Understanding farmers' indicators in Climate-Smart Agriculture Prioritization

in the Southern Agricultural Growth Corridor of Tanzania (SAGCOT)

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Acronyms

ACT	African Conservation Tillage Network
AEZ	Agro-ecological zone
AGRA	Alliance for Green Revolution in Africa
CCAFS	CGIAR Research Program on Climate Change, Agriculture, and Food Security
CIAT	International Center for Tropical Agriculture
CSA	Climate-smart agriculture
CSA-RA	Climate-smart agriculture rapid appraisal
IFAD	International Fund for Agricultural Development
MAWAKI	Maendeleo ya Watu wa Kilolo [*Association for the Development of Kilolo District*]
MUVI	Muunganisho was Ujasirimali Vijijini [*Rural Micro, Small and Medium Enterprises Support Programme*]
RUDI	Rural Urban Development Initiative
SAGCOT	Southern Agricultural Growth Corridor of Tanzania
SILC	Savings and Internal Lending Communities
SUA	Sokoine University of Agriculture
TAP	Tanzania Agricultural Partnership

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Summary

In order to increase the uptake of climate-smart agriculture (CSA) technologies, it is important to understand the contexts in which farmers operate. Farmers use different indicators to decide whether or not to implement, what to implement, and where to implement specific technologies. Identifying and understanding such indicators can be helpful to efforts aiming to scale out adoption. The purpose of this study was to identify indicators that farmers use to prioritize agricultural innovations, in general, and CSA, in particular.

Kilolo and Mbarali Districts lie in the Southern Agricultural Growth Corridor of Tanzania. Four participatory workshops, in the form of focus group discussions, were conducted in these two districts. In each district, a separate workshop was held with farmers from each agro-ecological zone (AEZ). Separate workshops were held with farmers and experts to explore differences between stakeholders and across the districts regarding perceptions of the status of soil fertility, prioritized practices, and ranking of indicators for prioritizing practices. Characterization of the AEZ, prioritization of practices, identification of indicators for prioritizing CSA, and selection of practices for demonstration as well as sites for the demonstration plots were done separately with men and women groups. Practices were prioritized using pairwise ranking, while indicators were scored on a rating scale from least important (1) to most important (5).

Results showed that, both in Kilolo and Mbarali Districts, farmers perceive the status of soil fertility as poor. Up to 60 % of the workshop participants were not satisfied with the status of soil fertility in their farms. More than 80% of workshop participants in each of the four workshops reported that they practiced burning. The main reasons for burning were to save labour and time and to reduce crop–livestock conflict.

The men's group in the upland zone in Mbarali District ranked mulching, water harvesting, improved varieties, and crop rotation as the most important practices in respective order. In the lowlands, both men and women groups selected irrigation, chemical fertilizer, and crop rotation as most relevant practices. Awareness and use of the practices was low among participants in the two workshops.

The most prioritized practices by the women's group in the uplands, Kilolo District, were improved breeds and improved varieties. Intercropping was the least prioritized practice. The men's group prioritized improved varieties and pesticides application, while irrigation and fertilizer application ranked lowest. In the lowlands, men's and women's groups prioritized irrigation, inorganic fertilizer and improved varieties as most important. Mulching and herbicides ranked as least prioritized. In addition, the men's group from the lowland zone ranked pesticide application among the

most important practices, while farmyard manure and zero grazing were ranked as least important.

Important indicators that farmers identified to prioritize agricultural practices across the two districts included yield, income, cost, labour, availability of inputs, the status of soil fertility, and knowledge about the practices.

Several practices were selected for the proposed CSA demonstration plots. The women's group in the uplands zone in Mbarali prioritized improved crop varieties, water harvesting, mulching, and fertilizer application. The men's group chose irrigation, herbicides, inorganic fertilizers, and seed selection. In the lowlands, improved crop varieties, inorganic fertilizer, farmyard manure, and mulching were selected by women. Men preferred seed preparation, right use of fertilizers (i.e., rate and type), integrated pest management, and improved storage. The selected important practices for demonstration in the uplands in Kilolo District were minimum tillage, soil testing, improved varieties, fertilizer application, and irrigation. Farmers in the lowlands chose production of clean seeds of different crops, such as tomatoes, beans, maize, and chillies. In addition, they were interested in learning about fertilizer application, pesticides application, and preparation and application of compost manure.

The findings of this research have several implications for policy. First, there is need to increase awareness of farmers about CSA practices, particularly those that they prioritize. The finding that farmers perceive poor soil fertility but do not prioritize soil fertility management practices implies the need to promote adoption of such technologies. Thirdly, a bottom-up approach that involves working with farmers to prioritize agricultural practices suitable for their specific AEZ and preferred by either the men or women is important to inform investment of limited resources to increase food security and resilience to climate risks while minimizing trade-offs. The findings highlight indicators that influence farmers' adoption of agricultural practices as well as constraints to implementation.

Introduction

Several agricultural technologies exist that can be classified as climate smart based on their potential to increase food security, adapt and enhance resilience to climate change, and reduce or remove greenhouse gases. By definition, climate-smart agriculture (CSA) is multidimensional – food security, resilience, and mitigation. Implementation of CSA is, however, very context specific. Together, the multidimensionality and context-specific approach of CSA implies that not only benefits and synergies may exist with its implementation but also trade-offs.

Prioritization of CSA technologies is a fundamental first step towards identifying locally appropriate CSA practices and understanding the trade-offs that adoption might bring. Prioritization is based on indicators that are important to the stakeholders. In this study, we focus on farmers and local experts to identify the indicators that they use to prioritize CSA practices. There is a paucity of knowledge on such indicators and how farmers use them to rank agricultural practices in general and CSA technologies in particular. An individual farmer's choice of a technology and ultimate use might depend on the attributes that farmers favor or disfavor about the technology or the perceived impact of the technology on their welfare.

The specific objectives of the study were to:

- Understand the criteria that farmers use to prioritize agricultural practices in general and CSA in particular;
- Understand the level of awareness and adoption of agricultural practices;
- Identify existing agricultural demonstration plots;
- Develop a prioritized list of CSA practices that farmers would like to implement in demonstration plots; and
- Establish suitable geographical locations for future CSA demonstration plots, including the CSA practices to highlight.

Methodology

The study was conducted in Mbarali and Kilolo Districts of Tanzania and is a follow-up to a recent Climate-Smart Agriculture Rapid Appraisal (CSA-RA) exercise in the Southern Agricultural Growth Corridor of Tanzania (Mwongera et al., 2014). Mwongera et al. (2014) provide a detailed description of the study site, including farming systems; constraints to agricultural production; perceptions on climate variability; and crop, land, soil, and water management practices. Participatory workshops in the form of focus group discussions were conducted separately with farmers and experts. A total of four farmers' workshops (two in each of the districts) and four expert workshops were conducted.

Based on the study site's agroecological setting, we held separate workshops with farmers representing the lowlands and uplands. Each farmer workshop had approximately 40 participants. Effort was made to generate a representative sample of workshop participants based on gender, agro-ecologies and age groups. The CIAT research team involved graduates from Sokoine University of Agriculture (SUA) to help with facilitation, note taking, and translations. Workshops started at approximately 9:00 a.m. and ended at 4:00 p.m. Below we describe the methodology used in the workshop both with farmers and experts.

Activity 1

Farmer workshops began with an icebreaker on perceptions of soil fertility. Each participant was provided with a blue and yellow card. Blue cards were used to indicate good soils, and yellow cards poor soils. Farmers could only select one of the two options and this was done separately for men and women. Care was taken to ensure that participants of different gender types did not compete to raise their cards. It was explained clearly that the exercise was not a competition between the group with the most cards of a given color, and that we were interested in learning what they thought about the status of soil fertility. A quick count of the raised card was then done. Follow-up questions asked farmers for reasons why they perceived the status of soil fertility to be good (for those who raised the blue card) and why they perceived the status of soil fertility to be poor (for those who raised the yellow card). The icebreaker ended with farmers' perceptions of the benefits and consequences of practicing burning.

Activity 2

Immediately after the icebreaker, a mapping exercise to characterize the agro-ecological zones (AEZs) was done, based on the variability in vegetation, soils, climate, and other distinct features. These farmer-

identified AEZs were used in subsequent sessions of the workshops.

Activity 3

Prioritization of CSA technologies began by asking farmers to name and briefly describe agricultural practices that they knew about. For each of the mentioned practices, farmers were asked to raise their hand if they had heard about the practice. A quick count by gender of the participants was then done. Similarly, farmers were asked to indicate, by a show of hands, how many were currently (present and last season) using the practice. A follow-up question asked about the benefits associated with each practice that farmers indicated they were using. Participants were further asked about any practices that they had abandoned. The facilitator then probed for the reasons why the practice had been abandoned. In cases where the gap between awareness and use was evident, farmers were asked for reasons why. To make sure that the list of practices was as extensive as possible, a pre-prepared list of relevant agricultural practices was compared with the farmers' list to check for any missing practices. In case of any, the missing practice was described, a photo was shown to the farmers and a question asked to confirm that they were not aware of the practice. The practices were then added to the list generated by farmers and the proportion of awareness indicated as zero upon confirming that indeed farmers were not aware of the practice. Finally, farmers were asked about the factors that they consider when deciding whether or not to use each of the practices that they were aware of and were using. This exercise generated what we refer to as a "master" list for each workshop.

Activity 4

With the master list of agricultural practices and the indicators that farmers use to select practices, participants were grouped into smaller groups based on the identified AEZ and by gender. Starting with the master list, farmers in the smaller groups were asked to identify specific practices that were relevant for their respective AEZ. This exercise generated a shorter list of practices. Farmers were then asked for the benefits of such practices and why they selected the practices as the most relevant for their AEZ. Follow-up questions asked about constraints to implementation and what farmers would need in order to implement the practices. A pairwise matrix was created to compare a single practice to another to generate a ranking of the practices selected for the AEZ.

Activity 5

Next, each farmer was provided with five seeds for scoring the indicators that they use to prioritize agricultural practices. One seed was used to denote that the indicator is least important while five seeds would mean that the indicator is most important. A brief discussion followed to understand why farmers choose a particular score for an indicator.

Activity 6

Finally, farmers in the respective smaller groups were asked to identify practices that they would like to try in a demonstration plot. A follow-up discussion focused on understanding whether there were any existing demonstration plots, what practices were being demonstrated, location of existing demonstration, how previous and existing demonstration plots were managed, whether there were any challenges in running the demonstration plots and how such challenges were resolved. For the new practices that were selected for demonstration, workshop participants were asked about their preferred locations for the demonstrations. They further suggested their preferred approach of managing the demonstration plots.

The detailed methodology is described in Mwongera et al., 2015.

Results and Discussion

Farmers' perception of the status of soil fertility

Across the Mbarali and Kilolo districts, most participants indicated that they were not satisfied with the status of soil fertility in their farms. A hundred percent of the participants from the lowlands in Mbarali indicated that soil fertility was poor. Sixty percent of participants from the uplands in both districts also reported poor soils. From the lowlands of Kilolo, 50% indicated poor soils. Table 1 presents indicators for the perceived soil fertility at each workshop.

The main indicator for low soil fertility, consistently mentioned by farmers in all the workshops, was a decline in yield. Farmers observed that, without fertilizer application, the realized yields were very low. Decline in soil fertility was mainly attributed to continuous cultivation. Farmers referred to their soils as "tired." An observation was that, in addition to observing poor harvests, farmers also learnt about poor status of their soils from messages by agricultural experts. In Kilolo, for example, it was reported that persistent communication from extension officers about the need to intercrop cereals and legumes influenced farmers' perceptions on the soil fertility status.

