procedures and the reported results. Every subsection starts with the tool(s) used and has results produced by that tool, so that all the findings can be traced to their methodological origin.

4. Discussion

This paper demonstrates three important results that undermine traditional CSA strategies: extreme gender inequalities in agricultural work generate unequal adaptive abilities; CSA adoption is critical, notwithstanding awareness; and institutional density is a significant mediator of uptake. Female Gulu do 45% of the work of crops compared with their male counterparts and are systematically denied commercial access to crop marketing, which is a form of structural inequality, with those who carry the main responsibility of food security having no access to income. This gendered division has a powerful influence on CSA adoption: labor-intensive methods, such as mulching, place more strain on women with limited time, and input-demanding methods are not accessible to women who do not have independent income. This puts (Das *et al.*, 2022) in a so-called poverty trap, in which low productivity prevents investment in productivity-promoting practices, leaving them vulnerable. Our results build upon (Huyer, 2021) by quantifying the size of the labor burden and associating it with adoption outcomes using wealth indices, which is necessary to design policies that will reduce the time women spend. A disconnect between knowledge and practice is revealed by the adoption gap (7–90% in Uganda; 4–34% in Tanzania), despite high awareness (>80%). Participatory data reflect the process: the costs of participation exceed the available cash, the workforce requirements are incompatible with peak seasons, the tenure of the land is unstable and not ready to support long-term investment, and institutional support is insufficient. These obstacles depend on gender, and wealthier households used capital-intensive techniques (improved varieties, fertilizers). In contrast, poorer households used labor-intensive techniques (intercropping, row planting), indicating that, in the absence of specific interventions, the scaling of CSA can strengthen the divide between the wealthy and the impoverished (Ansari *et al.*, 2025). The difference in institutional density between Gulu (21 organizations) and Kilolo (15 organizations) was associated with higher adoption rates in Gulu, consistent with institutional theory, which posits that the presence of organizations enables diffusion (Msweli *et al.*, 2024). Nevertheless, organizational mapping also indicated subtlety: women mapped more organizations than men, but their focus was on nutrition/welfare, whereas men focused on production/marketing, suggesting that organizational gender segregation can support rather than undermine inequalities. The Gross margin analysis, in which Kilolo's profitability (USD 591 vs USD 127) was high, sheds light on how crop choice determines the capacity to invest in CSA. The fact that Kilolo focuses on horticulture creates cash flows that allow it to acquire inputs, whereas the subsistence orientation at Gulu limits reinvestment (Kirina, 2025). This, however, masks its gender aspects, as men dominate high-margin cash crops. The climate calendar activities that reveal differences in gendered perceptions men identifying longer dry seasons as the source of income and women identifying rainfall unpredictability as the source of planting are based on differences in responsibilities and vulnerabilities, which are translated into differences in CSA priorities. Women gave high ratings to drought-tolerant

Table 6. Methodology findings matrix

Research questions	Method/tool used	Data generated	Main findings
How do gendered labor patterns shape CSA adoption?	Cropping calendars (gender-disaggregated focus groups, $n = 35$ Gulu, $n = 38$ Kilolo)	Monthly task allocation by gender for 3 priority crops per site	Women manage 45% more crop tasks in Gulu; men dominate harvesting (20% more) in Kilolo
Which organizations facilitate CSA access?	Organizational mapping (participatory venn diagrams, gender-disaggregated groups)	Network diagrams showing 21 organizations (Gulu), 15 organizations (Kilolo)	Higher organizational density in Gulu; women map more organizations but different types than men
How do men and women perceive climate variability?	Climate calendars (gender-disaggregated groups, three year types: normal, wet, dry)	Seasonal rainfall patterns for normal, wet and dry years by gender	Men identify longer dry seasons; women emphasize rainfall unpredictability; gender differences in year selection (2013 vs 2007 in Kilolo)
What long-term environmental changes have occurred?	Historical calendar (20-year participatory assessment, rating scale 1–5)	Trend data for rainfall, temperature, tree cover, soil fertility, crop yields, livestock	Maize yields declined 6→1.6 t/ha; rice 7→4 t/ha; soil fertility declining; rainfall decreasing
What are farmers' priority CSA practices?	Comparative ranking (paired comparison matrices, gender- and agro-ecology-disaggregated)	Frequency scores for each practice from pairwise comparisons	Top 5 practices differ by gender and location; seed selection ranked #1 by women in Gulu highlands; improved varieties #1 for men in Kilolo highlands
What is current CSA adoption rate?	Farmer interviews ($n = 22$ Gulu, $n = 26$ Kilolo, semi-structured surveys)	Awareness vs. adoption percentages for each prioritized practice	Adoption 7–90% (Gulu), 4–34% (Kilolo) despite awareness > 80% for most practices
What socioeconomic factors predict adoption?	Household surveys + PCA + t-tests ($n = 50$ per site, independent samples comparison)	Mean values for adopters vs nonadopters on age, literacy, dependency ratio, asset indices, information access	Adopters have higher wealth indices ($p < 0.001$), better information access ($p < 0.001$), higher literacy ($p < 0.001$); varies by practice
What is economic viability of farming?	Gross margin analysis (revenue - variable costs, data from household surveys $n = 48$ farms)	Net margins in USD for major crop enterprises	Kilolo farms earn USD 591 vs Gulu US$127; horticultural crops more profitable than subsistence crops

