# 13 Climate Change and Farmers' Adaptation: Extension and Capacity Building of Smallholder Farmers in Sub-Saharan Africa

Urban B. Kalimba and Richard J. Culas

**Abstract**

The efforts to reduce impacts of climate change have been taken by many African countries especially those which are highly exposed to the changing climatic condition and weather extremes. Many attempts have been directed in agriculture to adapt to climate change as agriculture is the main source of economy and livelihoods of the large population in these countries. Extension services, in particular, have been at the centre of the efforts taken by governments to build farmers' adaptation capacity for the impacts of climate change. This chapter reviews and analyses the current level of extension practices and the capacity building of smallholders farmers with specific reference to Tanzania and other countries such as Senegal, Malawi and Kenya. In particular, this chapter will look at how farmers can be adaptable to climate-smart agriculture (CSA) technologies. In doing so, this chapter will look at what extent climate change affects the agriculture sector of Tanzania, assess the CSA technologies' and practices' adaptation in the farming activities and examine extension approaches/methods being used to address the agricultural challenges in Tanzania and also in relation to the lessons learned from the other African countries (Senegal, Malawi and Kenya).

**Keywords**

Climate-smart agriculture · Smallholder farmers · Climate resilience · Adaptation · Agricultural extension · Participatory approach · Capacity building · Tanzania · Sub-Saharan Africa

---

U. B. Kalimba
Department of Agriculture and Cooperatives, Iringa District Council, Iringa, Tanzania

R. J. Culas (✉)
School of Agricultural and Wine Sciences, Charles Sturt University, Orange, NSW, Australia
e-mail: rculas@csu.edu.au


V. Venkatramanan et al. (eds.), *Global Climate Change and Environmental Policy*,
https://doi.org/10.1007/978-981-13-9570-3_13

## 13.1 Introduction

Agriculture is the mainstay of the Tanzanian economy; it accounts for about half of GDP and export earnings. In 2015, the contribution of the sector to the country's national gross domestic product (GDP) was approximately 32% (CIAT and World Bank 2017). A large part of agricultural GDP comes from food crops which account for about 65% while cash crops account for about 10%. Agriculture contributes about 95% of the national food requirements (URT 2014; FAO 2017) and almost one-third of the total export revenue of the country comes from agriculture (FAO 2016). The sector employs about 13 million people, which is equivalent to 59% of the country's working population (World Bank 2016). The significant part of the agricultural work force is provided by women where the estimates show that they produce more than 70% of the country's food.

Recently, climate change has increasingly emerged as one of the most severe global problems hampering economic growth across many sectors. Those sectors include agriculture, water, fisheries, forestry and other land use, wildlife, energy, industrial processes and product use, waste management, human health and the sustainable livelihoods of both rural and urban communities (Bie et al. 2008; Magombo et al. 2012). This problem is rampant particularly for African counties as it is considered to be one of the most significant threats to sustainable development due to its impacts on food security, economic activities and physical infrastructure (IPCC 2007).

Although there is a rich base of natural resources, agriculture in Tanzania is entirely rain-fed, a situation that makes the country more vulnerable to the impacts of climate change. Climate change has resulted in a general decline in agricultural productivity, including changes in agro-diversity (URT 2017). According to URT (2005), the famine events as a result of either floods or drought have become increasingly common since the mid-1990s and are undermining food security. It has also been reported that the prevalence of crop pests and diseases have increased and are posing significant challenges to agricultural production (URT 2017). Furthermore, the studies by the Tanzania Meteorological Agency (TMA) shows that some of the previous high productivity areas such as the southern and northern highlands will continue to be impacted by decreasing rainfall, repeated drought and a significant increase in spatial and temporal variability of precipitation (URT 2017).

The 2014 annual report of Climate Change, Agriculture and Food Security suggests that the efforts to reduce impacts of climate change in agricultural production requires the development of appropriate and feasible climate-smart and climate-resilient agriculture practices to reduce hunger and improve food security and income (CCAFS 2015a). Also, Gwembane et al. (2015) suggest strategies like building sustainable food systems and improving the productivity and income of smallholder farmers as the best approaches for creating communities resilient against climate change impacts. To achieve these goals, the United Nations Food and Agriculture Organization (2013) has recently recommended the adoption of CSA.

The adoption of CSA among farmers requires a well-organized extension system supported by sound government policies and institutional arrangements to effectively address climate change impacts. In many countries, extension services have been playing a critical role in supporting CSA adoption through technology development and information dissemination, strengthening farmers' capacity, facilitation and brokering and advocacy and policy support (Sala et al. 2016). Specifically, action will be needed to focus on extension for capacity development. This chapter will consider the importance of extension-led capacity building for smallholder farmers, enabling adoption of climate-smart agriculture practices and technologies as a strategy to sustain agricultural productivity, given the expected impacts in Tanzania.