Farmers who reported good soil fertility in the uplands of Mbarali indicated that they could obtain 10–12 bags (120 kg/bag) of maize per acre. They indicated that the major constraint to agricultural production was inadequate amount of water for irrigation. In Kilolo, farmers outlined that soil fertility was poor when they practiced monoculture, but intercropping improved soil fertility. Below we quote a few statements from the farmers:

> *"I have been a maize farmer since 2007. When I started farming, I practiced mainly monocropping – which makes the soil tired. Until recently, when I started following and implementing agricultural advice from the extension officer, yields were very low – 4 bags per acre. Since I moved from monocropping to intercropping and application of fertilizer, the yield is satisfactory. I get 12 bags of maize per acre."* **Female farmer, Kilolo District, lowland zone.**

> *"The soil is good because even without using fertilizer, I grow maize and harvest 5 bags per acre. When I apply fertilizer I harvest more (15 bags)."* **Female farmer, Kilolo District, lowland zone.**

> *"I started farming in 1993. After 4 years of continuous farming, the soil became tired. When I started following instructions from the extension officer, I changed my farming and introduced intercropping. Now the soil has regained fertility."* **Male farmer, Kilolo District, lowland zone.**

Table 1. Reasons why farmers perceive the status of soil fertility as poor.

Uplands, Mbarali	Lowlands, Mbarali	Highlands, Kilolo	Lowlands, Kilolo
In 3 acres, a farmer can only produce 18 bags (120 kg each) of paddy – with good soil fertility, the same size of land should yield 60 bags	The decline in yield of paddy shows that the soil is tired. They said that they used to harvest 30 bags of paddy without fertilizer application, but currently they are only getting 3 bags	The soil is tired due to continuous cultivation over many years	Stunted growth in maize
A lot of weeds	The soil is salty and negatively affects growth of paddy and maize	Soil erosion	Low yield of maize, i.e., 2–3 bags in an acre (40 m x100 m)
The soil is stony and sandy		Without applying fertilizer, you cannot harvest anything	
The soil is tired		Overcultivation of maize for a long time because farm sizes are small	
		Reliance on experience in farming, hence fertilizer is applied without knowledge of the limiting nutrients	
		Lack of knowledge on the types and amounts of fertilizer that is required	
		The advice they receive about intercropping with legumes in order to increase soil fertility	

In lowlands, Kilolo, where 50% of the farmers perceived their soils to be fertile, several reasons were given, which include good harvest even without applying fertilizer and good water holding capacity. Below we quote statements from the farmers:

"If you plant without fertilizer, the crop still grows well and, in an acre, you can harvest ten bags of maize."

"I grow onions and apply fertilizer twice in a season. When I harvest onions, I rotate with maize. I do not apply fertilizer on the maize crop and still obtain good yields."

"Ours soils here are mostly clay. The soils can, therefore, hold water for a longer time for the crop to use."

Reasons for burning and observed consequences

Burning is a common practice among farmers across the two districts. More than 80% of workshop participants in each of the four workshops reported that they practiced burning. Two types of burning are common: one where farmers collect the crop residue or vegetation in a pile and burn, and another one where the whole field is set on fire. Table 2 presents the main reasons for burning, by district and agro-ecology. The main reason given for burning was to clear the land for ploughing. Farmers found this practice to be time and labor saving during land preparation. Conflict between pastoralists and crop farmers also led to the choice of burning the fields to get rid of crop residues. This was particularly reported by participants from the uplands in Mbarali and lowlands in Kilolo. The same finding is reported by Mwongera et al. (2014).

Rice farmers, especially from the lowlands in Mbarali, indicated that crop residues from paddy have thorns, which if not burnt can be injurious during land preparation in the subsequent season. In the upland zone of Kilolo, farmers felt that maize stumps remain even when fields are grazed. Some farmers in Kilolo indicated that crop residues attract pests, and burning helps to control pests. Again, these responses raise important policy questions about the importance of understanding the drivers of farmers' decisions to implement agricultural practices and the trade-offs associated with introducing alternatives.

Although only a few farmers reported not to burn, the reasons given in favour of the practice were that crop residues are an important source of livestock feed, increase soil fertility when incorporated in the soil, and that burning destroys the soil. In the uplands in Mbarali, farmers who were not burning their fields said that the soils were salty and burning would have a negative effect by increasing the salt levels.

Table 2. Reasons for burning.

Mbarali District		Kilolo, District	
Uplands	**Lowlands**	**Uplands**	**Lowlands**
To destroy thorns in paddy after harvest	To clear land during land preparation	Increased soil fertility from the ashes	To kill pests such as termites
To make it easier to plough, especially using the power tiller	Paddy has thorns that can injure the farmer during land preparation	To clear fields for land preparation	To clear fields for the next season
To control livestock		Incorporation of crop residues brings pests that damage crops	Ploughing is mostly done using oxen, hence it is important that the fields are clean before ploughing
		Culturally and traditionally, burning has been going on	Because if you do not burn, livestock keepers will bring their livestock to your farm and destroy your soil

Table 3. Observations with use of burning.

Mbarali District		Kilolo, District	
Uplands	**Lowlands**	**Uplands**	**Lowlands**
After burning, the crops grow very well.	The soil dries up and hardens, making it difficult to plough	Crops yield more in the burnt spots and, when the whole field is burnt, harvest for maize and beans is high	Crops yield more in the burnt spots as a result of ashes, which increase the fertility
The next season after burning, crop yield is higher in the burnt spots but, in the following season, yields decline – the same is observed among farmers who apply Sulphate of Ammonia (SA).	The yield is higher at the burnt spots especially for paddy and maize	Burning increases yields only in the first season of burning; in the subsequent seasons, yield declines	Burning reduces soil fertility
The soil also dries up and becomes hard – the same is observed when they apply SA	Kills stubborn weeds	The soil becomes lighter and prone to soil erosion	
		Burning makes it easier to plough because the soil becomes soft	

Classification and characterization of agro-ecological zones

Workshop held with upland farmers in Mbarali

Figure 1 shows the different AEZs that were identified by farmers from the uplands. As shown, farmers identified two main zones: (1) uplands and (2) lowlands.

A number of challenges were identified for each zone. In general, participants said that the largest area in the district was lowlands. Below are the specific challenges that were identified for each AEZ.

Figure 1. Farmer-identified agro-ecological zones in Mbarali.

Uplands	Lowlands
Construction of too many bunds and ridges reduces land availability for crop production	Poor infrastructure (i.e., without floods, they cannot produce rice)
Soil erosion	Lack of water for irrigation
Very high run-off, hence limited amount of water in the upland	During periods of heavy rainfall farmers are unable to control surface run-off, hence crops are washed away
Pests, especially termites	Farmers do not know the types of fertilizer required in their area because soil testing is not done
Usually this zone has a lot of stones reducing the size of land under cultivation	

Farmers in the lowlands reported that they harvest more yields compared to those in the uplands because all the soil minerals that are washed from the uplands are deposited in their farms. On average, in a good harvest, farmers said that they harvest 18 bags of 150 kg each of paddy per acre. In a bad season, they reported 9–10 bags. In the uplands, farmers said that a good harvest can yield 9–10 bags of paddy per acre. This might reduce to 4 bags in a bad season. Farmers in the uplands, however, believed that they benefited more than those in the low land zone when the rain was less because they would block the water from reaching the flat lands.

On climate change, farmers in the lowlands reported that they had witnessed frequent droughts that resulted in production declines. Paddy and maize were the most affected crops. Other climate-related challenges include

unpredictable rainfall, reduced flow of water in rivers, and increased pest and disease incidences. Farmers attributed the irregular patterns of rainfall to increased deforestation. They further believed that industries were manufacturing a lot of chemicals that contributed to reduced rainfall.

Experts in the lowlands, Mbarali, identified several challenges to farming. These included:

- Unpredictable rainfall; the patterns of rainfall are irregular and even the intensity of the rainfall varies.
- Declining soil fertility and shallow soil depth in Kongolo ward.
- Changes in the cropping calendar.
- Increased pests (aphids, armyworms) and diseases (fungi, rust, bacterial – e.g., Fusarium wilt and bacterial wilt).
- Poverty among farmers.
- Poor infrastructure such as road and irrigation.
- Delay in planting by farmers.
- Lack of willingness among farmers to adopt improved varieties.
- Low use of improved inputs.
- Lack of capital for investment in agriculture.
- Limited access to credit combined with poor utilization of the loan.
- Inadequate extension services.
- Low prices for agricultural produce.
- Conflict between farmers and livestock keepers.
- Livestock diseases such as contagious bovine pleuro pneumonia, foot and mouth, light chain deposition disease, Newcastle disease, and African swine fever.

They also identified changes as a result of climatic factors. Such changes related to increased pest incidences and decline in yield especially in water melon, cucumber, and sesame.

Lowlands, Mbarali

Figure 2 shows farmer-classified agro-ecological zones by farmers from the lowlands, Mbarali. As shown, the eastern and northeastern parts are mountainous and forested, while the western and southern parts are lowlands. Most of the workshop participants were from the lowland zone. Characteristics given by farmers of the lowland:

- The soils are mainly clay and more fertile than the mountainous zone.
- Typically all crops are cultivated but mainly maize and rice.
- There are microcatchments that feed water into Ruaha River.
- The zone is bushy.
- Livestock keeping is common.

Main challenges in the lowland zone related to climate variability were identified as unpredictable rainfall, delayed rainfall, less rainfall, and prolonged drought. Similar to farmers from the uplands, farmers in the lowlands associated the climatic challenges with increased deforestation. When asked for the causes of deforestation, farmers reported charcoal burning to diversify household income. It was further indicated that livestock keepers cut trees to fence grazing areas and shelter for their animals, while farmers who experienced declining soil fertility mostly cut trees in an effort to extend crop production. Beside climatic challenges, farmers identified obstacles to agricultural productivity as poor infrastructure, pests and diseases, destruction of crops by birds, lack of storage infrastructure forcing farmers to sell their produce immediately after harvesting at very low prices, rudimentary tools for cultivation, high cost of herbicides and pesticides, and unavailability of chemical fertilizers.

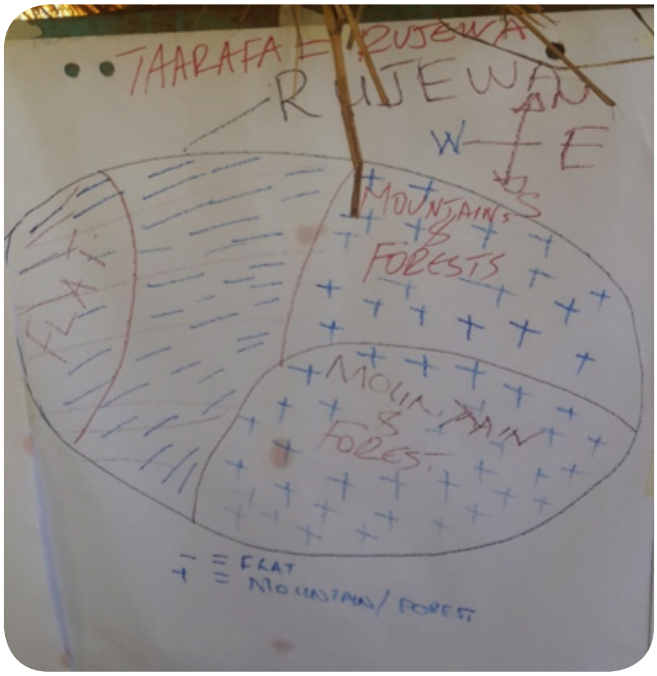

Figure 2. Identified agro-ecological zones by participants from the uplands, Mbarali.

Uplands, Kilolo

In the upland zone of Kilolo, farmers identified two AEZs: lowlands and highlands. Table 4 presents characteristics of the two AEZs.

Table 4. Characteristics and main challenges in the farmer-classified agro-ecological zones in Kilolo.

