Uptake and Dissemination Pathways for Climate-Smart Agriculture Technologies and Practices in Lushoto, Tanzania

Working Paper No. 173

CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)

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Abstract

Smallholder farmers in East Africa need information and knowledge on appropriate climate-smart agriculture (CSA) technologies and practices, and institutional innovations in order to effectively adapt to climate change and cope with climate variability. This paper assesses farmer uptake of climate-smart agricultural practices and innovations following a farmer learning journey through the Farms of the Future (FotF) approach. First, we explore and assess the various CSA technologies and practices, including institutional innovations farmers are using. Second, we identify and document farmer learning and dissemination pathways that can enhance uptake of CSA technologies and practices. Third, we identify existing institutions that can enhance uptake of CSA practices. We use household survey data, complimented with qualitative information from focus group discussions and key informant interviews. The results show farmers are using a variety of CSA technologies and practices, and institutional innovations. Improved crop varieties, agroforestry, and scientific weather forecast information were cited as the main CSA practices used. To minimize their risks and reduce vulnerabilities, farmers are diversifying and integrating five to ten practices in one season. *Matengo* pits, Savings and Credit Cooperative Organization (SACCOs) and energy efficient cook stoves were used by very few farmers due to high initial investment costs and unsuitability to the area. Over 95% of the farmers reported receiving agricultural information orally from a variety of sources including government extension workers, seed companies, researchers, traditional experts, neighbors, radio agricultural shows, religious groups, farmer groups, and family members. Farmers acknowledged the FotF approach as a useful tool that enabled them to interact with other farmers and learn new CSA practices and innovations.

Keywords

Climate-Smart Agriculture; Adoption; Dissemination pathways; Tanzania

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Contents

Acronyms

AIS	Agricultural Innovations Stakeholders
CSA	Climate-Smart Agriculture
FGD	Focus Group Discussion
FotF	Farms of the Future
IPCC	Intergovernmental Panel on Climate Change
SACCO	Saving and Credit Cooperative Organization
SARI	Selian Agricultural Research Institute
TMA	Tanzania Meteorological Agency

1. Introduction

Projected and observed impacts of climate change on agriculture, food security and poverty are raising global concerns. In East Africa, small-scale agricultural production is already under pressure. Small-scale farmers in the region already face numerous challenges including increasingly constrained access to land, decreasing land sizes and declining soil fertility (leading to low crop yields), and poor market access (Sanchez and Swaminathan 2005, Ali-Olubandwa et al. 2011, Jayne et al. 2014). Increasing population further creates immense demand for food, leading to increasing food insecurity and rising poverty levels (Okwi et al. 2007, Diao et al. 2010, Addae-Korankye 2014, Jayne et al. 2014). Farmers in the region mainly depend on rain fed small-scale agriculture for their livelihood that is extremely vulnerable to climate variability and change. Changes in rainfall patterns and temperatures are altering the functioning of agricultural landscapes in overwhelming and often destructive ways. Farmers are therefore compelled to adapt their agricultural practices to those that can build their adaptive capacity[1] and enhance climate resilience[2].

Future climate projections for East Africa show an increase in rainfall although some seasons will experience intensive droughts (Seneviratne et al. 2012, IPCC 2014). These changes in rainfall patterns, temperature and other extreme weather events are likely to increase crop failures, pest and disease outbreaks and degradation of land and water resources in East Africa. These impacts are likely to hit rural communities hard because of their high dependence on rain-fed agriculture, coupled with low adaptive capacity. Increasing climate uncertainties are also likely to lead to risk aversion behavior amongst farmers, forcing them to depend on low input and low risk agricultural technologies. Small-scale subsistence farmers have been identified as the most vulnerable to climate change in East Africa. Their

[1] Adaptive capacity is the capacity of a community to reconfigure itself in the face of climate change without substantial decreases in function (Resilience Alliance 2009). It is closely associated with the ability to learn, innovate, and cooperate in order to maximize group learning and share benefits.

[2] Climate resilience is the ability for an environment and people to handle stresses or recover from climatic disturbances or shocks. It is the capacity to thrive in the face of climatic challenge. Climate resilience in the context of rural agricultural-dependent communities comprises of ecological, social and economic resilience (Folke et al. 2002 p. 13, Brenson-Lazan 2003, Briguglio et al. 2005 p. 6-7).

vulnerability makes the effects of climate change to be far-reaching with potential negative impacts on future generations. For these farmers to adapt to climate variability while at the same time preparing for future climatic changes, they must improve their adaptive capacity in terms of knowledge and skills.

Farmers in East Africa have been making changes to their agricultural practices, targeting crop and livestock production, partly driven by changes in climate and other factors. These practices include use of new improved crop varieties and animal breeds, soil and land management practices, water conservation technologies and improved fodder production (Kristjanson et al. 2012). These technologies and practices are expected to boost adaptive capacity, food security and contribute to climate change mitigation in resource poor smallholder farming systems of East Africa—referred to as climate-smart agriculture (CSA) technologies. According to FAO (2009), CSA is defined as agriculture that sustainably increases productivity, resilience (adaptation), reduces or removes greenhouse gases (GHGs) (mitigation), and enhances achievement of national food security and development goals. CSA encompasses a basket of practices that are suitable to local climatic, social-economic and cultural environments.

In Lushoto, northern Tanzania, households are already adapting to changing climatic conditions (Lyamchai et al. 2011). Though the results were not conclusive in directly linking the adaptation strategies to climate change alone as there are other different drivers, climate change was cited as a key driving factor. The magnitude of behavioral change, however, appears to be limited to farming practices that are fairly easy to undertake without major disruptions to the farming system or substantial changes to land or labor allocation.

With the farming systems in East Africa already facing unparalleled pressures from different factors, new learning processes, knowledge and tools are desperately needed. In particular, increasing climate variability coupled with future dire predictions further reinforces the need for farmer trainings and knowledge to enable them build their adaptive capacity.

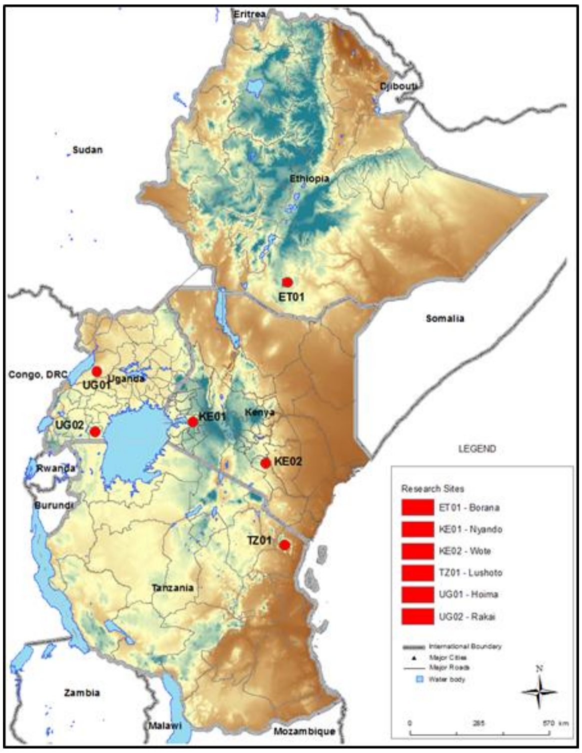
1.1 Climate Analogues and Farms of the Future Approach

In order to prepare for changing climatic conditions and strengthen their adaptive capacity, farmers need to understand what their future climate is likely to be. According to Williams et al. (2007), 30% of the world climates are expected to be completely novel under climate change, thus 70% of expected future climates already exist somewhere else on the globe. The spatial and temporal variability in climate can be used as a means of having a real experiment of what the future holds for a particular site. Farmers can start preparing for their future climate by learning from what their future climate is likely to be. The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) has developed a tool—climate-analogue tool—that can be used to connect sites with statistically similar climates (analogous) across space and or time (see Ramirez-Villegas et al. 2011 for a detailed description of the tool).