## 13.2 Research Problems

Climate-smart agriculture (CSA) technologies and practices are highly recommended to reduce the impacts of climate change to sustain agricultural productivity. The CSA approach aims "*to address the twin challenges of climate change and food security through sustainably increasing food security by increasing agricultural productivity and incomes; building resilience and adapting to climate change; and developing opportunities to reduce greenhouse gas emissions from agriculture*" (Williams et al. 2015; Sala et al. 2016). Achieving these objectives will require development of climate-smart agriculture technologies (Venkatramanan and Shah 2019), and transformations in the attitudes, behaviour and strategies and farming practices. Such a transformation will require efforts to improve the farmer's access to climate-resilient and smart agriculture technologies and practices (Sala et al. 2016).

For many years, agricultural extension has played a pivotal role in transferring important farming information to farmers with the purpose of enhancing their livelihoods by improving agricultural production. The emergence of climate change in recent years has increased risks in the agriculture sector which threatens its present and future performance. Rupan et al. (2018) argued that climate change is a new global challenge, giving extension agencies major challenges to their previous understanding of their client's needs. They must now revise their services in the light of growing water scarcity, increasing soil degradation and increasing climate uncertainty.

Recently, in many countries, the focus of extension provision has been altered in response to the changing nature of agriculture and needs of farmers. It has shifted away from the transfer of technologies and skills related to agricultural production from research to farmers, to more participatory approaches which emphasize the facilitation of innovations among farmers. According to Sala et al. (2016), these shifts are essential as they are aligned with the need for site-specific assessments to identify suitable agricultural technologies and practices needed for CSA. Nederlof and Pyburn (2012) have argued participatory approaches and methods have proven successful in many countries as an approach that encourage multiple stakeholders to innovate using emerging technologies.

The current state of extension services in Tanzania appears to observers to be not yet ready to take on the challenge of effectively equipping smallholder farmers to survive climate change. Here are some of the dimensions of its lack of preparedness. One immediately notices the low average ratio of extension officers to farmer households (1:630) and the limited technical capacity of local governmental authorities (public extension) to deliver agricultural information (particularly CSA), a problem that has slowed down the adoption of practices and technologies by smallholder farmers. Observers have also noted the lack of documentation of extension policies and procedures focused on increasing agricultural productivity and building climate resilience (Harris-Coble 2016; CIAT and World Bank 2017).

Additionally, “low budgetary allocation to the agriculture sector, inadequate access to reliable transportation for extensionists (particularly public extension workers), limited financial support to carry out demonstrations and field experiments, lack of working facilities and low salaries” (Daniel 2013) have contributed to low performance of this service to address climate change issues. Other challenges are mostly related to contemporary extension delivery systems (pluralistic approach) which tend to be weak and unsystematic, characterized by short-term projects and a lack of coordination between providers and advisers who lack the knowledge and skills to address the new demands (Sala et al. 2016). These challenges denote that the current extension services in Tanzania may not be sufficient to effectively deal with climate change issues.

Despite these challenges, the role of extension services will remain prominent in the efforts to address the problems of climate change in the farming environment due to its potential to act as an intermediary between research and farmers and as nodal points that bring together and facilitate multiple stakeholders to address complex problems and situations (Sala et al. 2016). However, many studies suggest the need for the improvement of extension services in Tanzania (Gwambene et al. 2015; Kangalawe et al. 2017; CIAT and World Bank 2017) to suit the requirements of climate change adaptation in the agriculture sector. This chapter will assess the current state of extension services and capacity building in Tanzania and suggest an alternative extension model to improve its performance in the face of climate change challenges.

## 13.3 Objectives of the Study

Generally, this study aims to assess the role and capacity of extension services to foster smallholder farmer adaptation to climate-smart agriculture practices and technologies in Tanzania and to suggest better ways of improving their performance in addressing climate change challenges for sustainable agricultural productivity. To address the existing challenges in the extension services, this chapter will specifically address the following areas:

1. To what extent climate change affects the agriculture sector of Tanzania
2. To assess the CSA technologies and practices adoption by farmers

3. To examine extension approaches/methods being used to address agricultural challenges in Tanzania
4. To suggest a better extension model to facilitate the CSA adoption among smallholder farmers

Accordingly, this chapter articulates the climate-change impacts, climate-smart technologies and a better extension model for smallholder farmers. The first part of this chapter will look at what extent climate change affects the agriculture sector of Tanzania, the second part will assess the CSA technologies and practices adoption in the farming activities, the third part will examine extension approaches/methods being used to address the agricultural challenges in Tanzania and also in relation to the lessons learned from the other African countries (Senegal, Malawi and Kenya) and the fourth part will look at the extension model that could be suggested to improve the adoption rate of CSA.