Characteristics of the different AEZs in Kilolo	
Uplands	**Lowlands**
It is forested and slopy	Fertile soils because all the soil that is washed from the mountainous areas ends up there
The soils are loamy	The rainfall is lower compared to the mountainous areas
The zone is humid	Main crops are maize, sunflower, cabbage, beans, and tomatoes
The zone receives good rainfall	High temperatures
All crops grow well	

Main challenges for the different AEZs in Kilolo	
Uplands	**Lowlands**
It is difficult to plough using oxen or tractor hence most activities are manual.	Irregular rainfall
The soil is lighter due to soil erosion hence the harvest is not as good as that of farmers in the lowland	Lack of capital
Transportation of produce is very difficult, forcing farmers to carry produce on their heads	High cost of fertilizers
High pest incidences	Low prices for agricultural produce
Soil erosion	

Lowlands, Kilolo

Participants broadly identified two zones: midlands and lowlands. Table 5 presents the characteristics of the two zones and the main challenges experienced in each one.

Table 5. Characteristics and main challenges in the farmer-classified agro-ecological zones in Kilolo.

Characteristics of the different AEZs in Kilolo	
Midlands	**Lowlands**
Free grazing	It is surrounded by rivers, such as Msoswa, Ruhua, Lukosi, Mnadaira, and Nyanzo
Main crops are tomatoes and maize	Udizungwa game reserve
Less rainfall	Main crops are maize, tomatoes, chillies, and sunflower
Most farmers do not apply fertilizer, hence low yield	Irrigation is a common practice
There are a lot of stones	

Main challenges for the different AEZs in Kilolo	
Midlands	**Lowlands**
Low soil fertility	High crop disease and pest (mice) incidences
High cost of chemical fertilizers and manure	High soil erosion caused by livestock keepers due to large herd sizes
Inadequate amount of water	Drought
Unavailability of labour	
Unpredictable rainfall	
High crop disease and pest (mice) incidences	
Soil erosion	

Specific challenges related to climate in the midlands were reduced rainfall, rise in temperatures, and unpredictable rainfall. Farmers in the lowlands mentioned decline in yields due to less amount of rainfall, and reduction in the volume of water in the rivers. Farmers blame the increased deforestation as the main cause of climate variability.

Awareness and use of agricultural practices

Awareness and use of agricultural practices in Mbarali District

Figures 3 and 4 show the practices that farmers in Mbarali upland zone were aware of and implementing. Several important messages can be derived from the figures. First, awareness of some practices both among men and women is very low. These include strip cropping, bunding, contour ploughing, rotational grazing, cover cropping, and agroforestry. Second, there is a gap in awareness between men and women. The percentage of male participants who knew about rotational grazing, improved breeds of livestock, compost manure, crop residue retention, mulching, fallowing, and manure application was higher compared to that of women. Third, there was a gap between the proportion of farmers who knew about agricultural practices and those who actually used the practice. Among men, this gap was seen in practices such as rotational grazing, improved breeds, integrated pest management, green manure, compost, farmyard manure, and fallowing. The percentage of male participants who indicated that they used these practices was much lower compared to those who said they were aware of the practices. Among female participants, a similar gap was seen in crop rotation, farmyard manure, green manure, and improved breeds.

We therefore asked for the reasons why some practices were not being practiced although a number of farmers were aware of the practices. Small herd sizes hence unavailability of adequate quantity of manure; rapid growth of weeds hence increasing labour burden for manual weeding; high cost of transporting manure; the perception that manure releases nutrients slowly; and the opinion that when

exposed to sunlight for long periods manure loses its nutrients, all constrain uptake of manure. Farmers mentioned lack of knowledge and reduction in the area of land available for cultivation as barriers to implementation of agroforestry.

Farmers expressed demand for improved farming practices. They reported that fertilizer application increases crop yield. They further indicated that herbicides reduce amount of labour required for manual weeding. In addition, they said that weeds killed by herbicides can be incorporated to increase soil fertility.

Mbarali upland zone men

	Awareness	Use		Awareness	Use
Agroforestry	16%	5%	Improved livestock breeds	29%	13%
Compost manure	26%	5%	Improved varieties	35%	19%
Contour bunding	10%	0%	Integrated pest management	26%	10%
Contour ploughing	26%	0%	Intercropping	23%	19%
Cover crops	6%	6%	Irrigation	39%	23%
Crop residue retention	16%	13%	Manure application	48%	15%
Crop rotation	19%	15%	Minimum tillage	35%	35%
Early land preparation	45%	39%	Mixed cropping	35%	26%
Early planting	39%	35%	Mulching	19%	13%
Fallowing	29%	3%	Pesticides application	32%	29%
Fertilizer application	19%	19%	Rotational grazing	29%	19%
Green manure	32%	6%	Seed selection	42%	39%
Herbicide application	35%	29%	Water harvesting	32%	16%

Figure 3. Awareness and use of agricultural practices by men participants from the uplands, Mbarali.

Notes: Awareness and use are computed as a percentage of the total number of workshop participants. For example, 19% of workshop participants had heard about crop residue retention, while 16% of the total number of participants who were present had actually retained crop residues in their farming.

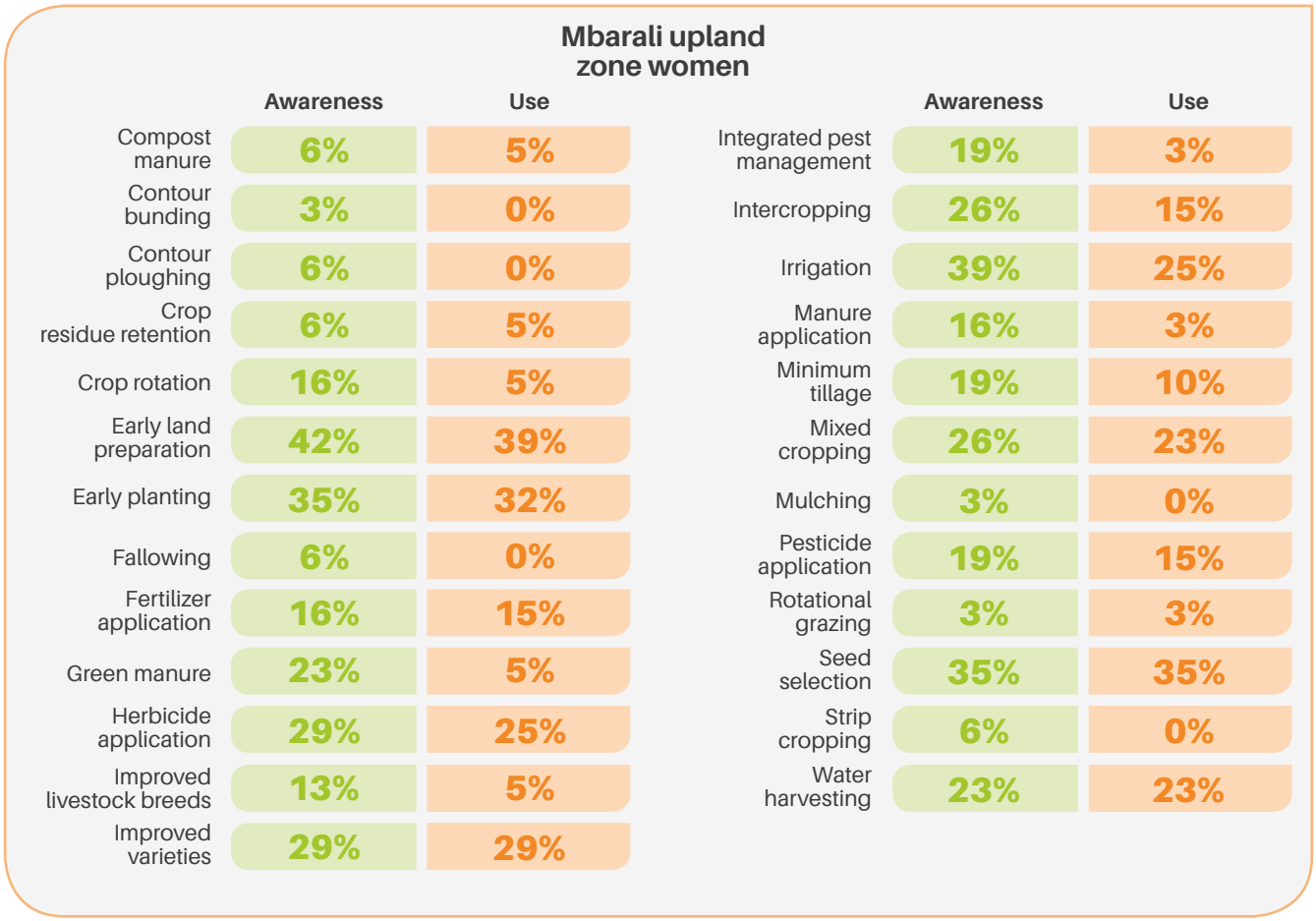

Figure 4. Awareness and use of agricultural practices by women participants from the uplands, Mbarali.

Notes: Awareness and use are computed as a percentage of the total number of workshop participants. For example, 23% of workshop participants had heard about water harvesting, while the same proportion of the total number of participants who were present had actually practiced water harvesting.

In the lowlands, Mbarali, although there was no much difference in awareness about agricultural practices between men and women, Figures 5 and 6 show important awareness–use gap. This gap was mostly observed in improved varieties, zero grazing, green manure, cover crops, crop rotation, intercropping, fallowing, and application of farmyard manure.

Farmers gave several reasons why some practices were not being implemented even though they were aware of them. They particularly reported that improved varieties were expensive and susceptible to pest attacks. Farmers further believed that in case of shortage of rainfall, the loss was much higher with improved varieties than with local varieties. Farmyard manure was not common because most farmers either did not own livestock or the herd sizes were very small. Farmers also said that they preferred chemical fertilizer to manure because the latter takes a longer time to release nutrients. Transportation costs was also reported to hinder use of manure. Some farmers further reported that because most of the land was rented, they did not apply manure because they were unwilling to improve fertility of land that did not belong to them. Shortage of land also explained why farmers did not practice fallowing. They further indicated that leaving the rented land fallow was a great economic loss.

The main reason why crop rotation was not practiced is because rice is the main crop in the lowlands. Farmers indicated that it is not easy to rotate another crop with rice. Moreover, inadequate amount of rainfall makes it difficult for farmers to rotate crops.