The Farms of the Future (FotF) approach uses the CCAFS climate-analogue tool to connect farmers to their possible future climates through farmer-to-farmer exchanges between spatial analogue sites. Spatial analogues refer to areas whose climate today appears to be similar to the future projected climate of a particular location. Linking farmers to areas experiencing their plausible future climate can facilitate knowledge sharing and learning, and provides opportunity for transferring technologies and innovations that can improve farmers' adaptive capacity.

In East Africa, the FotF approach was first piloted in 2012 in Lushoto in the northern Tanzania highlands (see Jarvis et al. 2012). Lushoto is one of the six CCAFS sites in East Africa (Figure 1). The climate-analogue tool was used to identify plausible alternative future climate (spatial analogue) sites for Lushoto— sites with a current climate similar to the projected future climate of Lushoto.

Figure 1. CCAFS sites in East Africa



Source: CCAFS

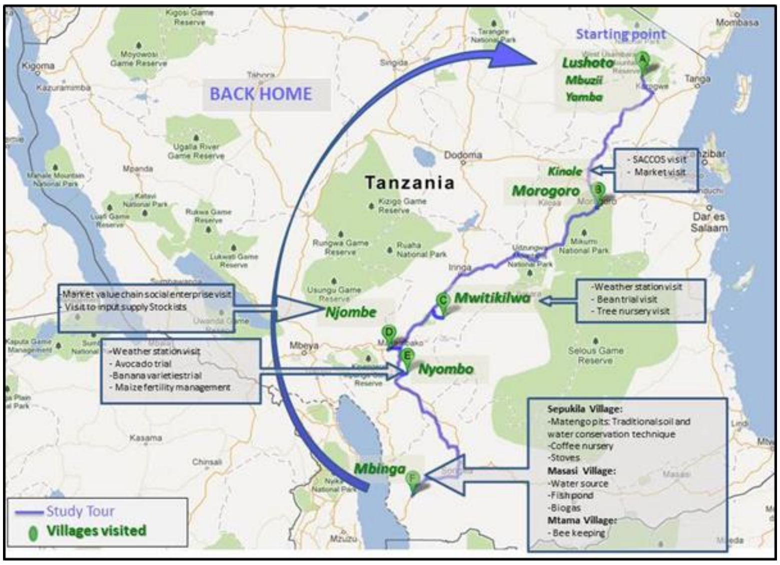
Fifteen farmers from two villages (Yamba and Mbuzii), and comprising of men and women and five key agricultural innovation systems (AIS) stakeholders[3] from Lushoto took part in a 10-day learning journey to several sites including Morogoro, Mufindi, Njombe and Mbinga in the Southern Highlands (see Figure 2). Farmers were selected based on a criteria developed by the community that included gender balance, age, farmers involved in CCAFS activities and who had been interviewed during the CCAFS baseline survey (Lyamchai et al. 2011, Nelson et al. 2012). The AIS actors were drawn from different economic sectors including tourism, agricultural input dealers, community development organizations, and agricultural and livestock sectors.

Farmers and the AIS stakeholders were exposed to various CSA technologies and institutional innovations for adaptation and risk management during the learning journey with five major stops (Figure 2). The CSA technologies that farmers were exposed to included crop breeding,

[3] AIS stakeholders are strategic partners who come together to address specific agricultural issues with practical solutions usually along the agricultural value chain

soil and water management, tree and coffee nurseries, fish rearing, beekeeping, and avocado, banana and maize production. The institutional innovations included markets, value chains, input supply systems, SACCOs, energy production and conservation (biogas, improved stoves), tree nursery and community weather stations. Some of the farmers were trained in amateur filming and photography and provided with handheld flip cameras to document the learning process to enable sharing of their learning experiences with other farmers within their communities who did not participate in the learning journey.

Figure 2. Map of learning journey and opportunities in analogue sites



Source: CCAFS

1.2 Objectives

Effective climate change adaptation requires appropriate technological and institutional innovations, including an enabling policy environment that can reduce the farmer's vulnerability to climate-related risks by creating economic opportunities that build livelihoods and increase resilience (Gifford et al. 2011). An effective adaptation strategy needs to adequately address physical and biological impacts of climate change, as well as local people's norms, values and tolerance of conditions and risk (Productivity Commission 2011). At the heart of climate change adaptation is farmers' access to information and knowledge on appropriate innovations that provide resilience in the face of climate variability and change. Indeed, creating an environment and opportunities where farmers can learn from other farmers who are currently experiencing their plausible future climatic conditions can increase their future adaptive capacity.

Through the learning journey, farmers and the AIS stakeholders from Lushoto were exposed to their plausible future climate, including potential technological and institutional ways of adapting to these changes. This study is a follow-up of the FotF pilot in Tanzania. We hypothesize that by participating in the learning journey, farmers were motivated to act and innovate, share widely their learning experiences with other farmers within their communities and other neighboring communities, and that the AIS stakeholders have been instrumental in supporting farmers to act and innovate to enhance their adaptive capacity. This paper examines the effectiveness of the FotF approach as a mechanism for enhancing adaptation learning, and identifies promising information dissemination pathways. First, we explore and assess the various CSA technologies and institutional innovations farmers have using after the learning journey. Second, we identify and document farmer learning and dissemination pathways that can enhance uptake of CSA technologies and practices. Third, we identify existing institutions that enhance uptake of CSA practices. The paper addresses three research questions:

- What CSA practices are farmers using after the learning journey?
- What factors hinder uptake of CSA technologies and practices?
- What dissemination pathways are farmers using to share information on CSA?