## 13.4 Current Agricultural Systems in Tanzania

### 13.4.1 Farming Systems

According to Mnenwa and Maliti (2010), farming systems in Tanzania can be classified into 10 categories based on natural resource base (including water, land, grazing areas and forest); climate (of which altitude is one crucial determinant); landscape (including slope); farm size tenure and organization; dominant pattern of farm activities and household livelihoods (including field crops, livestock, trees, aquaculture, hunting and gathering, processing and off-farm activities) and leading technologies used which determine the intensity of production and integration of crop, livestock and other activities. Another study which focused on differential ownership of assets such as land and livestock activities and incomes in Tanzanian rural areas classifies farming systems into small-scale, farmer-managed irrigation, rain-fed maize production and intensive upland fruit and vegetable production (Mnenwa and Maliti 2010). Furthermore, the study of Kisusu (2003) revealed two farming systems in central Tanzania namely dairy cattle and irrigated rice farming.

### 13.4.2 Impacts of Climate Change on the Agricultural Sector in Tanzania

Climate change refers to the "variation in either mean state of the climate or in its variables persisting for a long and an extended period (decades or longer). While climate variability refers to sudden and discontinuous seasonal or monthly or periodic changes in climate or its components without showing any specific trend of temporal change" (IPCC 2013; Venkatramanan and Shah 2019). Several studies have been conducted on temperature and precipitation projections in Tanzania. For instance, the study by Chang'a et al. (2017) shows that the mean temperature anomaly increased while the average rainfall anomaly decreased between 1961 and 2015.

Climate change impacts can be observed through an increasing frequency of seasons with few rain events, short irregular periods of rainfall seasons, poor rainfall distribution within the seasons and temperature changes (URT 2014; Gwambene et al. 2015; Coulibaly et al. 2015). The current climate change is associated with increased greenhouse emissions as a result of increased burning of fossil fuels. Also, large-scale changes in land use like deforestation also contribute to these emissions (URT 2017). The climate projection studies in Tanzania show that increasing greenhouse emissions have a significant impact on temperature and rainfall changes.

Various studies have revealed that the poor performance of the agriculture sector in Tanzania is impacted by overdependence on rain-fed agriculture and increasingly unpredictable climate change (Ehrhart and Twena 2006; Enfors and Gordon 2008; Müller et al. 2011). Also, the study by Rowhani et al. (2011) revealed that a seasonal increase in temperature by 2 °C as predicted by 2050 would lessen yields of rice, sorghum and maize by 7.6%, 8.8% and 13%, respectively, in Tanzania whilst a 20% increase in rainfall variability will lessen yields of rice, sorghum and maize by 7.6%, 7.2% and 4.2%, respectively, by 2050. Further, other studies by Ahmed et al. (2011), Arndt et al. (2011), and Rowhani et al. (2011) have also predicted that the future climate change may cause severe challenges for the agriculture sector in Tanzania.

Besides, the projections by the Intergovernmental Panel on Climate Change (IPCC) shows that by 2020, while about 75–250 million people in the developing countries including Sub-Saharan African countries will be vulnerable to increased water scarcity as a result of climate change, the agricultural productivity from rain-fed production systems may decline by up to 50%. It implies that many African countries will face a serious shortage of food, a situation likely to exacerbate food insecurity and malnutrition (IPCC 2007).

### 13.4.3 CSA and Its Prospects in Tanzania

CSA endeavours to achieve development and food security through an approach that encompasses climate responsiveness and agricultural growth and development. Like many other countries, Tanzania has initiated a government-led programme and the CSA Guideline (URT 2017) to provide favourable mechanisms to foster CSA as well as to direct public, private and international institutions towards CSA in the country. The purpose of this chapter is to examine the status of CSA in Tanzania regarding institutional arrangements and strategies towards the achievement of sustainable agriculture under climate change challenges. Furthermore, this part will seek to relate these efforts with progress in the uptake of CSA technologies and practices among smallholder farmers of Tanzania.