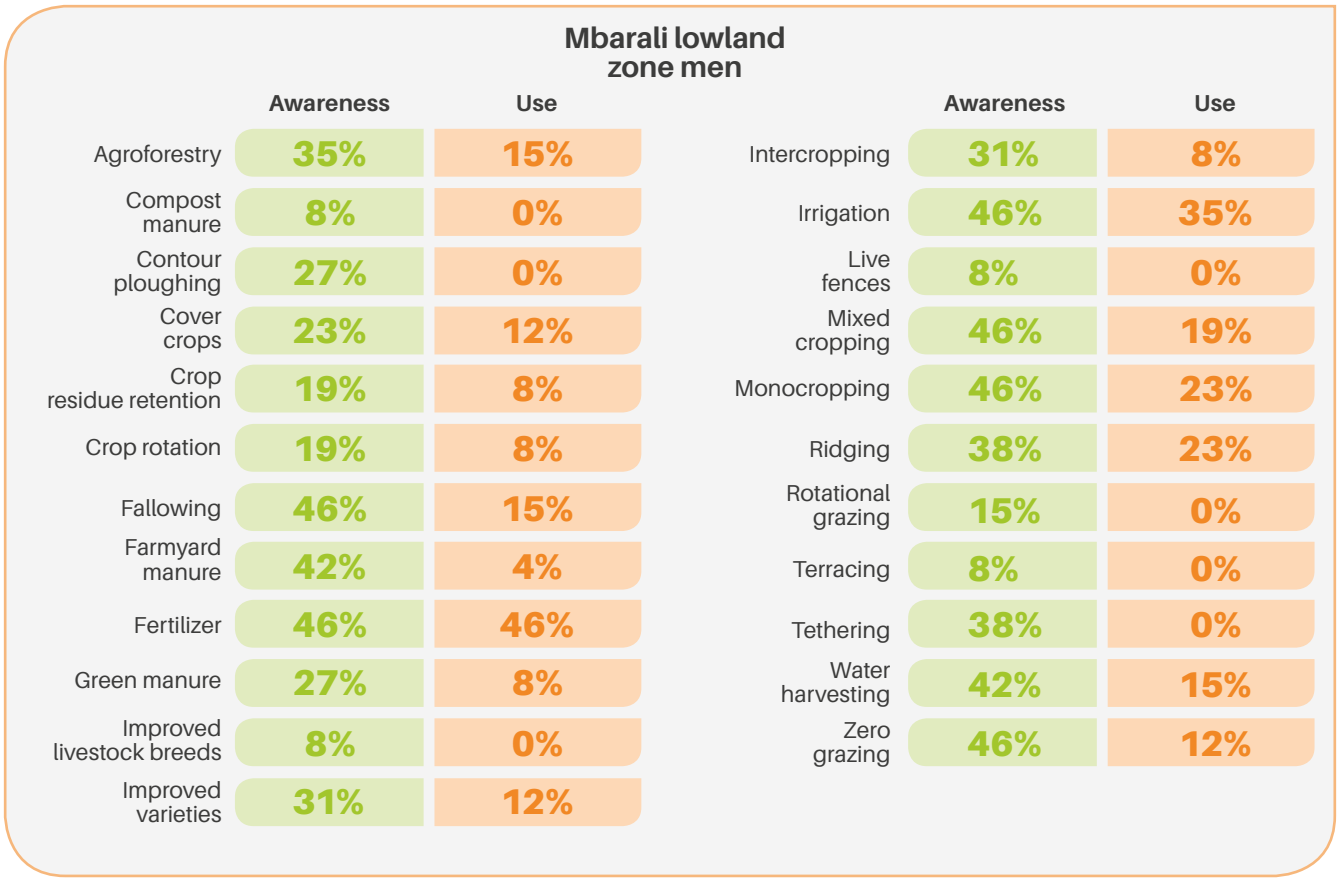

Figure 5. Awareness and use of agricultural practices by men participants from the lowlands, Mbarali.

Notes: Awareness and use are computed as a percentage of the total number of workshop participants. For example, 35% of workshop participants had heard about agroforestry, while 15% of the total number of participants who were present had actually practiced agroforestry. Practices such as compost manure, contour ploughing, improved livestock breeds, and rotational grazing had no single participants reporting their use.

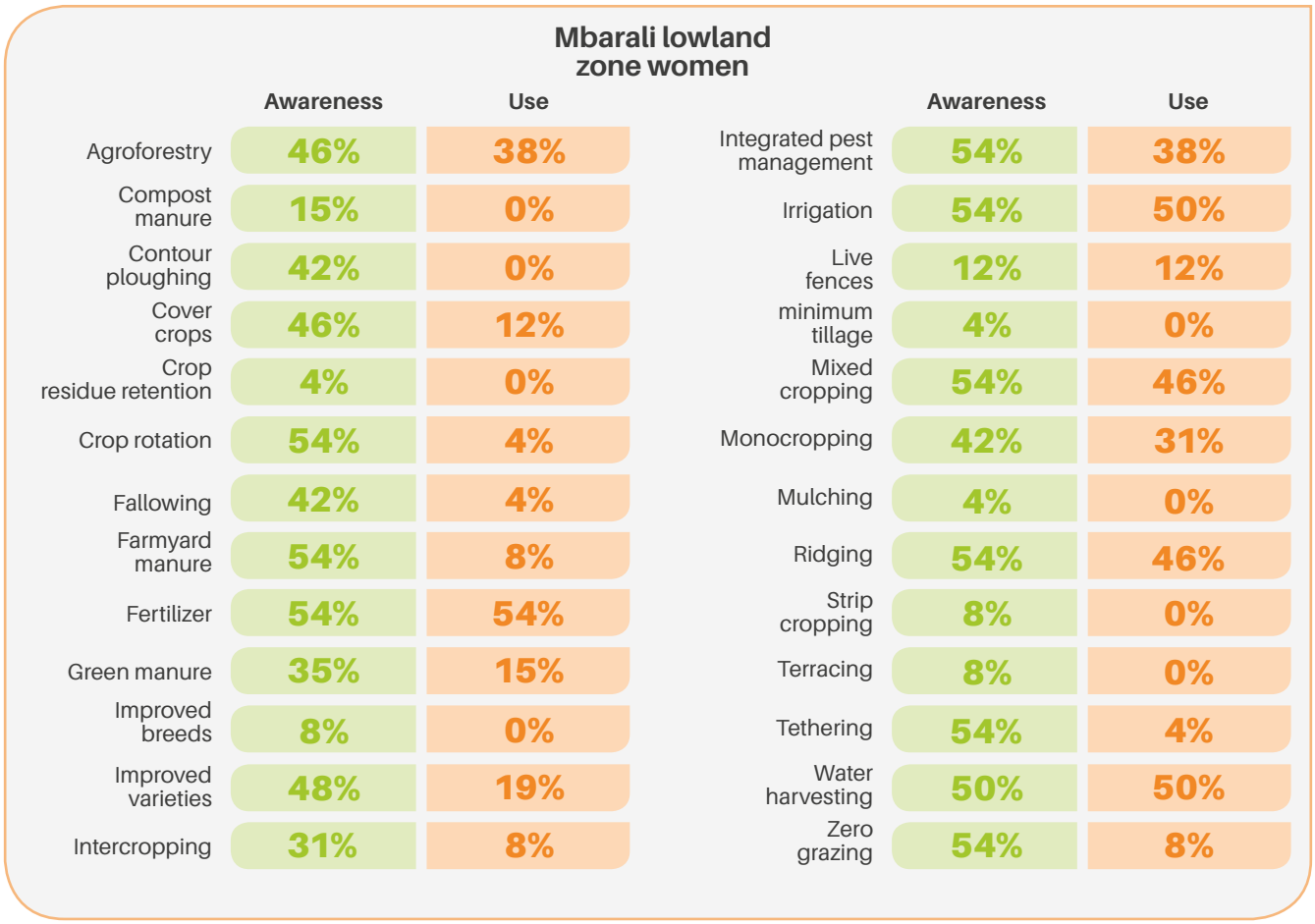

Figure 6. Awareness and use of agricultural practices by women participants from the lowlands, Mbarali.

Notes: Awareness and use are computed as a percentage of the total number of workshop participants. For example, 45% of workshop participants had heard about crop rotation, but only 4% of the total number of participants who were present had actually practiced it. Practices such as compost manure, crop residue retention, improved livestock breeds, reduced tillage, and mulching had no single participants reporting their use.

Awareness and use of agricultural practices in Kilolo District

Similar to Mbarali, the proportion of farmers who were aware about agricultural practices was low in Kilolo (Figures 7–10). Very few farmers in the uplands are aware of mulching, reduced tillage, agroforestry, composting, and improved breeds. The proportion of farmers implementing improved agricultural practices was low even when farmers were aware of these practices.

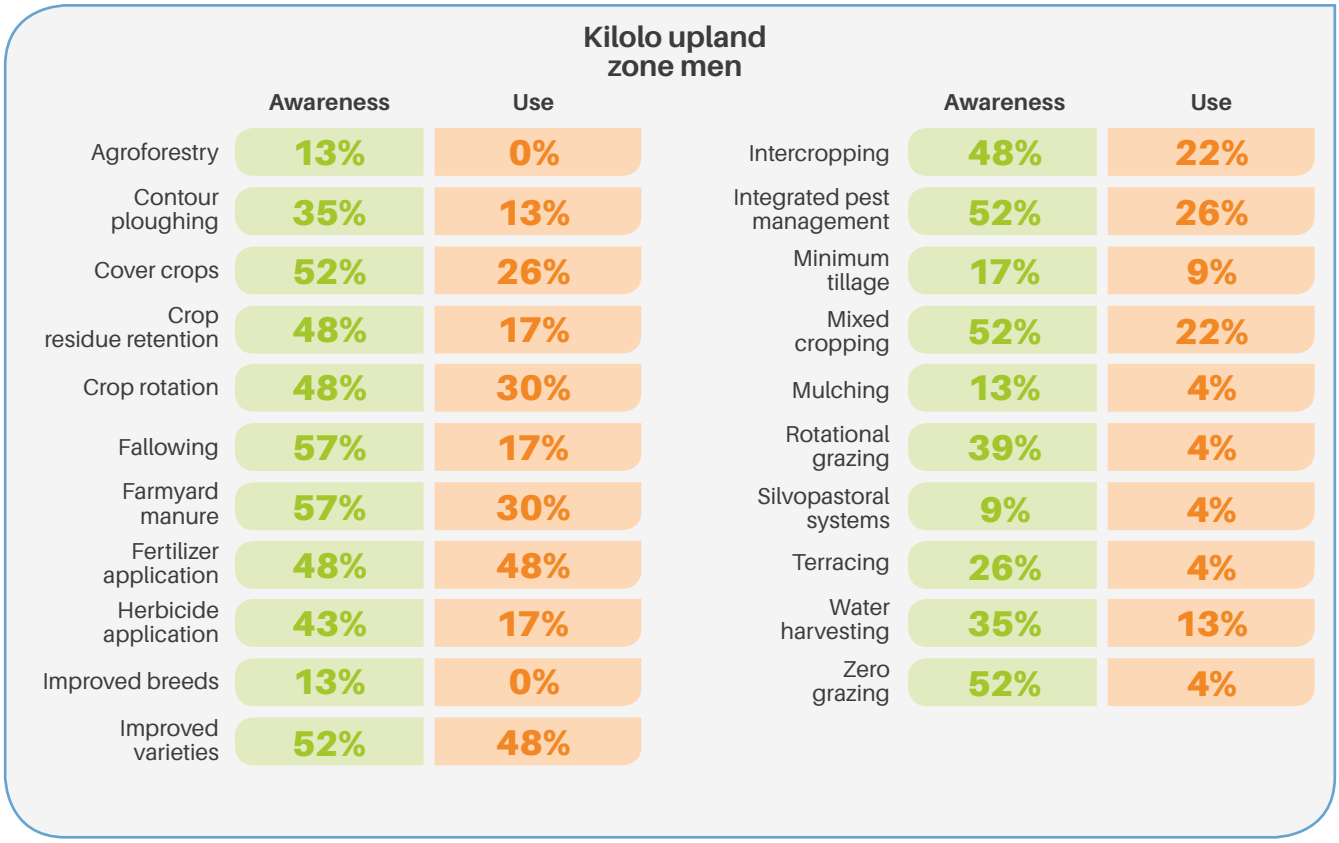

Figure 7. Awareness and use of agricultural practices by men in uplands, Kilolo.

Notes: Awareness and use are computed as a percentage of the total number of workshop participants. For example, 48% of workshop participants had heard about crop residue retention, while 17% of the total number of participants who were present had actually practiced it. Practices such as improved livestock breeds and agroforestry had no single participants reporting their use.