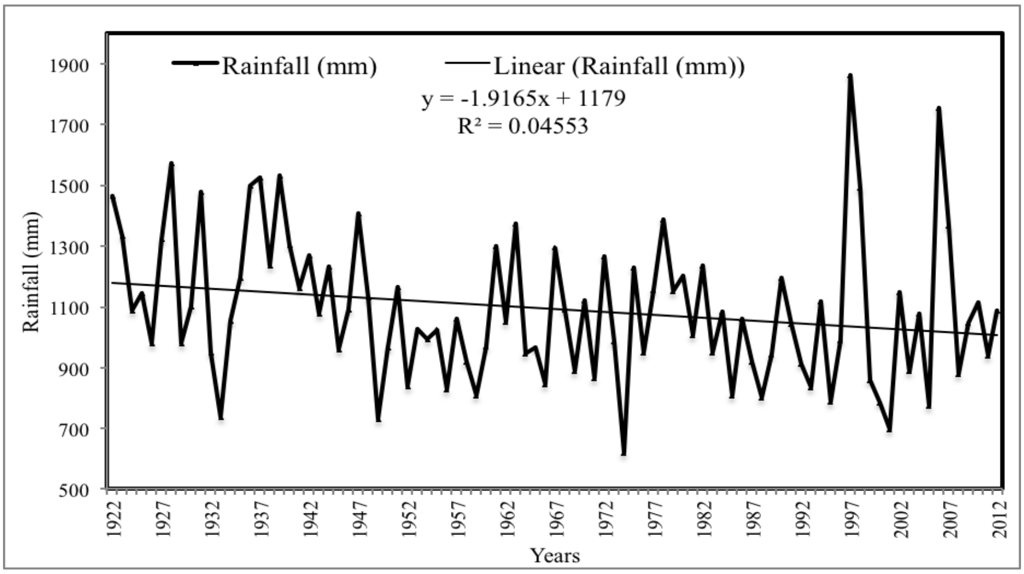
2. Methodology

2.1 Study site

Lushoto is one of the six CCAFS sites in East Africa where researchers, local partners, and farmers are working together to evaluate a portfolio of CSA interventions (Figure 1). Through these strategic partnerships, the aim is to improve farmers' income and resilience to climatic risks and boost their ability to adapt to climate change.

Lushoto is part of the Usambara Mountains and is a global hotspot for biodiversity. With its excellent climatic conditions, Lushoto attracts not only farming communities but also tourists. Lushoto is characterized by two agro-climatic zones—humid warm and humid cold zones. Annual rainfall pattern is bimodal, ranging from 1200 to 1300 mm per year. However, the rainfall amounts have been decreasing over the years as indicated in Figure 3 (TMA 2009a and 2009b). The wet seasons are in March-May and October-December each year. The mean annual temperature is 16°C, with a humidity of 70% (TMA 2009a and 2009b). Lushoto's landscape is highly heterogeneous, with diverse micro eco-zones within a relatively small area and characterized by very hilly slopes, with wide valley bottoms.

Figure 3. Long term annual rainfall trends in Lushoto(1922–2012)



Source: Tanzania Meteorological Authority 2014

Lushoto is among the most densely populated rural districts in Tanzania, with an average land size of about two acres per household. Majority of farmers depend on subsistence crop production for their livelihood, including fruits and vegetables (Lyamchai et al. 2011). The higher elevation areas are characterized by mixed crop-livestock and intensive farming systems, while the lower elevation areas are characterized by agro-pastoral farming systems that are intensively cropped with a variety of vegetables throughout the year. Soil erosion is a huge challenge mainly due to the steep terrain, deforestation and high population pressure.

2.2 Data

Data were collected through household surveys, complemented with qualitative information from community-level FGDs from four villages, and key informant interviews. Of the four villages, two (Yamba and Mbuzii) were villages where some of the farmers participated in the FotF learning journey, while the other two (Gare and Kwang'wenda) are villages adjacent/neighboring Yamba and Mbuzii. We hypothesize that farmers who participated in the learning journey were more likely to start sharing their learning experiences with farmers within their villages and neighboring villages (i.e. people they are familiar with).

In each village, 20 households were selected from the original CCAFS baseline survey households and interviewed; including the 15 households who participated in the learning journey from the two villages, and taking into account gender balance (see Lyamchai et al. 2011). A total of 81 households were interviewed. The household survey collected information on household characteristics, CSA technologies and practices and their benefits (including CSA practices that farmers learned on the FotF trip), who is using and not using and why, and sources and types of information on CSA. All the 15 farmers and AIS stakeholders who participated in the FotF journey were interviewed using both closed and open-ended questions[4].

Three FGDs were conducted with different groups of farmers: 15 participants of mixed gender for the farmers who took part in the learning trip; and separately for men and women who did not participate in the learning trip, with an average of 20 farmers for each FGD. Planning for the FGDs was done through the village elders who informed the selected participants. Information collected from the FGDs included farmers' perception on the FotF as a learning tool, lessons learnt and challenges, CSA practices and institutional innovations farmers have started implementing after the learning journey, how farmers shared what they learnt with other farmers, if the other farmers are using what was shared, including modifications to the CSA practices. Questions used in the FGDs were tailored for the FotF and the non-FotF farmers. The FotF participants were expected to share what their experiences were before, during and after the climate journey. The non-FotF farmers responded to questions on their experiences from what they had learned from FotF farmers.

Over 80% of the households interviewed were male-headed, with an average household size of 4.8 people (Table 1). Most of the households had at least a member who had attained primary education (i.e. at least 7 years of schooling in Tanzania). Slightly more than one-

[4] The open-ended questions enabled the farmers to express their views when they felt that they had not satisfactorily responded in the closed ended questions, thus allowed the researcher to discover and note down new responses that farmers gave instinctively.

quarter of the households had members who had completed secondary school education, with very few households having members who had completed tertiary education.

Table 1. Household characteristics

Demographic characteristics	Percentage of households (n=81)
Sex of respondent (%)	
Male	66.7
Female	33.3
Household type (%)	
Male headed	82.7
Female headed	17.3
Highest level of formal education of any household member (%)	
None	4.9
Primary (8 yrs of elementary education)	61.7
Secondary (4 yrs of high school)	27.2
Tertiary (post-high school training)	6.2
Average household size (no. of people)	4.8

3. Results and discussion

3.1 Uptake of CSA technologies and practices

The 15 farmers and AIS stakeholders who took part in the learning journey in 2012 were exposed to various CSA technologies and practices, and institutional innovations (Figure 2):

- *Soil and water conservation practices*: Use of *Matengo pits* (a traditional soil and water conservation technique), irrigation and terracing, and minimum tillage;
- *Forestry innovations and environmental conservation strategies*: Establishment and management of a tree nursery, establishment and management of fruit trees, agroforestry trees, construction of terraces that are reinforced with drought tolerant fodder grass strips, coffee seedling nurseries and bio digesters;
- *Cropping technologies, innovations and livelihood diversification*: Early planting, intercropping, intensive cropping of cloves, black pepper, potato trials, avocado and coffee varieties, a coffee nursery and bee keeping;

- *Improving access to finance through collective action*: Establishment of a savings and credit (SACCOs) group, a scheme that has enabled farmers to pool resources and bargain for better prices;
- *Weather information services:* A community managed weather station, where farmers collect climate data, which is then shared with the TMA. This community managed weather station raised the farmers' consciousness of the changing climate and the importance of integrating indigenous knowledge and scientific weather forecasts as well as develop strategies to support TMA to gather climate data from the local level.

Consideration of the above practices is based on the three pillars of CSA that seeks to address demand for increasing agricultural productivity and incomes, building social-ecological resilience of livelihood systems to climate change, while minimizing agriculture's contribution to GHG emissions (FAO 2013). Benefits of the different CSA practices are summarized in Table 2.