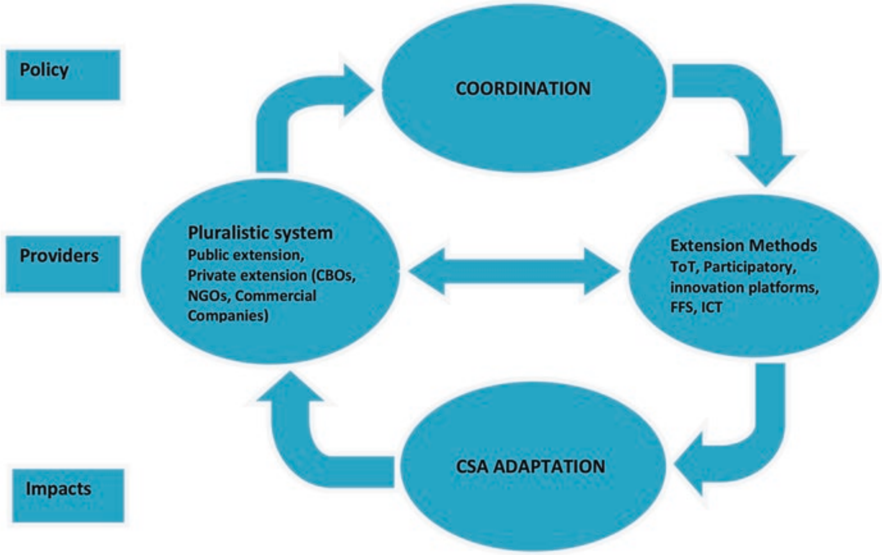


**Fig. 13.1** A CSA extension model. (Source: authors' construction)

### 13.4.4 CSA Concept

According to FAO (2010), climate-smart agriculture aims at achieving the so-called "triple win interventions". These interventions must increase agricultural yields (food and income security), make agriculture more resilient in the face of climate extremes (adaptation) and increase the ability of the farming systems to sequester greenhouse gases (GHGs), particularly carbon dioxide (mitigation) (Fig. 13.1). In the context of Tanzania, CSA is perceived as an "agriculture approach that sustainably increases productivity and income; increases the ability to adapt and build resilience to climate change; and enhance food and nutrition security while achieving mitigation co-benefits in line with national development priorities" (URT 2017).

According to URT (2017), CSA in Tanzania has been designed to ensure sustainable agriculture through integrated water management approaches, management of land and ecosystems at landscape scale and includes techniques, such as mulching, intercropping, conservation agriculture, pasture and manure management and innovative practices, programmes and policies, such as improved crop varieties, better weather forecasting and risk insurance. Apart from that, it should emphasize agroecological approaches to soil, nutrient, water and ecosystem management with explicit attention to the importance of preserving genetic resources of crops and animals including wild relatives, which are critical in developing resilience to shocks.

### 13.4.5 Adaptation Strategies

Smallholder farmers in Tanzania have been employing different practices in their farming activities to reduce the expected impacts of climate change. Although those practices varied from place to place, in most cases they are similar. The common practices include early land preparation, early planting, dry planting, planting of drought-tolerant crops, planting of early maturing crops, mulching, irrigation, tree planting and the use of indigenous knowledge (URT 2017). Other strategies include replanting, intercropping, crop rotation, minimum tillage, use of water harvesting pits, digging irrigation trenches and terracing. Livestock farmers also adapt by growing grasses and perennial fodders, using farm by-products and doing additional activities such as crop farming.

Apart from farmers' efforts, extension services have been backstopping with technical assistance through various capacity-building programmes to help smallholder farmers to adapt to climate change. Efforts are also being made to promote use of improved seeds (such as early maturing and drought-tolerant seed varieties) and adoption of soil and water conservation techniques (such as intercropping, minimum tillage, water-harvesting technologies, ridging and agroforestry). Besides, training on appropriate use of industrial fertilizers and manuring are conducted, and alternative sources of income like agro-processing, mushroom cultivation and off-farm activities are encouraged to build the resilience of smallholder farmers to climate change. For livestock producers, extension agents promote the use of improved breeds and improved livestock management, artificial insemination, milk value-adding and improved fodder to help farmers to reduce the impacts of climate change.

Moreover, the research institutes have also been involved in promoting various CSA-related technologies and practices including a system of rice intensification (SRI), different water-harvesting techniques, use of weather information by knowledge sharing, face-to-face meetings, village meetings, workshops and training (URT 2017). Also, they have been conducting various climate change research initiatives and developing several types of improved seeds and breeds of crops, livestock and fish that are highly productive and drought- and disease-tolerant.