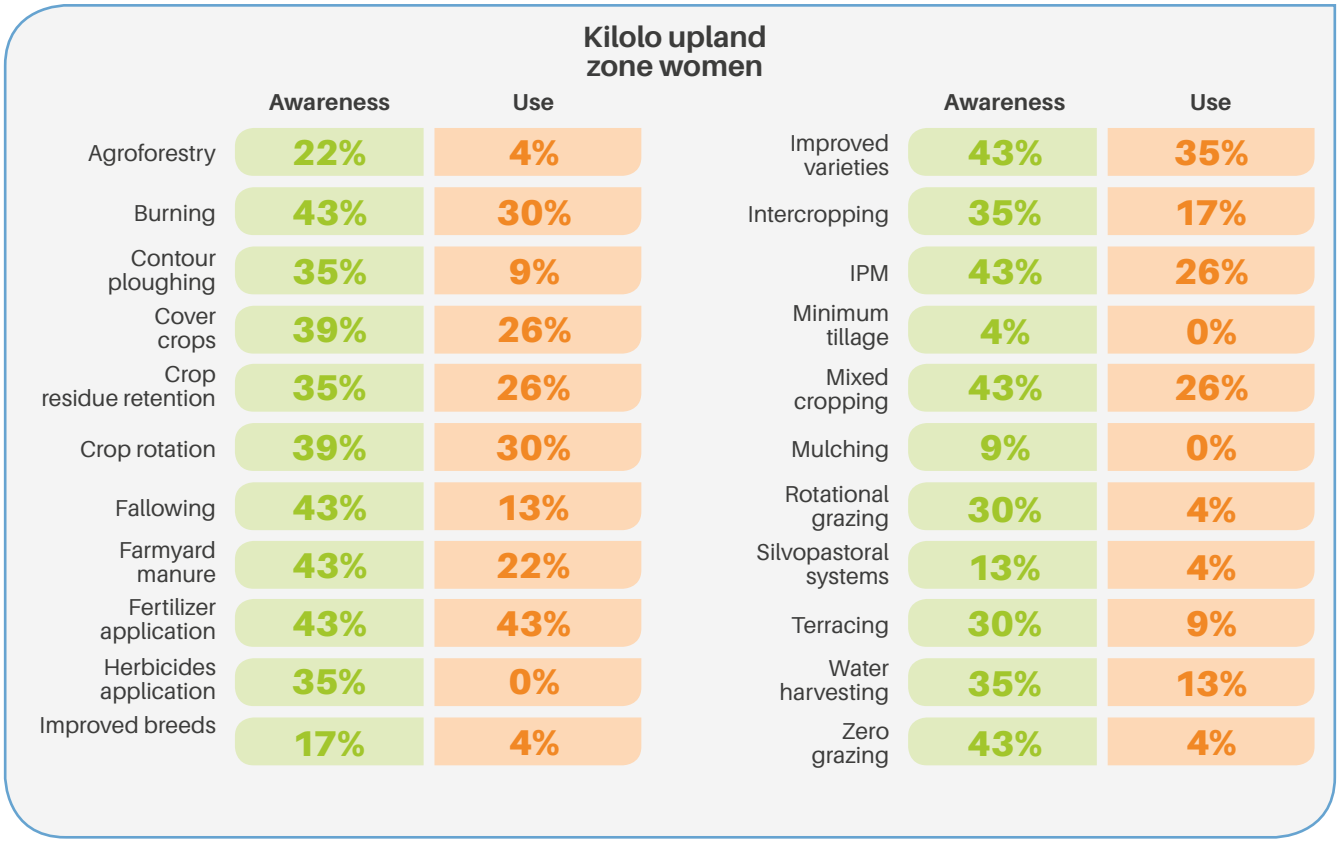

Figure 8. Awareness and use of agricultural practices by women in uplands, Kilolo.

Notes: Awareness and use are computed as a percentage of the total number of workshop participants. For example, 35% of workshop participants had heard about intercropping, while 17% of the total number of participants who were present had actually practiced it. Practices such as reduced tillage and mulching had no single participants reporting their use.

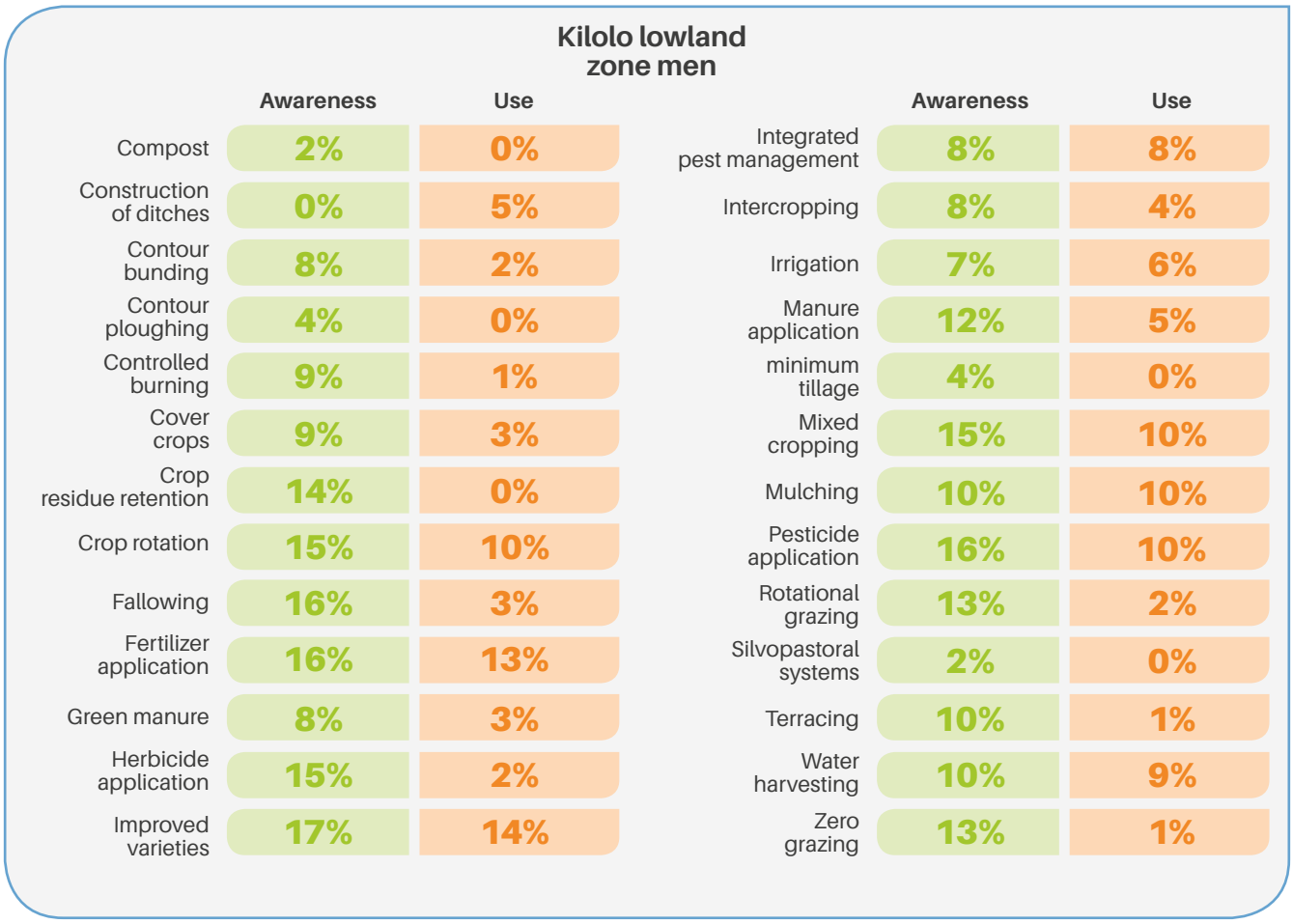

Figure 9. Awareness and use of agricultural practices by men's group in lowlands, Kilolo.

Notes: Awareness and use are computed as a percentage of the total number of workshop participants. For example, 17% of workshop participants had heard about improved varieties, while 14% of the total number of participants who were present had actually planted improved varieties.

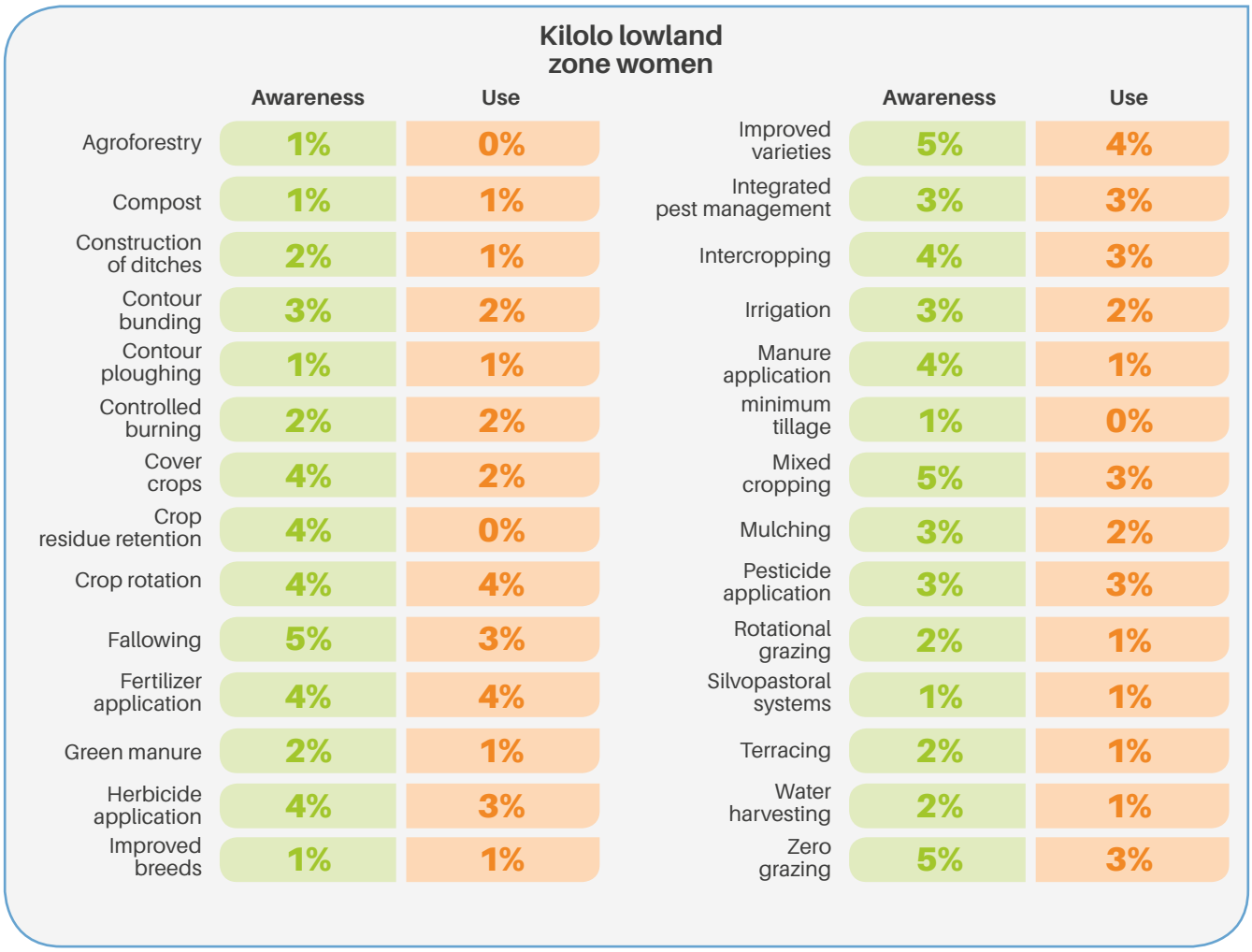

Figure 10. Awareness and use of agricultural practices by women's group in lowlands, Kilolo.

Notes: Awareness and use are computed as a percentage of the total number of workshop participants. For example, 4% of workshop participants had heard about cover crops, while 2% of the total number of participants who were present had actually planted cover crops.

In this particular workshop, the total number of female participants was very low compared to the other workshops.