Several factors influence farmers' ability to adopt CSA practices. Among the key factors include a) availability and access to resources needed to use the practices such as land, labor and financial capital, b) potential benefits to be accrued vis-à-vis other practices, c) whether they have the required skills and information to use it, d) ability to cope with challenges that might arise during or after using the practices and e) compatibility with local social and cultural practices (Waithaka et al. 2007, Diale 2011, Sanga et al. 2013). For farmers in Lushoto, ability to adopt CSA practices is influenced by the above factors, albeit for different technologies and practices. Table 3 summarizes the uptake of the CSA technologies and institutional innovations by the farmers who took part in the learning journey (FotF farmers) and those who did not participate (non-FotF farmers). Improved crop varieties, agroforestry, and scientific weather forecast information were the main CSA practices farmers were using, with similar patterns of uptake for FotF and non-FotF farmers. Few farmers adopted the use of *Matengo pits,* SACCOs, energy efficient stoves, with no significant differences between the FotF farmers and non-FotF farmers.

Table 2. Benefits of the CSA technologies, practices and institutional innovations farmers were exposed to during the journey*

CSA Practice	Benefits
Matengo pits	Promotes an integrated soil, water and nutrient management by retaining water, the use of crop residues to support the pits leads to improved and sustained soil fertility and crop productivity, reduced soil erosion, and enhanced soil carbon sequestration.
Irrigation	Small-scale irrigation offer key opportunities for adaptation as water supplies dwindle and rainfall becomes more erratic. Through irrigation, farmers can diversify into high value crop production such as horticulture thus reducing risks of crop losses and increasing incomes.
Terracing	Promotes soil and water conservation, especially on steep slopes to reduce soil erosion and increase water percolation. The terraces are reinforced with grass strips and agroforestry trees (for timber and fruits) thus contributing to mitigation and increased incomes.
Traditional and scientific weather forecasts	Reduces risks associated with failed seasons or variable rainfall and enable farmers to make better farming decisions for improved productivity and risk management.
Agroforestry	Establishment of deep root, drought tolerant leguminous trees that fix nitrogen and shed leaves during the rainy season, providing organic residues and nutrients. Contributes to carbon sequestration, reduces soil erosion and moisture stress, and tree products that are sold for income.
Biogas and use of efficient stoves	Reduces greenhouse gas emissions by utilizing methane from cow dung to generate energy for household consumption. Replaces purchase of kerosene and harvesting of trees thus saving family income. Bio-slurry is used as manure hence increases soil fertility. Efficient stoves are combustion and fuel-efficient and reduce air pollution, cooking time and time spent acquiring firewood.
Composting	Composting of crop residues and organic domestic wastes is used for soil fertility and therefore improve crop productivity. Also contributes to improved soil structure, moisture retention and reduced emissions from application of raw animal manure.
Crop rotation	A crop diversifying practice that is used to achieve crop diversity, reduce incidences of pest and diseases of particular crops, improves soil structure and soil fertility through nitrogen fixing crops and reduces soil erosion.
Drought and disease tolerant crop varieties	Adaptive crop varieties that are stress tolerant and disease resistant; early maturing to avoid crop loss from shorter growing seasons or unreliable rains. This leads to improved productivity and reduced risk of crop failure.
Drought tolerant and deeper rooted fodder grasses and/or legumes	Contribute towards food security and increased livestock productivity. Use of improved fodder leads to reduction of emissions from enteric fermentation of livestock through improved digestion. Increased milk production and heavier animal weight leads to more income.
Early planting and use of early maturing crop varieties	Varieties that are more adapted to low and unreliable rains, and shortened growing seasons thus leading to reduced risk of crop failures.
Minimal tillage	Conserves soil moisture and controls erosion through minimum soil disturbances. It improves crop productivity and reduces soil compaction thus reducing emissions.

CSA Practice	Benefits
Intercropping	Intercrop of legume and non-legume crops and trees contributes to nitrogen fixation, improved water retention, reduced crop failures to drought, pest and diseases. Leaves of trees intercropped are also used as mulch and compost, thus contributing to above ground carbon sequestration.
SACCOs	Offer safety nets to farmers through stronger marketing power. SACCOs also offers access to credit for farmers to implement the CSA Practices such as irrigation equipment and inputs (seeds and fertilizers)
Management of a tree nursery and tree planting	Tree nurseries provide income. The trees contribute to soil fertility and help control erosion, provide fuel wood and timber, medicines and fruits. Trees can trap or "sink" large amounts of atmospheric carbon.
Livelihood diversification	Diversification of crops, livestock (bee-keeping), trees and irrigation are potential responses to overcoming unreliable rainfall and drought. This will minimize weather-induced losses and stabilize incomes.

*See Peterson et al. 2014 for a detailed description

Table 3. Uptake of CSA practices and innovations farmers were exposed to during the learning journey

CSA practices and innovations	Percent of FotF farmers (n=15)	Percent of non-FotF farmers (n=66)	Overall % using the CSA (n=81)
Improved crop varieties	100.0	93.9	95.1
Agroforestry	93.3	83.3	85.2
Scientific weather forecasting	73.3	66.7	67.9
Efficient stoves	26.7	27.3	27.2
Matengo pits	13.3	4.6	6.2
SACCOs	6.7	3.0	3.7
Biogas, bio digester	6.7	0.00	1.2

After learning about scientific weather forecasts during the learning journey, most farmers in Lushoto are now appreciating and increasingly using both indigenous knowledge and scientific weather forecasts from TMA to plan their farming activities in a particular season, thus making better farming decisions. Before the learning journey, most farmers mainly used indigenous knowledge weather forecast information provided by the traditional forecasters (Mahoo et al. 2015). Combination of scientific and traditional knowledge ensures that farmers are informed on the likely date of onset of rains, duration and amount of rains to expect, types and variety of crops to grow, types of inorganic and organic fertilizer to use and when to apply them. The weather information is packaged and disseminated through flyers that are posted at community boards, shared through the church and community meetings.

According to one of the women farmers who participated in the learning journey:

"Adapting to climate change is both a science and an art. It involves and requires engagement of several practices, science, actions and magic… that is unique and probably unrepeatable elsewhere. In my case, I now consciously make farming decisions using weather information especially on when to start land preparations, what maize or beans seed to buy and when to grow it" FotF farmer.

The low rates of uptake for the biogas digester can be attributed to high initial capital investments. SACCOs is an institutional innovation that also had very low uptake. In Tanzania, SACCOs have been known to improve the investment climate by providing opportunities for rural people to secure returns on their savings and access to loans at affordable interest rates (World Bank 2002, Wanyama et al. 2008) and can therefore contribute to risk management. SACCOs are also a form of collective action that can help farmers, especially women to increase farm productivity and access to credits and markets, share knowledge, information and productive assets, provide greater bargaining power in sourcing for farm inputs and better prices for their produce and empowerment (Alpert et al. 2009). This is more so for women who in the absence of men, get opportunities to participate in decision-making and take on leadership roles (Alpert et al. 2009, FAO 2010, FAO 2011). Despite its low uptake in Lushoto, SACCOs can improve the welfare of its members by providing an alternative way for farmers to save their earnings and access loans at more affordable interest rates. According to a female farmer:

"Low crop yields due to unpredictable rains prior to the start of the growing season, diseases and pests all affect the quantity and quality of produce we get. By joining a SACCO, at least, we will pull our produce together and be able to market as a whole thus reducing exploitation by middle men and women. We also get to pool our resources together and we can get loans that can enable us purchase seeds that can withstand less rainfall".