NGOs also play an essential role that contributes to promoting CSA technologies and practices through training, radios, television, mobile phones, seminars, demonstrations, FFS and integrating approaches. Most of them focus on the promotion of crop technologies and practices that include an application of organic fertilizers, use of bio-pesticides and use of improved seed varieties. In the livestock sector, they promote enhanced techniques and methods such as cross-breeding of local chicken, goats, sheep, pigs and cattle as well. In fisheries, NGOs encourage aquaculture and sustainable fishing as measures to adapt to and mitigate the impacts of climate change in the sector (URT 2017). However, URT (2017) reported that the response of the private sector in Tanzania in providing extension delivery and creating incentives for farmers to adopt new CSA methods is still low due to several factors including low participation of private industry in extension delivery, and thus small number of farmers are receiving extension services at the village level.

### 13.4.6 CSA Adoption Among Smallholder Farmers in Tanzania

A study conducted by Gwambene et al. (2015) in the Southern Highlands of Tanzania revealed that smallholder farmers of this area had adopted various agricultural practices to combat different environmental problems such as climate change and land degradation; they also found a low rate of adoption among many smallholder farmers. Other studies (Nyanga et al. 2011; Taneja et al. 2014) associate this low adoption with several factors including, but not limited to, a lack of appropriate implements, insufficient appropriate soil fertility management options, inadequate and sometimes inappropriate technical information and limited/poor access to credit.

The standard adopted CSA practices, particularly in crop production, include mulching, zero/minimum tillage, crop cover, contour ploughing, irrigation, crop residue incorporation, agroforestry, crop and livestock farming, terracing, mixed cropping and crop rotation (Gwambene et al. 2015). Crop rotation received a high priority as 71% of interviewed farmers had adopted it. This was followed by mixed cropping, terracing and livestock farming; approximately 40% of the respondents took each. Mulching and zero/minimum tillage received the lowest priority. Interestingly, despite the prevailing adoption level of CSA practices, the study found that most farmers were not aware of the meaning of CSA and its relevance to their farming activities. This problem may be contributed to by the lack of adequate extension services to educate smallholder farmers about CSA.

The findings of Nyasimi et al. (2017) support this argument by showing that many smallholder farmers in Northern Tanzania were willing to use CSA technologies and practices but they could not because of lack of knowledge and skills. However, the response from the smallholder farmers who were interviewed in the study of Gwambene et al. (2015) showed that most of the time, smallholder farmers tend to adopt farming practices which are perceived to be feasible and that can increase yield and food security.

Several factors cause the low adoption of CSA technologies and practices in Tanzania. Lack of appropriate technical information and the massive cost of CSA technologies are the primary constraints to the adoption (Nyasimi et al. 2017). Other limitations include a low degree of mechanization within the smallholder farming system, lack of appropriate implements, insufficient appropriate soil fertility management options and limited/poor access to credit. To a large extent, the existence of these constraints denotes the weakness of current extension services in addressing farming challenges and promoting CSA practices among smallholder farmers in Tanzania. The findings of Sala et al. (2016) support this argument by pointing out that insufficient extension services are among major limiting factors for the adoption of CSA in developing countries including Sub-Saharan Africa which is caused by inadequate and inexperienced extension workers.

Despite the existence of a well-elaborated framework for CSA in Tanzania, the approach does not seem to be performing at a satisfactory level. The low CSA adoption among smallholder farmers can justify this claim. The discussion in this chapter associates this low transformation with the existence of weak coordination and linkages between CSA actors (both public and private) and financial resource constraints that face government units and departments responsible for the promotion of CSA. It seems that the government does not prioritize the framework for CSA regarding budget allocation and also the extension agencies have not yet succeeded in linking and coordinating CSA actors for better performance.

## 13.5 Extension Model Currently Applied in Tanzania

Msuya et al. (2017) argue that well-targeted agricultural extension services and farmer capacity building strategies are both essential to enable rural communities to meet the challenges of the modern world. In dealing with complex farming challenges like climate change, extension services should ensure constant coordination and communication among crucial actors to facilitate the dissemination of technologies and a continuous flow of farming information in the agricultural environment. This part will assess the relevance of the current extension system applied in Tanzania. This assessment will concentrate on its capacity building role, its performance in addressing farming issues and will also analyse extension methods/approaches being used to disseminate farming information and technologies.