Selected most relevant practices and prioritization, by district and agro-ecological zones

Selected practices in uplands, Mbarali

Farmers were asked to select, from the master list, practices that they thought were most relevant for their zones. Table 6 shows the practices that were selected by the men's group in the uplands, Mbarali, as the most relevant and the benefits associated with each practice. Table 7 presents results of the women's group in uplands, Mbarali. Crop rotation was commonly selected by both men and women. The main reasons for selecting crop rotation were because it increases soil fertility and that it allows the farmer to identify suitable crops for specific plots.

Another practice that was common between men and women was herbicides application. The main reasons why farmers selected herbicides were related to reduction in the workload and time associated with manual weeding. The implication of this finding to policies on CSA is that efforts to introduce alternative approaches for weed control must address the labour and time constraints. There were important challenges that were raised by the men's group about application of herbicides, namely lack of knowledge on application of herbicides, high cost of the input, and the problem of fake chemicals.

The findings reported in Tables 6 and 7 show that farmers could understand the benefits of agricultural practices but barriers to adoption remain. The results further indicate that adoption is not without trade-offs. Mulching, for example, was reported to create a favorable warm environment for seed germination, improve soil texture, and conserve soil moisture. However, constraints such as unavailability of mulch, competition for use as livestock feed, and increased pest incidences were reported to limit uptake.

Table 6. Relevant practices selected by the men's group from the uplands, Mbarali.

Practice	Benefits
Early land preparation	Better yields; allows for proper planning of activities; to prepare for the rains; reduces workload
Early planting	Better yields; more income; to prepare for the rains
Seed selection	To select good-quality seeds that are disease free, high yielding, disease resistant; marketable produce
Intercropping	The intercrop might provide vegetables; conserves moisture; increased soil fertility; crop diversification hence reduced risk of crop failure; reduces cost of renting land as different crops can be grown in a plot
Fertilizer application	Increased yield
Herbicide application	Reduces cost of weeding; increases soil fertility; reduces the amount of time and effort required to weed
Crop rotation	Increases soil fertility; controls diseases; farmers are able to know which crop performs best in what plot
Irrigation	Guaranteed harvest compared to rain-fed farming; increased food security due to more production

(continues)

(continued)

Practice	Benefits
Pesticide application	More yield; controls pests
Fallowing	Increased soil fertility

Table 7. Relevant practices selected by the women's group in uplands, Mbarali.

Practice	Benefits	Challenges
Early land preparation	To prepare for the rains; better yields; more income; to plant in time; good prices because of early harvesting; labour is available when you prepare land early	-
Improved varieties	High yielding; reduced risk of crop failure; marketable produce; disease resistant	Lack of access to fertilizer; lack of knowledge about improved seeds and where to find them
Livestock manure	Increases soil fertility; the soil does not get tired; can release nutrients for a long time	High costs of transportation
Stop burning	The soil does not get tired; increased soil fertility; when vegetation decomposes, it brings useful microorganisms; vegetation reduces surface run-off; vegetation controls soil erosion	Pastoralists will bring their cattle to your farm if you do not burn; neighbours sometimes burn other people's fields
Herbicide application	Makes it easier to weed; the soil becomes good; increases soil fertility; reduces the amount of time spent in the garden weeding	Lack of knowledge on herbicide application; high cost of the input; adulterated chemicals
Water harvesting	If the rain stops when the crop is still tender, you can irrigate; gardens next to the harvested water are moist; the ponds can also be used to rear fish	The area is very stony; conflicts between pastoralists and crop farmers – pastoralists use a lot of water for their livestock
Crop rotation	The soil does not get tired because of inclusion of crops that enhance soil fertility in the rotation; diversified production; the soil becomes easier to cultivate	Drought makes it difficult to grow more crops; unavailability of seeds to plant another crop when you harvest one; unavailability of good quality seed
Mulching	Creates warmth that allows seeds to germinate earlier; improves soil texture; conserves soil moisture	Unavailability of mulching material because burning is common; competition for the mulching material by livestock keepers; increased pest incidences

Selected practices in lowlands, Mbarali

Table 8 shows the practices that were selected by the women's group in the lowlands, Mbarali, and the associated benefits. Table 9 shows the practices that were selected by the men's group. Both men and women chose irrigation, chemical fertilizer, and crop rotation as most relevant practices in the lowlands. The benefits given for these practices are related to the major constraints identified by farmers for this zone, namely low soil fertility and inadequate amount of water for irrigation. The proportion of farmers that were aware about irrigation and chemical fertilizer was slightly higher among women than men (Figures 5 and 6). More women were aware of crop rotation than men (Figures 5 and 6). Adoption of the prioritized practices was low even when farmers were aware of them.

Table 8. Practices selected by the women's group in the lowlands, Mbarali.

Practice	Benefits
Cover crop	• Protects the soil from direct sunlight • They are vegetables • Helps to conserve soil moisture • Suppresses weeds
Chemical fertilizer	• Increases soil fertility • Increased yield
Bunding	• Controls soil erosion • Makes it easier to implement irrigation
Integrated pest management	• Reduces cost of pest control
Irrigation	• Possible to produce crops when there is no rain • Allows for cultivation of more crops
Livestock manure	• Increases soil fertility • Reduces cost of buying chemical fertilizer • It is easy to obtain because even your neighbour can provide • Releases nutrients for a longer time
Crop residue retention	• Increases soil fertility • Reduces cost of buying chemical fertilizer
Crop rotation	• Allows the soil to regain fertility • Helps to control pests • Conserves soil moisture • Increases soil fertility because of growing different crops

Table 9. Practices selected by the men's group in the lowlands, Mbarali.

Practice	Benefits	Challenges
Irrigation	• Guaranteed harvest and income • Continued production even when there is drought • Even livestock feed is available with irrigation	• Inadequate amount of water for irrigation • High cost of equipment such as water pump • Poor irrigation infrastructure • Lack of land to use for water harvesting
Crop rotation	• Increases soil fertility • Increased income because farmers can plant several times	• High cost of seeds especially during planting time • Lack of knowledge
Mixed cropping	• Diversified production per unit area • Reduces weeding • It is a way to cope with risk such as drought	• The main crop is rice, which occupies a lot of farm land, hence reducing amount of land available for diversified cropping
Improved varieties	• Increased yield and income • Drought tolerant • Early maturing	• High cost of improved varieties • Lack of knowledge on growing improved varieties • Easily attacked by diseases • Fake seeds
Farmyard manure	• It has long-term benefits • Increases soil fertility • Makes the soil easy to till • Increases yield • The cost is lower if you keep livestock	• High transportation costs • Lack of knowledge on application
Fertilizer	• Increases yields • It is easily available • Increases income	• Without rain, application of fertilizers may cause a huge loss • If used for a long time, it damages the soil
Row planting	• Increased yield • Makes it easier to weed	• It is time consuming • It is costly • Lack of knowledge on proper spacing

Prioritization of practices using pairwise matrices, Mbarali

As explained in the methodology section, pairwise ranking was used to prioritize practices. In this section, we present results of the selected practices and pairwise ranking men's and women's groups in the different identified AEZs in Mbarali. As shown in Table 10 below, the men's group ranked mulching, improved varieties, water harvesting, manure application, and crop rotation as the five most important practices in respective order. We find that even for the prioritized practices, the percentage of farmers who were aware and using these practices was low (Figures 3 and 4). As presented in Tables 7 and 9, several constraints explain why farmers in the uplands and lowlands might not be able to implement the practices they prioritize. Strikingly, although a high percentage of farmers in Mbarali perceived the status of soil fertility as "bad," fertilizer and manure application was ranked at the bottom by both women and men, especially in the lowlands. Improved varieties and water management practices (irrigation and water harvesting) are prioritized in Mbarali.

Table 10. Prioritized agricultural practices in upland and lowland AEZ in Mbarali District, by gender.

Uplands				Lowlands	
Men		Women		Men	
Practice	Rank	Practice	Rank	Practice	Rank
Mulching	1	Bunds	1	Correct spacing	1
Improved varieties	2	Irrigation	2	Improved varieties	2
Water harvesting	3	Integrated pest management	3	Crop rotation	3
Manure	4	Crop residue	4	Irrigation	4
Crop rotation	5	Cover crops	5	Mixed cropping	5
Early land preparation	6	Fertilizer	6	Farmyard manure	6
No burning	7	Compost manure	7	Fertilizer	7
Herbicides	8	Crop rotation	8	-	-

Selected and prioritized practices in Kilolo District

In the uplands, the women's group selected fertilizer application, intercropping, fallowing, improved breeds, improved varieties, contour ploughing, and agroforestry as the most relevant practices. The men's group selected improved varieties, pesticides, mulching, crop rotation, fertilizer, and irrigation. Table 11 presents the benefits that farmers associate with each of the practices selected by the women's group in the uplands, Kilolo.

In the lowlands, female participants selected herbicide application, improved varieties, fertilizer application, irrigation, mulching, and pesticides. Table 12 shows the benefits associated with the selected practices.

As shown in Table 13, the most prioritized practices by the women's group in the uplands were improved breeds and improved varieties, while fertilizer application was the least prioritized. The men's group in the uplands prioritized improved varieties and pesticide application, while irrigation and fertilizer application were ranked lowest. In the lowlands, the women's group prioritized improved varieties, irrigation, and fertilizers; while mulching and herbicides were least prioritized.

Challenges identified by farmers were mostly related to the use of herbicides and irrigation. Farmers indicated that herbicides are non selective and, therefore, destroy other crops. Inadequate amount of water for irrigation was the main barrier for irrigation. When asked about why they were not implementing other practices that

they were aware of, farmers reported that fallowing is not practiced because of the small sizes of land; lack of knowledge on modern technologies; agroforestry is not practiced because farmers lack access to tree seedlings. In order to implement such practices, farmers indicated that they would require training.

They also suggested that the number of extension agents should be increased. The men's group in the lowlands ranked improved varieties, pesticides, and irrigation as most important, while farmyard manure and zero grazing were ranked as least important (Table 13).

Table 11. Practices selected by the women's group in the uplands, Kilolo.

Practice	Benefits
Fertilizer application	• Increased productivity
Intercropping	• Increased soil fertility
Fallowing	• Increased soil fertility • Controls pests
Improved breeds	• Better production
Improved varieties	• High yield • Marketable
Contour ploughing	• Controls soil erosion
Agroforestry	• Conserves moisture for a longer time

Table 12. Practices selected by the women's group in lowlands, Kilolo.

Practice	Benefits
Herbicide application	• To control weeds, especially in onions; reduces cost of weed control; increased yield; more income
Improved varieties	• Increased yield; increased income; marketable
Fertilizer application	• Healthy plants; high yields; conserves soil moisture
Irrigation	• Less rainfall especially in the lowlands; guaranteed harvest
Mulching	• To control pests such as locusts in tomatoes; to conserve soil moisture; controls soil temperature
Pesticides	• Reduces pest damage

Table 13. Prioritization of agricultural practices in Kilolo District.

Uplands				Lowlands			
Women		Men		Women		Men	
Practice	Rank	Practice	Rank	Practice	Rank	Practice	Rank
Improved breeds	1	Improved varieties	1	Improved varieties	1	Improved varieties	1
Improved varieties	2	Pesticides	2	Irrigation	2	Irrigation	2
Fallowing	3	Mulching	3	Fertilizers	3	Early planting	3
Contour ploughing	4	Crop rotation	4	Pesticides	4	Pesticides	4
Agroforestry	5	Fertilizer	5	Herbicides	5	Correct spacing	5
Fertilizer	6	Irrigation	6	Mulching	6	Fertilizer	6
-	7	-	-	-	-	Crop rotation	7
-	8	-	-	-	-	Zero grazing	8

Indicators that farmers use to select practices

Farmers reported to use different indicators to select agricultural practices. As shown in Tables 20–23, the indicators selected are, in most cases, ranked very important. Such indicators are important because they help to identify not only barriers to uptake of the prioritized practices but also the trade-offs that adoption might bring. It can be seen that farmers rank yield and income as very important but are also most concerned about costs, farm size, availability of inputs, rainfall, and knowledge about the practice.