High membership fees of approximately Tanzania Shillings 10,000 (equivalent of USD 6) and lack of understanding of the importance of SACCOs among the farmers were reported as the major limiting factors, implying the need for information and awareness among farmers on the importance of collective action including savings groups that can enable them cope during seasons of low rainfall that leads to low agricultural productivity. One farmer noted that:

“We need to start saving for the future of our children because our rainfall patterns are changing and our children might not rely solely on farming to survive. We need to start building assets that do not rely on rainfall. Investment in non-farming activities can provide our children with a soft cushion to land on during periods of food shortages. Through SACCOs, we can start saving little amounts each week or month. But the membership fee is rather high especially for female headed households. Maybe such women can be supported by financial organizations and given loans to start non-farming activities”.

Other farmers concurred that through their *MBUKWA* SACCO (with 19 members from two villages—Mbuzii and Kwang’wenda) they have been able to improve their price bargaining power especially for farmers who are growing vegetables on the valley bottoms. The SACCO is enabling the members to have a collective voice and access ago-advisory information especially during their meetings. According to the chairperson of the SACCO:

“Our SACCO is relatively new and we are muddling through the process to ensure that it is functional. But we have greater incentive to make it work because all the members know each other, their interests in agriculture and we can adapt the SACCO to reflect our members changing needs and circumstances. Our focus is to improve our member’s livelihoods as the climate is changing”.

Other CSA practices farmers were exposed to such as bee keeping, fish farming in ponds and agricultural value addition enterprises that can generate income have not been taken up by farmers in Lushoto. For example, FotF participants learned about food processing, however, none of them has started a food processing enterprise. Farmers cited lack of knowledge on value addition enterprises, bee keeping and fish farming, implying the need for follow-up training and support to farmers through the extension systems. According to a woman farmer:

“I needed more information on some of the technologies that we learned during the journey to enable me and other farmers to start it on our farms. We did not spend sufficient time on the journey to learn in-depth about the technologies and hence most farmers are reluctant to take the risk. For instance, I do not know where to get beehives and unfortunately I have not contacted the District Agricultural officer".

Farmers who were not using scientific weather information cited unreliability and inaccessibility of weather information as the main reason. Women particularly reported that they hardly get weather information to adequately plan for their farming activities. Moreover, weather information is usually passed on to the women through their husbands or village chiefs, and in most cases they do not know how to use the information. While there are multiple initiatives in East Africa that are aimed at producing and delivering climate information services for farmers (UNDP 2011, Conway et al.2010, Lu 2009), many challenges still remain in terms of accurate and timely weather and climate forecasts to support farmers efforts to adapt to a changing climate and increasing climate risks.

A young woman reported that:

"I have heard that we will have less rainfall this year. But what does that mean? What crops should I plant when we have less rain? That is a difficult question to answer because the information provided is not enough to assist me to plan what crops to grow, when, what fertilizer to use, which livestock should I save since I might not have enough water for all the animals".

During the FGDs, farmers expressed the importance of integrating traditional and scientific weather forecasting and packaging it in a user friendly way. To be effective for farmers, the weather forecast information (indigenous and scientific forecasts) should be timely and complimented with agro-advisories such as crop suitability, cultivar selection, planting date, planting density, weeding, water management, pests and diseases, and fertilizing.

After learning about *Matengo pits*, some farmers tried the technology on their farms and found it unsuitable for their environment. *Matengo pits* are labor intensive to establish and not suitable for the soil type and topography of Lushoto. The major soil types in Lushoto are Humic and Chromic Acrisols, Luvisols and Lixisols for most of the mountainous hilly areas, while the valley bottoms have Fluvisols and some pockets of Gleysols (Meliyo et al. 2001, Sijmons et al. 2013). Bench terracing is also labor intensive and dangerous because of the steep slopes in Lushoto. For other CSA technologies such as irrigation, fish farming, biogas digester and inorganic fertilizers, high initial investment costs were cited as the main reason for the low adoption rates.

Some of the suggested specific actions that could improve farmers' uptake of the practices included timely availability of weather information and in a language they could understand. As indicated in Table 1, majority of the farmers interviewed had no formal education or only attained primary education. Other suggestions included cheaper and easier to establish water harvesting techniques and soil conservation measures that are suitable to their soil type and the steep landscape of Lushoto, access to initial financing to purchase inorganic fertilizers, irrigation and biogas generation equipment and, training on establishment of terraces on steep slopes. Motivation to act and articulation of demand for agricultural extension support was another important dimension of adaptive capacity building that emerged as an aspect of the FotF approach. Seeing and hearing the advantages of having weather stations has helped to create demand for the equipment amongst participants and training on how to collect climate data.

3.2 Awareness and uptake of CSA technologies and practices

Apart from the specific CSA technologies farmers were exposed to during the learning journey, we also examined the overall level of awareness and use of other CSA technologies among farmers in Lushoto. The farmers reported over 20 different CSA practices that they were aware of, and these practices are either used on their own or in different combinations within the farm. Most of the CSA practices reported by the farmers are consistent with the FAO (2010) definition of CSA (see introduction chapter). Table 4 summarizes the various CSA technologies and practices used for crop and livestock production, soil and water conservation, energy saving and other income generating activities. Majority of the farmers interviewed were aware of the different CSA practices. More than three-quarters of the households were aware of improved or multiple stress tolerant crop varieties such as *Lyamungo90* bean variety, composting, inorganic fertilizers, early planting, cut and carry livestock feeding, agroforestry and local drought tolerant varieties. More than half of the households were aware of intercropping, minimum tillage, mulching, crop rotation, scientific and traditional weather forecasting, non-burning, terraces and contour planting and improved fodder. Fewer households (less than 45%) were aware of biogas, *Matengo pits*, SACCOs and strip cropping—these four were among the CSA technologies and practices that farmers who participated in the FotF were exposed to during the learning journey.

To what extent are farmers using the CSA technologies they are aware of? Overall, there was a high correlation between awareness and use of the CSA technologies. Of the CSA technologies that farmers were aware of—improved crop varieties, composting, cut and carry feeding, use of inorganic fertilizers, agroforestry and early crop planting—were the most commonly used by the farmers (Table 4). Biogas for efficient energy use and improved cook stoves are some technologies that have been identified for reducing GHG emissions. Waste from animals used in biogas equipment for anaerobic digestion can provide solutions to energy supply for cooking and lighting in Lushoto, and the by-product as agricultural fertilizer (SEA and Amathemba 2011, Monnet 2003, Chand et al. 2012). Despite the biogas technology utilizing energy sources without depleting natural resources and environmentally friendly, investment costs for farmers in Lushoto are very high thus limiting their adoption. *Matengo pits* for water conservation and involvement in SACCOs were the other two practices least used by the farmers.