Source(s): Authors' own work

varieties and water harvesting (in response to food crop uncertainty). In contrast, men rated storage and access to markets highly (in response to cash crop volatility). Gender-blind programs that presuppose that all priorities are equal will take care of the male concerns and leave the female vulnerabilities unaddressed. The present study is a methodological contribution and proof that participatory tools can be combined with quantitative analysis to yield both locally-based and generalizable results, and, as such, provide a replicable gender-disaggregated CSA prioritization methodology (van Asseldonk *et al.*, 2024). Policy implications are evident: it should be gender-responsive, i.e. explicitly assess labor impacts; women must have access to inputs and revenue; and institutional changes. Wealth-differentiated strategies require subsidies/credit for resource-poor farmers, information services for better-resourced farmers. Limitations include small samples, which restrict statistical power; a cross-sectional design, which limits the ability to study temporal dynamics; and self-reported data, which are prone to bias. The use of longitudinal designs and larger samples, combined with regression analysis and a qualitative study of intra-household dynamics, should be adopted in the future. In addition to CSA, evidence indicates that climate vulnerability is a social construction mediated by gender, wealth and institutional access and that it necessitates structural interventions (subsidies, credit and tenure security) rather than information dissemination. The CRV framework fosters participation as it is operationalized, and it is no longer rhetoric but an actual policy mechanism.

5. Conclusion

This paper introduced the Climate Smart Agriculture Rapid Appraisal (CRV). This paper shows that CSA prioritization has to take into consideration gendered labor division, institutional density and the dynamics of profitability explicitly. Combining PRA tools that analyze climate and gender with RRA techniques that collect household and economic variables to collect indicators connected to all 3 CSA pillars is what makes this instrument interesting. To promptly and thoroughly evaluate CSA priorities that are relevant to a given setting, the CRV uses a multi-stakeholder participative method. This paper will demonstrate that the Climate Risk and Vulnerability (CRV) methodology has been effective in revealing gendered vulnerabilities and climate-sensitive agriculture in Uganda and Tanzania. The results indicate that women face distinct challenges in adapting to climate change, particularly since they are often responsible for food security within their households. The CRV methodology enables a more nuanced understanding of local climate risks and CSA adoption prospects by incorporating gender-differentiated data. The study's findings suggest that CSA initiatives should be designed to address the distinct needs of both male and female populations, ensuring that the voices of women are incorporated into the development and implementation of climate adaptation measures. Our ability to validate results and confirm relationships and communication was made possible by triangulating data from several techniques. Aside from outlining important organizations and necessary capacity development to promote investments in developing supportive environments at cultivated community, district and regional levels, the CRV also included essential details on paths for outperforming CSA inside the regional and sub-region. It is more accurately described as a procedure that gathers results to be used in the subsequent cycle of implementing a program or initiative. Among the many potential next steps is the development of on-farm trials to evaluate CSA techniques and the cultivation of strategic alliances with influential organizations. The data gathered may be utilized for CSA intervention strategy, funding guidance, gender targeting possibilities and stakeholder participation in the program and project-related activities. To amplify and correlate the data obtained, none of the technologies operate alone but rather complement one another. Also, the tools aren't the result; they're only a foundation for further investigation into the correlations between factors and contexts, which will lead to change and innovation in agriculture. The tool helps to make sure that groups with varied biophysical and social characteristics are benefiting from the current worldwide goals for agricultural growth.

6. Policy implications

One way to improve the method would be to gather data on gender perspectives in agriculture, how they've changed over the years in reaction to new possibilities like CSA, how techniques are adopted, and the advantages experienced at different sizes. Policymakers and development organizations should give special priority to gender-sensitive CSA strategies to improve agricultural productivity and resilience in vulnerable communities. Further studies should be conducted on a longitudinal study to assess the effectiveness of gender-sensitive practices in CSA and determine their efficacy, as well as their consequences on socio-economic conditions. Regarding teaching, the CRV tool and the study's results can be applied to the teaching of agriculture to enhance climate resilience and gender equality in farming activities. Through the incorporation of participatory methodologies, which this study uses in its curricula, teachers can be better positioned to prepare students, especially in third-world nations, to address real-life problems in CSA and gender-sensitive rural development.

The paper has essential research, practice and societal implications, especially in the way the Climate-Smart Agriculture Rapid Appraisal (CRV) framework may be used to inform policy development, inform investment choices and influence gender-sensitive CSA intervention. The findings present a way to develop CSA scalability in terms of entry points, allowing CSA practices to be widened and diversified for local contexts. The CRV tool can help governments and development agencies prioritize climate-resilient agriculture investments that consider gendered power dynamics, access to resources and power structures in decision-making. The study has the potential to inform the policy agenda by providing evidence-based and gender-sensitive information, influencing changes in policymaking in a way that allows for the development of equitable climate change adaptation policies, as well as ensuring that agricultural resilience is established in a manner beneficial to both men and women. On the societal level, the results can impact societal attitudes toward gender equality in agriculture and climate resilience. The paper on the gendered effects of climate change and its suggestions for gender-sensitive CSA practices can create awareness about the necessity of inclusive agricultural practices.

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