Table 14. Indicators that farmers use to select agricultural practices in uplands, Mbarali.

Indicator	Men's group	Women's group
Yield	5	5
Cost	5	5
Knowledge/Skills	5	5
Transportation, e.g., for manure	5	5
Weed infestation	2	5
Availability of inputs	5	5
Farm size	5	5
Rainfall	5	5
Soil fertility	5	5
Indigenous knowledge	2	5
Labour	5	5
Time	5	5
Income	5	5

Note: Indicators were scored on a scale ranging from 1 "not important at all" to 5 "very important ."

Table 15. Indicators that farmers use to select agricultural practices in lowlands, Mbarali.

Indicator	Women's group	Men's group
Yield	5	4
Income	5	5
Soil fertility	5	5
Sustainability of land	5	5
Availability of water	5	5
Knowledge/skills	5	5
Cost	5	5
Pests/diseases	5	4
Farm size	5	5
Type of seeds	5	5

Note: Indicators were scored on a scale ranging from 1 "not important at all" to 5 "very important."

Table 16. Indicators that farmers use to select agricultural practices in uplands, Kilolo.

Indicator	Women's group	Men's group
Yield	5	3
Income	5	3
Soil fertility	5	4
Sustainability of land	5	4
Availability of water	5	5
Knowledge/skills	5	3
Cost	5	5
Pests/diseases	5	4
Farm size	5	5
Type of seeds	5	5

Note: Indicators were scored on a scale ranging from 1 "not important at all" to 5 "very important."

Table 17. Indicators that farmers use to select agricultural practices in lowlands, Kilolo.

Indicator	Women's group	Men's group
Yield	5	5
Income	5	5
Soil fertility	5	5
Sustainability of land	5	NS
Availability of water	5	5
Knowledge/skills	5	5
Cost	5	5
Pests/diseases	5	NS
Farm size	5	5
Availability of seeds	5	5
Availabiliy of labour	NS	5
Availability of equipment	NS	5

Notes: NS = indicator was not selected by the group.
Indicators were scored on a scale ranging from 1 "not important at all" to 5 "very important."

Demonstration plots

Demonstration plots in uplands, Mbarali

The following practices were selected by the women's group for the CSA demonstration plots: early land preparation; improved crop varieties; water harvesting; mulching; and fertilizer application. Farmers identified four existing demonstration plots located in Kongolo, Nyasa, Chang'ombe, and Mashara. Table 24 presents the practices that were being implemented in the existing demonstration plots.

Farmers suggested that new demonstration plots should be located in Kongolo-Mswiswi. They further suggested that demonstration plots should be owned and managed by farmers themselves. They recommended that the Rural Urban Development Initiative (RUDI) and the village leadership should be involved.

The men's group recommended that a demonstration plot be located in Mahongole, Ipatagwa. They would like the following practices to be demonstrated: irrigation; application of herbicides; application of chemical fertilizers; application of herbicides; and seed selection. They suggested that farmers should work with extension agents to form groups. They would also like farmers groups and different organizations such as RUDI to be involved. In Mahongole, the location that farmers selected for a new demonstration plot is a school located close to government offices. They recommended demonstration plots to be on farmers' individual farms.

Table 18. Existing demonstration plots in uplands, Mbarali.

Demo site	Practice/activity	Management
Kongolo	• Growing improved varieties • Using modern technologies • Row planting • Proper spacing • Leveling of the garden • Harvesting • Improved storage techniques	RUDI and the government working with farmers
Nyasa	• Row planting • Fertilizer application • Transplanting paddy seedlings	RUDI
Chang'ombe	• Timely seed preparation • Use of improved varieties • Row planting	RUDI There is one demonstration plot where all villagers learn
Mashara	• Market access • Modern technologies • Not mixing harvested grains of different quality for maize and rice • Improved storage	BRA working with extenson agents and farmers

Demonstration plots in lowlands, Mbarali

The following practices were selected by the women's group for demonstration: improved crop varieties; fertilizer application; application of farmyard manure; fallowing; mulching; and improved planting techniques. Table 25 presents existing demonstration plots and the practices in those demonstration plots.

Farmers suggested that new demonstration plots should be located in Ibohola, Mwakaganga, and Mwanavala. They prefer the demonstration plots to be owned and managed by a village agricultural organization "shirika la kilimo la kijiji." They further suggested that farmers should form groups and elect leaders. The selected members would go and learn from the demo then come back and train others. Village extension officers should manage the demonstration plots.

The men's group selected the following practices for demonstration: seed preparation; proper use of fertilizers (i.e., proper rates and type); integrated pest management; and improved storage. The recommended sites were Imarilo Songwe and Mwenda Mtitu. Farmers suggested that the demonstration plots should be located on village land and that management should involve the extension officer. Farmers further suggested that other organizations should be involved as well. No existing demonstration plot was identified by the men's group.

Table 19. Existing demonstration plots in lowlands, Mbarali.

Demo site	Practice/activity	Management
Ibohora	• Improved/modern agricultural practices	• Individual farmer
Mwenda mtitu	• Row planting (rice)	• Ushirika wa umwagiliaji Mwendamtitu
Mwanavala	• Improved agricultural practices	• Extension agent

Demonstration plots in uplands, Kilolo

Farmers in the women's group from the flatlands identified an existing demonstration plot run by One Acre Fund and the African Conservation Tillage Network (ACT) under the Alliance for a Green Revolution in Africa (AGRA). Farmers are encouraged to work in groups. They learn from the demonstration plot and share the knowledge with their neighbours at home. Conventional versus modern technologies are compared, e.g., the use of fertilizer. One Acre Fund, in addition to training farmers, provides agricultural inputs on credit.

When asked where they would like to have new demonstration plots, farmers said that they would like the site to be selected by the District Council of Kilolo. They would like the demonstration plot to be managed by an organization, and that farmers should be encouraged to form groups. They recommended that every ward should have its own demonstration plot.

The men's group from the lowland and upland zones identified existing demonstration plots in Iramba, Mawambala, Kitowo, Lusinga, and Ngongwa. The demonstration plot in Iramba aims to provide farmers with training on farming including correct spacing and fertilizer use. The demonstrations are run by Savings and Internal Lending Communities (SILC) and are located around the ward offices. The demonstration plot in Mawambala aims to increase agricultural productivity among farmers. It was started by Clinton Foundation and is managed by an individual. The demonstration plot trains farmers on planting techniques, timely weeding, herbicide application, and use of improved varieties. The demonstration plot in Kitowo is mainly involved in providing farm inputs to farmers under One Acre Fund. Lusinga was started by an organization called Cheetah Development and aims to train farmers on sweet potato production. In Ngongwa, the demonstration plot is managed under Clinton Foundation and trains farmers on improved farming practices.

The five important practices that were selected for demonstration by the men's group include: minimum tillage, soil testing, improved varieties, fertilizer application, and irrigation. Farmers identified Dabaga and Kitowo as the suitable locations in the upland and lowland, respectively. They would like farmers to organize themselves and work in groups and that an individual's land should be used. They would further like the following organizations to be involved: churches and mosques, Maendeleo ya Watu wa Kilolo (MAWAKI), and One Acre Fund.

Demonstration plots in lowlands, Kilolo

The men's group in the lowlands identified an existing demonstration plot in Msosa. The demonstration plot trains farmers on onion production and also links farmers to export markets. Through the demonstration plot, farmers learn how to control pests.

Farmers in the men's group said that they would want to learn about production of clean seeds of different crops, such as tomatoes, beans, maize, and chillies. In addition, they were interested in learning about fertilizer and pesticide application, and preparation and application of compost manure.

The sites recommended for demonstration plots were Mlafu in the uplands – managed by elected members of the community; in every ward in the central zones – managed by extension officers. Farmers recommended that churches, such as Lutheran and organizations such as One Acre Fund should be involved.

Experts' workshop results

Experts' workshop in uplands, Mbarali

Experts in the uplands of Mbarali identified challenges related to unpredictable rainfall, low soil fertility, pests and diseases, low income, poor infrastructure, unwillingness among farmers to follow advice from extension agents, low adoption of improved technologies, lack of capital for investment in agriculture, limited access to credit, limited access to extension advice, emergence of human diseases, low market prices, and conflict between farmers and livestock keepers. Several practices had been abandoned by farmers in the uplands of Mbarali District. Such practices included labour-sharing during major farming activities, e.g., planting, weeding, and harvesting commonly known as "*mgoe*" or "*mjanwa;*" fallow cropping is no longer practiced because of the increase in population; shift from manual weeding to use of herbicides such as round up; shift to using power tillers as opposed to hand-hoe; change from using organic manure to the use of chemical fertilizers such as urea; increase in sunken beds; row planting using ropes as opposed to broadcasting "*mchakamchaka*." Farmers had abandoned the practices for several reasons: shortage of land due to population pressure makes it difficult to practice fallowing; harvest is large with little amount of seeds; large sizes of land encouraged the practice of labour-sharing but with the reduction in the size of land, the practice has stopped; increased use of improved technologies; reduced labour demand and time for weeding when herbicides are used, e.g., round up and 24D; knowledge on the use of chemical fertilizers has expanded; there is increased yield with the use of chemical fertilizers; farmyard manure increases growth of weeds hence farmers do not like it; and combine harvesters cannot reach the sunken beds.

Common crop practices in uplands, Mbarali, were identified as increased use of fertilizers and inputs such as powertiller, improved seeds, combine harvesters, and integrated pest management. Experts further identified common livestock practices, including dip tanks and spraying to control pests, vaccination, improved breeds and artificial insemination services, reduced herd sizes, zero grazing, and mixed farming.

Important soil management practices that experts identified included farmyard manure; planting on ridges especially maize, sweetpotatoes, and sunflower; planting trees along River Bwili to control soil erosion; village by-laws which prevent inappropriate use of soil in the village, e.g., large herds of cattle; and crop rotation in maize production zones, especially in the scheme areas of Bwili, Ipatagwa, Moto Mbaya, Nyasa, Kapyo, Azimio, Kongolo Mswiswi, and Suhela.

When deciding whether or not to implement a practice, experts indicated that farmers care about generating more income, increased yield, and profits.

The experts recommended soil testing, drip irrigation, farmyard manure, adapted varieties of crops, water harvesting technologies, conservation agriculture, education on fallowing, crop rotation, reduced use of chemical fertilizers, maintenance of irrigation canals, and intercropping. For livestock, integrated crop livestock production systems; zero grazing; destocking; keeping small livestock such as rabbits, chicken, and ducks; and construction of improved structures were recommended.

Experts' workshop in Lowlands, Mbarali

Three zones were identified by the experts who attended the workshop in Ubaruku, namely Ilongo, Madibila, and Rujewa. Because the experts were from lowlands, subsequent activities focused on this zone. The experts identified several challenges to agricultural productivity in lowlands, Mbarali, including:

- Unpredictable/irregular pattern of rainfall.
- Less rainfall.
- Inadequate amount of water for irrigation.
- Soil erosion.
- Farmers rely a lot on their own indigenous knowledge and accumulated experience paying little attention to experts' advice.
- Except for rice, farmers do not apply chemical fertilizers on other crops, such as maize, beans, groundnuts, etc.; this is mainly because of unpredictable rainfall.
- Declining soil fertility.
- Poor roads and irrigation infrastructure.
- Experts are not well facilitated in their activities, e.g., lack of seminars and trainings.
- High temperature causing very high rates of evaporation.
- The soil dries and cracks, hence crops do not grow well.
- Poor postharvest handling techniques resulting in high postharvest losses, especially in rice.
- Lack of capital.
- Low market prices for agricultural produce, partly due to low quality of the produce; there are also no standard measures of output.
- Salty soils in some areas due to excessive evaporation.
- Lack of knowledge on pesticide application.
- High pest and disease incidences, especially in tomatoes, green pepper, and cucumber. Paddy is affected by leaf rust and rice gall midge.
- Conflict between crop farmers and pastoralists due to competition for resources.
- Poor quality of seeds and fertilizer.
- Strong winds cause losses among rice farmers who grow "Biriani" variety.
- Some rice varieties currently grown by farmers change colour to yellow after harvesting, thus reducing its value in the market.