While most farmers are aware of many CSA practices and innovations, only a small number of the farmers are adopting the practices. Figure 4 shows the CSA practices with the highest discrepancies between awareness and use (i.e. practices farmers are aware of, yet very few use them on their farms). Most farmers indicated their willingness to use the CSA practice but are constrained by several factors including cultural practices such as land tenure and ownership rights, labor requirements, high investment costs, and lack of skills and knowledge on how to use the practices. Irrigation and SACCOs, for example, require high initial investments and Table 4 shows that these two practices had the largest discrepancies between awareness and use. Studies have shown that belonging to a rural social or marketing group enhances social and financial capital allowing trust, idea and information exchange (Place et al. 2004, Alene et al. 2008). Thus membership to a group e.g., a SACCO can increase the uptake of a CSA practice. However, membership to a SACCO will require subscription fee that most farmers in Lushoto cannot afford even if they would like to belong to the SACCO.

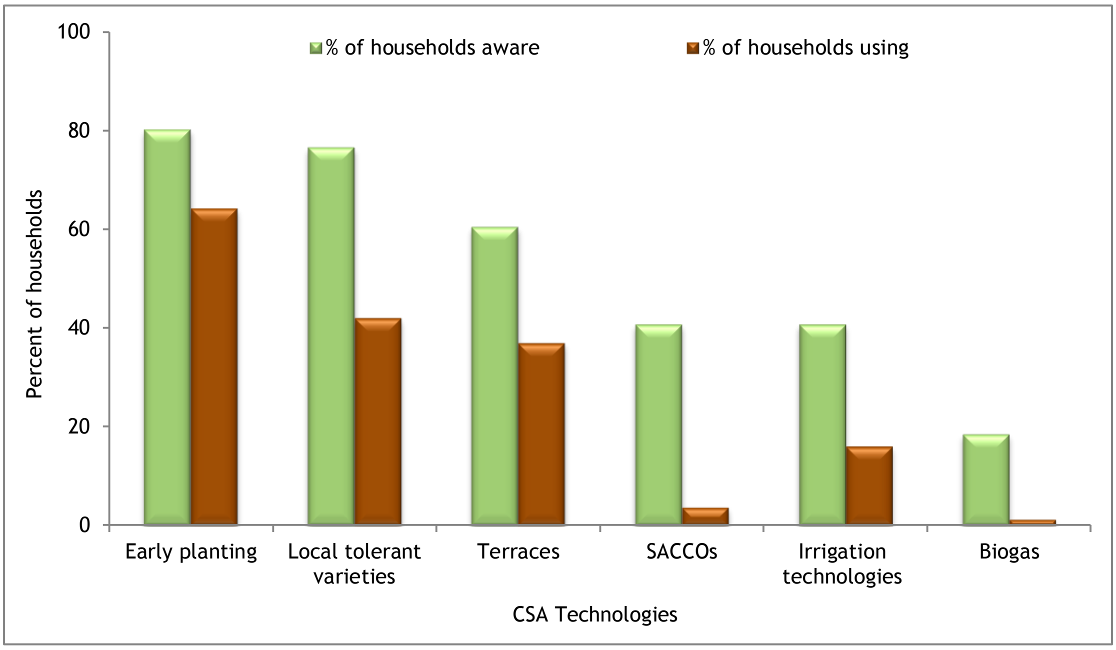
Table 4. Awareness and use of CSA technologies and practices in Lushoto

CSA technologies and practices	Percent of households aware of the CSA technology and practice	Percent of households aware and using the CSA technology and practice	Pearson Correlation Coefficient
Improved crop varieties	97.5	95.1	0.69
Composting	88.9	87.7	0.94
Cut and carry feeding	87.7	80.3	0.76
Chemical fertilizers	86.4	81.5	0.83
Agroforestry	85.2	85.2	1.00
Early planting	80.3	64.2	0.66
Local crop varieties[1]	76.5	42.0	0.47
Intercropping	74.1	67.9	0.86
Minimal tillage	71.60	70.7	0.97
Mulching	69.1	66.7	0.94
Scientific weather forecasting	67.9	67.9	1.00
Crop rotation	66.7	65.4	0.97
Traditional weather forecasts	66.7	65.4	0.97
Non-burning	65.4	63.0	0.95
Terraces, contour planting	60.5	37.0	0.62
Improved fodder	58.0	53.1	0.91
Irrigation technologies	40.7	16.1	0.53
SACCOs	40.7	3.7	0.24
Efficient stoves	38.3	27.2	0.77
Organic pest control	38.3	35.8	0.95
Strip cropping	28.4	23.5	0.88
Biogas, biodigester	18.5	1.2	0.24
Matengo pits	16.1	6.2	0.59

[1]These are local varieties preferred by farmers and least affected by extreme weather conditions, pest and diseases.

*Significant at the 0.05 level (2-tailed). **Significant at the 0.01 level (2-tailed)

Figure 4. CSA practices with the largest discrepancies between awareness and use



On-farm diversification through various farming enterprises such as different varieties of crops, different types of livestock (including bee keeping, poultry) and fish farming are important risk management strategies and can cushion farmers and their families during bad seasons or years. In addition, farmers can engage in non-farming activities such as value addition enterprises. Livelihood diversification on-farm and off-farm is a key risk management strategy and can also increase farmers adaptive capacity (Hellmuth et al. 2007, Osbahr et al. 2010, Nelson et al. 2012, Canon 2014).

3.3 Gender differentiated preferences and use of CSA

In this section, we examine the most important CSA technologies and practices used in Lushoto, and if they differ by gender. Households were asked to rank (of equal weighting) the CSA practices based on their benefits and potential to enhance their capacity to adapt to climate change (Table 5). The three most commonly cited CSA practices for women were intercropping, strip cropping, use of inorganic fertilizers and early planting. For men, the practices were minimal tillage, cut and carry feeding for livestock, and use of improved crop varieties. There were significant gender differences in preference and use of CSA practices. For example, 80% of the men cited use of minimal tillage as important compared to 20% of the women, while intercropping was cited as important by 72% of the women compared to

28% of the men. There were no significant gender differences in preference and use of chemical fertilizers and strip cropping (Table 5).

Table 5. Gender differentiated CSA practices cited as the most important for adapting to climate change by farmers

Most important CSA practices	Percent of households		
	Total (n=81)	Male	Female
Improved crop varieties	51.9	73.8	26.2
Composting	44.4	72.2	27.8
Chemical fertilizers	37.0	56.7	43.3
Agro forestry	28.4	73.9	26.1
Intercropping	22.2	27.8	72.2
Cut and carry feeding	21.0	76.5	23.5
Strip cropping	13.6	54.6	45.5
Minimal tillage	12.4	80.0	20.0
Early planting	9.9	62.5	37.5

On-farm diversification through various CSA practices within a farm is crucial in climate risk management, especially amongst the smallholder farmers of Lushoto. Farmers in Lushoto are already integrating several CSA practices on their farms to minimize losses from crop and livestock during extreme weather events. On average male headed integrated 10 CSA practices, compared to five CSA practices for women headed households. These findings are consistent with findings from previous studies that report increasingly diversified smallholder farms in East Africa (Iiyama et al 2008). The differences between male and female headed households could be attributed to a) women have limited access to and use of assets such as land and hence unable to adopt long-term practices such as agroforestry, b) women pursue different livelihood portfolios and c) men are more risk takers in that they have access to assets including credit and extension services.