### 13.5.1 Extension Structure in Tanzania

In Tanzania, agricultural extension services are provided mainly through the Ministry of Agriculture Food Security and Cooperatives (MAFC) and the Ministry of Agricuture Livestock and Fisheries (MALF). According to the general government reforms of 1999, the responsibility for extension services in terms of policy formulation, issuance of guidelines and provision of technical assistance to local authorities is under the two directorates in the ministerial levels: the Crop Development and Livestock Development divisions, being assisted by their respective assistant directors (Rutatora and Mattee 2001). With the decentralization of extension services (as per Local Government Act No. 6 of 1999), the Ministry of Regional Administrative and Local Government has been mandated to supervise extension activities at the farm level (Mvuna 2010). Besides being a core function of the government, agricultural extension services have been and remain almost entirely financed by the government. However, both MAFC and MALF also provide room for private agencies to participate in the provision of agricultural extension services, particularly to smallholder farmers. According to Mwamakimbula (2014), this strategy has augmented the efforts of the government in transferring farming information and also to speed up the rate of adoption of various agricultural technologies and practices among farmers. Besides, it has helped to reduce the financial burden of government in funding extension services and reduce the deficit of public extension workers as well. In contrast, the study of Sala et al. (2016) found weak and unsystematic pluralistic “extension systems” in various countries, which are characterized by short-term projects, inadequate coordination between providers, insufficient financial and human resources and advisers who have insufficient knowledge and skills to deal with the new challenges.

### 13.5.2 Agricultural Extension in Building Smallholder Farmer Capacity to Adapt to Climate Change

Awareness creation is one of the responsibilities of extension services. This is the important first stage in introducing an intervention to address any agricultural farming challenge. Extension workers can choose to use the awareness meetings to sensitize smallholder farmers on climate change issues (Mkisi 2014). Mandleni and Anim (2011) reported that agricultural extension plays a crucial role in creating awareness among smallholder farmers of the expected effects of climate change which will help them to make informed choices on available climate change adaptation technologies and practices.

The findings of Taneja et al. (2014) and Sala et al. (2016) suggest that the CSA interventions should be location specific because to a large extent their adoption needs to be well suited to users regarding willingness, ability to practice, knowledge and their investment capacity. These findings are supported by the report of FAO (2014) which asserts that "CSA is not just a set of practices that can be universally applied, but rather an approach that involves different elements embedded in local contexts." This implies that the participatory approaches and consideration of indigenous knowledge are to be considered during the process of conducting the needs assessment as well as during the project implementation phase. The findings of Kaaria et al. (2007) and Nederlof and Pyburn (2012) reveal that extension providers in many countries have achieved positive results using participatory methods/approaches such as participatory technology development (for example, Farmer Field School).

However, it is not a must that all new developed farming technologies and practices are innovated through indigenous knowledge; they can even come from outside sources. Barakabitze et al. (2015) argued that even though farmers generally possess rich indigenous knowledge, agricultural research should continue to develop scientific knowledge and to improve technologies for agriculture. In such a situation, extension services can use demonstrations as an approach for educating farmers on newly developed techniques from research centres. The results of Okunade (2007) and Khan et al. (2009) agree that demonstrations are very useful in transferring knowledge and skills that are necessary to implement the new agricultural technology.

Sharing the experimental findings and newly developed innovations help to facilitate their adoption among farmer communities. The extension worker can use a combination of approaches throughout the process of dissemination of agricultural technology or practice. Sala et al. (2016) maintain that traditional extension approaches (such as interpersonal interaction, demonstrations, field days and printed materials) can still be used when disseminating newly developed agricultural technologies, information and practices. Mkisi (2014) also reported that field days have proven successful in publicizing the new/improved "crop varieties and livestock breeds" and "drought and disease" tolerant technologies in Malawi. Similarly, Okunade (2007) reported that field days were a practical approach in inducing attitude changes among smallholder farmers in adopting new agricultural technologies.

To minimize risks which are associated with climate change, it is imperative that accurate and well-communicated weather information be accessible to farmers as a critical component for planning and action. Agricultural extension plays a role in translating and disseminating information on the weather forecast to smallholder farmers for better planning. The report of Stigter et al. (2013) emphasizes this role of extension by suggesting the need for client-helpful weather information and early warning that could increase the preparedness of smallholder farmers, allowing them to adapt to climate change dynamically, incrementally and in a timely manner. The extension services have the capacity to do this by using different methods such as mass media and farmers' meetings, to mention two.

Climate change and variability have emerged as a new cross-cutting issue in agriculture extension service provision. The available extension staffs have either no or little understanding of this problem and thus they lack capabilities to train farmers on recommended CSA technologies and practices. CIAT and World Bank (2017) reported that the low extension service capacity to deal with climate change issues is one of the significant constraints to CSA adoption in Tanzania. According to Mkisi (2014), capacity building of extension workers is amongst the vital roles of extension services; he suggests the need for building capacity (periodic training) and creating awareness to extension staff on climate change so that they have the knowledge and skills to promote adaptation interventions.