Experts further identified practices that farmers used to implement but had abandoned. Such practices included: broadcasting of seeds, very little use of fertilizers and herbicides, use of local seeds, ploughing using hand-hoe, slash and burn, and mixed cropping. When asked why they had made changes in their farming, farmers reported that broadcasting was abandoned because row planting combined with proper spacing increased yield and reduced wastage of seed; knowledge of improved practices among farmers had improved; spraying with herbicides reduced the cost of land preparation compared to slash and burn; and combine harvesters and powertillers had replaced sickles for harvesting and hand-hoe for ploughing.

Important indicators identified by experts to select agricultural practices included: high yield, reduced workload, reduced cost of production, improved quality of produce, time-saving, and marketability of produce.

Several crop practices were recommended by experts for the lowlands of Mbarali, including greenhouse horticultural production, irrigation, improved varieties, farmyard manure, intercropping, and introduction of border crops to control diseases. In addition to crop-related practices, experts also recommended artificial insemination, zero grazing, improved pastures, pest control, and fish farming.

Experts identified an existing demonstration plot in Uhamila. The objectives of the plot were to train farmers on improved farming practices (farmer field school) and on production of fruit crops such as pawpaw, oranges, and mangoes. The demonstration plot was introduced by the government. Thirty farmers were selected for training, and seedlings were purchased from Morogoro and supplied to the farmers. The specific location was at Uhamila primary school in Uhamila village, Rujewa ward. The main challenges that were identified for the demonstration plot in Uhamila were related to the small size of land under demonstration, shortage of water, theft, insecurity, the demonstration plot was not fenced, poor attendance because people expected money, and lack of protective gears. For a new demonstration plot, experts selected Imalilosongwe ward, Ulunda village; Ubaruku ward, Mwakaganga village; and Rujewa ward, Uhamila village. The main crops grown in the district are paddy, maize, onions, groundnuts, sunflower, and Bambara nuts. They would like the demonstration plots to be managed by the extension officers in each ward. Participatory methods were recommended for implementation. Experts further suggested that gender should be taken into consideration. Activities in the demonstration plot should follow the cropping seasons and be accessible to farmers. Important partners that were suggested include Uyole Agricultural Research Institute (ARI-Uyole); district agricultural and development officers; township executive officer; township agricultural, irrigation, and cooperative officer; township livestock and fisheries development officer; and township planning officer.

Experts' workshop in uplands, Kilolo

Kilolo District was classified by experts into three AEZs, namely Kilolo, Mazombe, and Ruaha Mbuyuni. Kilolo zone has two planting seasons. The challenges in this zone related to farming include: unpredictable rainfall that affects the time of land preparation and planting; stunted growth of crops due to irregular patterns of rainfall; disease and pest outbreaks; dry soil due to shortage of rainfall makes it difficult for crop residue to decompose.

Mazombe zone has one planting season. The challenges in this zone included shortage of rainfall causing crops to stunt, increasing disease and pest incidences, reduced

pasture for livestock, and outbreak of human diseases such as malaria. The soil was perceived to be fertile but experts reported that the dryness as a result of less rainfall makes the soil not suitable for cultivation. The zone is hot.

Ruaha Mbuyuni-Mahenge also has one season. The soil is mainly sandy-loam. The main challenges in the zone included shortage of rainfall, delayed rainfall, high temperature causing high evaporation, outbreak of crop pests and diseases, and reduced pasture.

General challenges facing the district were identified by experts as income poverty; increased incidences of human diseases; limited knowledge of improved farming practices among farmers; farmers are not willing to adopt improved practices; unreliable market for agricultural products; poor road infrastructure; and inappropriate choice of inputs such as fertilizers.

Several changes in forest cover and river flow were reported, namely the land has become bare; loss of water catchment areas; reduction in the volume of water in rivers; increased deforestation; drying of rivers; and drying of wetlands.

Experts indicated that farmers were no longer planting on ridges because they wanted to conserve moisture and improve soil fertility by allowing crop residues to decompose, intercropping, e.g., maize and beans, mixed cropping, zero tillage, and fallowing. The main reasons why some practices had been abandoned included modern farming such as ploughing using tractors and ox-plough, high cost of weed and pest control, and the perception that intercropping reduces plant population per unit area resulting in low productivity, introduction of mechanization had also made farmers to abandon intercropping, diseases and pests have made farmers to stop practicing mixed cropping because different crops are attacked by different pests and diseases, zero tillage is not practiced because farmers and experts perceive that the soil is exhausted and that there is need to plough deep in order to mix the inner and upper soil, fallowing is not feasible any more due to reduction in land sizes.

Common crop management practices in Kilolo as reported by experts were: use of power tillers although hand-hoes are still common; crop rotation; use of herbicides and pesticides; mixing the soil with pesticides; large-scale farmers are using seeders for planting; improved varieties; farmyard manure is mainly used by farmers who plant local varieties; pest and disease control using local pesticides such as Utupa, Lidupala, Linung'anung'a, and pepper; and chemical fertilizers such as DAP, CAN, and urea. There were also common livestock practices identified by experts, namely free grazing, tethering, zero grazing in the areas where dairy cattle projects have promoted the technology, e.g., in Mtitu, Lulanzi, and Ilamba, and pest and disease control. Beyond crop and livestock management, experts indicated that crop rotation, contour ploughing, e.g., in Lulanzi, fallowing, use of compost manure, and construction of ridges were common soil and land management practices.

Important indicators that farmers use to select agricultural practices as identified by experts in Kilolo included: yield, size of the household, capital, prices, land characteristics such as slope, location of the farm, and soil erosion.

Contour ploughing, construction of ridges, terracing, zero tillage, integrated pest management, drip irrigation, and soil testing were the practices recommended for Kilolo by experts. The main crops in the Kilolo District are maize, beans, green peas, Irish potatoes, sweetpotatoes, cabbage, tomatoes, rice, and sunflower.

Five demonstration plots were identified in Kilolo by experts: 1) One Acre Fund, on maize; 2) Clinton Foundation, on soy bean, maize, and sunflower; 3) Briteen, on maize; 4) Tanzania Agricultural Partnership (TAP), on maize and vegetables; and Cheetar, on Irish potatoes. Several challenges were identified with existing demonstration plots. These were related to:

- Management of the plots and lack of follow up by the initiators.
- Lack of cooperation by extension agents.
- Feedback to farmers is low.
- Low trust for most of the organizations initiating demonstration plots.
- Lack of markets.
- Low participation by farmers.

Experts suggested that the following partners should be involved in new demonstration plots: extension officers, village leaders, and local government authority.

Experts' workshop in lowlands, Kilolo

Experts in Ilula also classified Kilolo District into three main zones: Kilolo, Ilula, and Ruaha Mbuyuni. The main challenges in Ruaha Mbuyuni were reported as high temperature; frequent drought; high incidence of pests and diseases such as onion thrips, red mites, and caterpillars; strong wind, hence soil erosion because the zone has very little vegetation cover; and low soil fertility. For Ilula, Kilolo, the identified challenges related to less rainfall; unpredictable and delayed rainfall; hard pan of the soil after rains due to soil erosion; high incidence of pests and diseases such as maize stockborer, nematodes, red spider mites, etc.; low soil fertility; farmers are forced to use fertilizers in order to increase yields; loss of pastures; and inadequate amount of water for irrigation.

There were several practices that farmers in Ilula had abandoned. These included storage of seeds using local knowledge of hanging the crop in the kitchen, trap crops, zero tillage, farmyard manure, recycling of seeds, storing maize with the stover, burning crop residue to control pests, use of local pesticides such as Manung'anung'a, cover crops, e.g., pumpkins, and planting more than one seed in a hole especially in maize, beans, and pumpkins. When asked why farmers had abandoned the practices, experts reported low yields observed when farmers planted more than one seed in a hole; extension agents have advised farmers not to use the above practices; it is difficult to weed when maize is intercropped with pumpkins as a cover crop; increased availability of chemical pesticides has reduced the use of local pesticides; unavailability of enough quantity of manure limits the use of the practice; farmers have moved to improved seeds because they mature faster and are also tolerant of climatic shocks; and availability of pesticides has made farmers stop growing trap crops.

Common practices in lowlands, Kilolo, include crop rotation; improved seeds; correct spacing; use of herbicides, pesticides, and fertilizers; irrigation, e.g., drip irrigation, furrow irrigation, etc.; improved storage; pest control in livestock; vaccination of livestock; improved breeds of livestock; improved feeding of livestock, e.g., concentrates; artificial insemination; agroforestry with fruit trees; construction of ridges and bunds; planting star grass to control soil erosion; and contour ploughing. When deciding what practices to implement, experts indicated that farmers consider high yields, markets, time, quality of produce, taste, and availability and accessibility of the technology. When asked about the practices that they would recommend for lowlands, Kilolo, experts reported: improved varieties, improved irrigation, improved breeds, artificial insemination, and water harvesting. The five main crops in lowlands include maize, tomatoes, onions, sunflower, beans, and sesame.

Participants identified one demonstration plot by Muunganisho was Ujasirimali Vijijini (MUVI), which focused on production of tomatoes. The organization worked with a farmer group called Faraja. Both men and women were involved. Main challenges were that participation by farmers was very low because farmers joined the demonstration plot expecting to be paid money; the demonstration plot was very far from the main road; and lack of / delayed delivery of inputs. For new demonstration plots, experts would like the village government, extension agents, farmers, and agro-dealers to be involved.

Conclusions

CIAT conducted the current study with the purpose of gathering and documenting the indicators that farmers and experts use to prioritize CSA technologies. The study was conducted in Mbarali and Kilolo Districts in the Southern Agricultural Growth Corridor of Tanzania (SAGCOT) as part of the IFAD-funded study titled "Increasing food security and farming system resilience in East Africa through wide-scale adoption of climate-smart agricultural practices."

Using a participatory approach, the study finds that yield, income, cost, labour, availability of inputs and equipment, time, and knowledge are important indicators that farmers use to prioritize agricultural practices that they implement. Prioritization differs by agro-ecological zone and gender, reinforcing that CSA is very context specific. Across the districts, awareness on the prioritized practices, particularly related to soil and land management, was low. Adoption rates for most prioritized practices in both Kilolo and Mbarali was low. There were ongoing demonstration plots in both districts, but demand for new demonstration plots in specific geographical locations was expressed to increase farmers' knowledge on the prioritized practices.

Addressing the demand for knowledge on CSA might be helpful to promote adoption and out-scaling. An important channel to achieve this objective is through demonstration plots, especially since there is demand from farmers.

Encouraging uptake will, however, ultimately require focus beyond yield and income to include other important indicators that farmers care about. From a qualitative standpoint, promoting labour-saving, yield-enhancing technologies and making these technologies available is important. From a quantitative point of view, there is need to gather and analyze quantitative data in order to empirically assess factors that explain uptake of CSA as well as to quantify the magnitude of the trade-offs that adoption of CSA might create.

CIAT is currently collecting data to perform such analysis. Working through local partners, CIAT is also setting up demonstration plots to train farmers on the practices that they prioritize in specific agro-ecological zones.

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