It is interesting to note that neither male nor female headed households mentioned efficient energy stoves as one of their three most preferred CSA practices. The energy stove practice that farmers learned during the climate journey reduces amount of fuelwood used, and it would significantly improve indoor air quality and therefore improve the health of the women (Wilkinson et al. 2009). The traditional methods of cooking that women use, including open air fire, causes death from chronic obstructive pulmonary disease, pneumonia in children under the age of five, lung cancer and other non-communicable diseases such as heart disease, stroke and cataract (Smith et al. 2004, Rehfuess 2006). Moreover, energy efficient stoves have been shown to reduce up to 40% fuel consumption within households (Smith et al. 2004, FAO 2006). This provides a triple win strategy for income, health and mitigation and yet the women farmers in Lushoto did not mention it as important. This calls for increased awareness for women on advantages and benefits of using energy efficient stoves.

3.4 Sources of CSA information and dissemination pathways

In this section, we explore how farmers in Lushoto access information about CSA and other services that support CSA such as weather and credit information. We also look at the CSA dissemination pathways. Households in Lushoto access weather and agricultural information from various sources, with majority of the households relying heavily on radio, friends and relatives, as well as their own observations for information, particularly weather forecasting information, both in the short and longer run (Lyamchai 2011, Mahoo et al. 2015). The government is a key source of information on pest and disease outbreak projections. Traditional sources or indigenous knowledge are still relied upon by some, particularly with respect to forecasts of extreme events and the onset of the rains (Lyamchai 2011). Newspapers, local groups and NGO's, village meetings, TVs are not common sources of weather or agricultural information in Lushoto.

Most of the farmers (over 98%) reported that they receive the agricultural information orally. This is applicable for crop and livestock production as well as tree planting activities. For crop production, farmers need information on time of planting, use of proper seed, proper seed spacing, crop rotation, use of traditional and scientific weather information and appropriate land preparation practices such as no-tillage. For livestock production, farmers would like information on proper feeds and fodder production and management, vaccination, deworming, reducing the number of herd and zero-grazing system. Government extension services is the main source of the oral information (75%), with other sources including own experience (26%), traditional knowledge (11%), researchers (7%) and neighbors (6%), agri-service providers and seed companies. Farmers reported that the information they receive can enable them to start preparing for the changing climate. This was reported by more than 99% of the respondents. Improving agricultural productivity was the major motivation for seeking and using information and technologies on crop husbandry, new varieties and techniques and improvement of soil fertility.

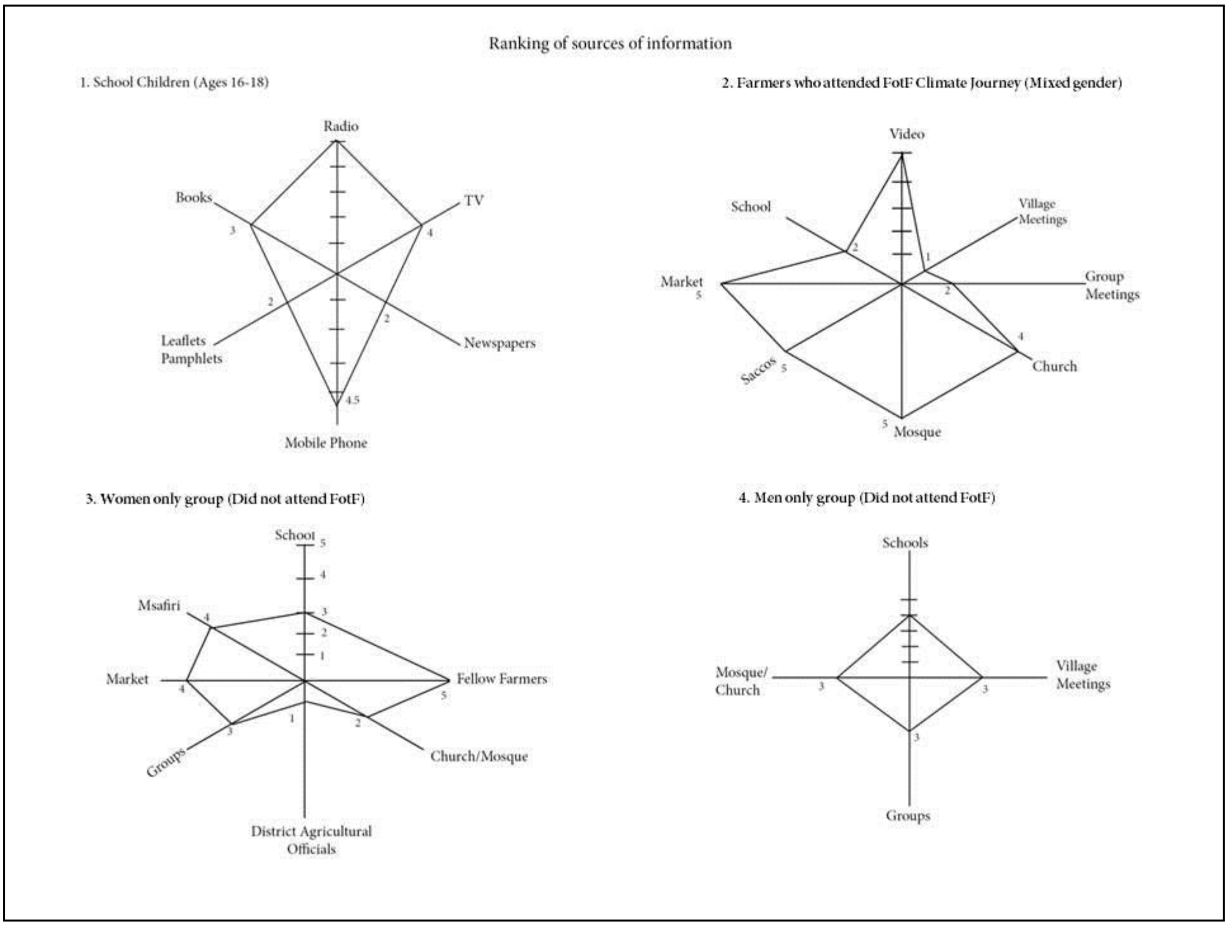
More than half (55%) of the respondents, indicated that the men make decisions on how information is used within the household, while 23% said that it is the woman, 13% pointed out that both women and men are involved in the decision making process. In terms of use of new technologies, 44% of the respondents pointed out that both men and women are involved. It is therefore critical to ensure that information is shared within the entire household including both women and men. The information also needs to be packaged to suit the different audiences.

The farmers and the AIS who participated in the FotF learning journey were expected to widely share what they had learnt with other farmers. During the journey, participating farmers used video recording (flip cameras) to document the learning process. Upon return, the video clips were edited and shared with other farmers in Yamba and Mbuzii who did not participate in the learning visit. Farmers who participated in the learning journey shared information on tree planting, SACCOs, land conservation, beekeeping and *Matengo pits*, mainly with family members (28%), members of the same village (32%), members of the neighboring village (30%) and members of other far-away villages (10%).