### 13.5.3 Extension Approaches/Methods and Their Performance

The approaches in providing extension services to farmers have frequently been changing to meet the demands of the changing environments where it operates. To ensure sufficient provision of extension services in Tanzania, various extension approaches/methods have been used and these include, but are not limited to, the supply-driven, demand-driven, pluralistic extension systems, training and visit (T&V), non-governmental extension system (NGOs), commodity-based extension, farmer field schools (FFS), and farmer-to-farmer diffusion (Msuya et al. 2017).

The study of Nyasimi et al. (2017) showed that the government extension services are the primary source of oral information (75%) concerning climate change education to Tanzanian smallholder farmers followed by other sources which include a farmer's own experience (26%), traditional knowledge (11%), researchers (7%), neighbours (6%), and agro-service providers and seed companies. However, the study conducted by Msuya et al. (2017) found private extension (NGOs, CBOs, and private agribusiness) was perceived by extension agents to be more effective than public sector extension. According to Rutatora and Mattee (2001), this is because most of the private extension services are project oriented which tends to intensify activities and resources to the extent that shows visible and tangible results, and most of the time they supplement their interventions by integrating with other services including credit, agro-inputs and training.

The assessment of the extension model currently applied in Tanzania reveals several weaknesses that contribute to hampering the efforts towards adaptation among CSA smallholder farmers (Table 13.1). This includes limited financial resources due to low prioritization of climate change activities by the government, low and ineffective utilization of available extension methods/approaches, inadequate human resources and extension facilities. On the other side, the assessment reveals the critical roles that are being played by extension services in promoting CSA adoption among smallholder farmers. These results suggest a need to transform agricultural extension systems to meet the demand of changing farming challenges.

## 13.6 Experience from Other African Countries (Senegal, Malawi and Kenya)

The efforts to reduce impacts of climate change have been taken by many African countries especially those which are highly exposed to the changing climatic conditions. Many attempts have been directed at the agriculture sector because it is among the most vulnerable economic sectors to climate change while also being the sector on which the livelihoods of a large proportion of the population depend. Extension services have been at the centre of these efforts, using different approaches and methods to provide a nexus between farmers and other stakeholders of climate change. This chapter will analyse those efforts specifically in Senegal, Malawi and Kenya with a focus on climate change adaptation.

### 13.6.1 Senegal

The economy and livelihood of many people in Senegal are highly dependent on the agriculture sector. According to FAO (2016), the agricultural industry employs more than 70% of the workforce and represents about 17% of the country's gross domestic product. About 90% of agriculture in Senegal is rain-fed which is currently facing rainfall variability, especially in the northern region where crops are affected by uncertain climate conditions such as low rainfall and prolonged drought (Khouma et al. 2013). Like in many other countries, the frequent occurrence of these phenomena implies that the climate of Senegal has changed. In Senegal, the increased number of extreme weather events and climate shocks in recent years has pushed farmers to adopt various climate change adaptation practices and raised the need for more reliable weather information to assist them in farm management decision-making that may help minimize climatic risks to reduce frequent food shortages.

#### 13.6.1.1 CSA Practices in Senegal

In Senegal, according to CIAT and BFS/USAID (2016), crop production typically involves the use of high-quality certified seeds and short-cycle varieties. Other practices include crop diversification, good agriculture practices (fire control, weeding), intercropping, drip irrigation, agroforestry, assisted natural regeneration, use of

**Table 13.1** An analysis of extension approaches/methods being used in Tanzania

| Approach/ method | Description | Strength | Weakness |
|---|---|---|---|
| Training and visit (T&V) | Training and visit (T&V) based on top-down approaches (supply-driven) was introduced and sponsored by the World Bank until the late 1990s. The primary goal of this approach was to increase food production (Swanson 2010). This approach continued to be used alongside other approaches even after the World Bank project phaseout. The study of Rutatora and Mattee (2001) explains that in Tanzania under the Agricultural and Livestock Extension Rehabilitation Project (NALERP) the former T&V (which was based on the transfer of technologies (ToT)) was modified and became more participatory and continued to be used by extension workers | One of the key strengths of this approach is the provision of access and translation of scientific innovations and information to help farmers in improving farm production. The evidence from the Agricultural and Livestock Extension Rehabilitation Project (NALERP) showed that it had achieved its goal of increasing agricultural production and increased farmer awareness of specific technical advice and increased the rate of their adoption especially to the farmers covered by the extension workers (Rutatora and Mattee 2001) | The weakness of this approach is that it does not involve farmers in identifying the challenges and adapting the research to local conditions (non-participatory). It assumes that knowledge is coming from the external source and farmers should be the recipients of the particular expertise rather than being integral to the innovation. This implies that issues of relevance, cost-effectiveness, ownership and sustainability are abandoned by this approach, a factor that predicts its failure in the future |