Farmers were asked about the practical CSA information dissemination pathways that can be used to reach majority of farmers, especially women and other disadvantaged groups. Understanding dissemination pathways involves considering horizontal (peer-to-peer through face to face interactions, word of mouth, farmer meetings) and vertical (upwards and downwards amongst farmers, extension providers and researcher to farmers, use of radios, cellphone) pathways (Burke 1999). Decisions on which dissemination pathway to use depends on farmers' skills, needs and resources to receive and use the information (Biggs 1986, Lawrence 1997). We used FGDs and participatory mapping exercise to enable farmers to visually map the different CSA dissemination pathways. The FGDs generated a simple checklist of critical stakeholders that are considered as important sources of information. Afterwards, Cobweb networks diagrams were drawn by FGDs to help in visualizing the relative importance of sources of information on CSA practices (Figure 5). A higher point indicates the most preferred as well as trusted source of CSA information.

The Cobweb mapping revealed that informal and formal institutions such as village and religious groups are the most common institutions for accessing information. They provide less formalized but effective methods of communicating any information within Lushoto as well as spreading the CSA practices to other neighboring villages. This was noted in the FGDs for FotF farmers and women only. For school children who are potential future farmers, they preferred the latest information and communication technologies especially mobile phones and television. This is important for scaling up CSA practices among the youth because an effective dissemination pathway depends not only on how successful the pathway influences farmers' decision to adopt, but the number of people receiving the information. Through mobile phones and television, scaling up CSA practices can reach more farmers and future farmers as well.

Figure 5. Cobweb diagram showing ranking on importance of different sources of information on CSA technologies and practices



Despite the increased interactions, dissemination and sharing of information about CSA practices amongst farmers, access to new CSA practices will be hampered by persistent poor linkages between farmers and agro-advisory services providers. Discussions with farmers shows that the information flow and linkages between extension officers and farmers is still weak and there is need to improve access to information for farmers, including exploring others ways that farmers can easily access information on CSA technologies and practices. The combination of a changing climate and declining soil fertility is making farmers not only demand for weather and agro-advisory services but are ready to invest time and money to access these services.

3.5 Farmer's perceptions of the learning journey

Through FGDs, farmers (those who participated in the learning journey and those who did not) and the AIS were asked their perceptions of the learning journey in order to help researchers improve similar visits in the future. Farmer's perceptions of the FotF journey were similar to those reported from the post visit analyses by Nelson et al. (2013). For most farmers, the journey was a useful tool for learning different CSA practices, interacting with other farmers and AIS stakeholders. The timing of the FotF learning journey was excellent, as the farmers got to learn from other farmers while crops were still in the field. Including the AIS actors in the learning journey enhanced the farmers learning experiences, as they provided explanations and opportunities for discussions for certain CSA technologies for which the farmers had limited knowledge and understanding. Presence of AIS actors was to facilitate learning between them and the farmers (Nelson et al. 2012) as well as sharing of information with other farmers who did not participate in the learning journey.

Specific areas where improvements are needed included trip duration—where the farmers observed that they did not get enough time to absorb all the knowledge that they were learning; more representation from the women and youth; and increasing the total number of farmers participating to be proportional to the population of a given target area. While the selection criteria for participation in the learning journey was based on gender balance, spread across different ages, comprised of 50% of farmers surveyed in CCAFS survey, farmers demonstrating capabilities in filming (Nelson et al. 2012), only two out of the 15 participants were women. Of the five AIS actors who participated, only one was a woman (Community Development Officer). Low participation of women farmers is largely attributed to the cultural practices and barriers within the communities, where men are uncomfortable with their wives spending nights out of the home. Rural women, who are agrarian based and provide most of the agricultural labor, will be highly vulnerable to the impacts of climate change and therefore, more women need to participate in learning initiatives (FAO 2010, AfDB 2011, UN 2011).

The diversity of AIS actors from government and private agricultural entrepreneurs drawn from a range of sectors including agriculture, business, tourism and social development shows that the impacts of climate change is being felt across all sectors of Tanzania's economy. Indeed, the impacts of climate change at farm level can ripple through affecting business and the entrepreneurial community because if agriculture fails, farmers will not have income that can sustain business. For the AIS actors, the learning journey increased their understanding of the impacts of climate change and how it is affecting communities across Tanzania.

As a community development officer reported:

"Throughout the journey, I observed farmers soaking in agricultural information from other farmers along the way. I too learned how a changing climate is affecting families and their livelihoods. The experience from the journey has improved my understanding of climate change and the various climate-smart practices that farmers can adopt both in Lushoto and other villages of Tanzania".

Other AIS actors shared similar sentiments. An agricultural input trader commented that:

"I have to keep up to date with weather information from radios and newspapers, especially the onset of rains and how much rains we expect each season. This will enable me to stock the right type seeds for farmers. For example, maize seed that can grow in a short period of time is going to be appropriate for farmers when we have less rain. I will also need to keep in contact with the extension officer who can provide the latest information on climate-smart practices".

Apart from the agricultural input trader, the rest of the AIS actors have not influenced adoption of CSA practices amongst Lushoto farmers including those who participated in the learning trip. Results from the FGDs discussions show that there has been no interaction between the farmers and the other AIS actors after the journey. The District Agricultural and Livestock Development Officer and the District Extension Officer who are in direct contact with the farmers have not shared what they learned with the farmers. This shows that the information flow and linkages between extension officers and farmers is still weak and there is need to improve access to information for farmers, including exploring others ways through which farmers can easily access information on CSA technologies and practices.

4. Conclusion

East Africa smallholder subsistence farming is already facing unprecedented stress, with climate variability and change presenting additional challenges. Therefore farmers need to be prepared to cope with climate variability and adapt to climate change. Failure to be prepared for the effects of climate change is likely to result in increased food insecurity, malnutrition, poverty and in some cases a breakdown in social structures. Current and future farmers need to be prepared not only with CSA technologies, but also supported by other enabling factors such as timely weather information, crop and livestock insurance, credit, institutions such as farmers' organizations. Access to climate adaptation, mitigation and risk management information is key to minimizing the impacts of climate change. Government, private sector, NGOs and CBOs can facilitate good "startup" conditions each season by providing – climate information, agronomic husbandry practices and training – a package of risk management tools. By providing farmers with appropriate information about their circumstances and environment, they will be well placed to assess risks, identify vulnerabilities and use appropriate CSA practices.

The FotF approach is a useful tool for stimulating adaptation learning as it enables farmers to know what their future climate will be like and to start preparing for it. Adding a learning journey where the farmers are able to visit areas already showing their future climate provided an opportunity to learn from other farmers who are already experiencing their plausible future climatic conditions, thereby strengthening their capacity to adapt. The learning journey also enabled farmers to identify new sustainable and climate resilient agricultural practices, to be inspired and be motivated to change. The farmers were able to understand their environment better by comparing and contrasting it to other environments (farming practices, cultural and social norms). Finally, use of FotF approach to enhance farmer-to-farmer adaptation learning should be supported by follow-up training, especially for those technologies and practices where farmers have very limited knowledge. Continuous learning and sharing of CSA practices, climate and agro-advisory information should become an essential tool for farmers, financial institutions and agro-advisory service providers. This will inevitably enhance farmer's adaptive capacity while improving their knowledge, changing their attitudes towards climate-smart farming.

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