| | | | |
|---|---|---|---|
| Non-governmental extension system (NGOs) | This type of extension has increased in recent years especially after the introduction of restructuring policy (decentralization by devolution) by the government which allows private organizations to supplement public extension services | The use of participatory (demand-driven) approaches by many NGOs facilitates the emergence of innovations among farmers which help to solve challenges based on their priorities. The observations in Tanzania show that the simple organization structures of many NGOs tend to give staff members more scope to address the immediate situation on the ground and so address the local concerns. Also, NGOs can be more effective as compared to public extension services because their coverage is limited and thus the intensification of efforts can deliver better outcomes. However, the tendency of being territorial and having a higher degree of autonomy pose problems for the coordination of extension efforts (Rutatora and Mattee 2001) | Some of the weaknesses of NGOs include the reluctance to share information with public workers because they want to have all the credit for any achievement. Also they do not prefer collaboration to safeguard their independence, and apart from that they tend to concentrate on relatively small geographical coverage (Msuya et al. 2017) because they usually operate under project bases and in many cases they are biased in selecting those project areas; the issue of sustainability is critical especially when donor financing ends (MAC 2000) |

(continued)

**Table 13.1** (continued)

| Approach/ method | Description | Strength | Weakness |
|---|---|---|---|
| Farmer field schools (FFS) | This is a group-based experiential learning approach which aims to build famer capacity to learn, understand and make informed decisions in their fields. Presently, it is a widely used extension approach in Tanzania | In a farmer field school, groups of farmers meet regularly in the field with a facilitator to observe, talk, ask questions and learn together. This participatory (interactive) kind of extension approach helps farmers to be innovative and improve their decision-making in farming activities. A group approach facilitates rapid spread of farming information among farmers rather than one-to-one paths like a contact farmer. Also, during "special" topic sessions in the FFS, farmers can learn a wide range of technical and social topics which are related to their farming activities such as water and sanitation, household livelihood security, marketing, child labour and climate change to name a few. Moreover, it helps farmers in learning by doing, reduces the cost of production, provides a systematic evaluation of different technologies, and promotes community organization (Khatam et al. 2010). According to Braun and Duveskog (2008), the networks of FFS groups in Sub-Saharan Africa have increased farmers' voice and power and access to services and markets | Despite the strengths that make it a highly recommended approach in many developing countries, it has some weaknesses which somewhat limit its adaptability. Massive expenses on the implementation of FFS appear to be a burden to the funding organizations (public/private). FFS is a time-consuming process which requires more highly committed members. Additionally, different challenges in handling a group may arise, for instance, an environment of competition between farmers during the learning process (Khatam et al. 2010) |

| | | | |
|---|---|---|---|
| Information and communication technology (radio, TV, mobile phones, social media) methods | Communication is crucial for addressing extension problems related to participation, integration, capacity building, decentralization and sustainability as a human dimension (World Bank 2007). In the recent years, extension delivery has increased the use of information and communications technology-based (ICT-based) methods to deliver farming messages to farmers. In Tanzania, mobile phones, radios and TV stations are now used to inform farmers about agricultural best practices, agriculture marketing, climate change issues and weather forecasts | An ICT-based approach has a more significant potential to reach many farmers at once than any other extension method. Rupan et al. (2018) argues the ICT-based method is the best extensive covering method in the environments of developing countries where the significant constraints of national extension systems are the shortage of field extension personnel and limited resources to reach large numbers of farmers spread widely across geographical areas. Furthermore, he explains the ICT-based approach is the best-suited option for awareness raising and thus it has a potential to contribute to climate mitigation, adaptation and increased food security. It is an effective method of conveying the more straightforward messages to farmers which does not necessarily require extension personnel to do this task, for example, climatic information. Also, mass media is a cost-effective method compared to other ways considering geographical coverage against costs | The ICT-based approach does not suit in disseminating complex farming knowledge which requires more practical learning processes because learning by doing is somewhat challenging with this approach. In this approach, the interactions between participants are limited as compared to other approaches such as group based. In developing countries like Tanzania, poor network coverage, especially in the rural area, could be a constraint to access information through mobile phones and, besides, massive costs of TV and its accessories could be another limitation to the farmer to use it |

stone bunds for water management, application of organic fertilizer, mulching and composting and use of neem as a biological pesticide, particularly in the horticulture and arboriculture sectors. Livestock CSA practices include intensification and sedentarization of livestock and changing herd species for small ruminants. Pastoralism and, especially nomadic transhumance, is a common adaptation strategy practised in the northern parts of Senegal to cope with the climatic stresses and limited resources in the region (Diouf et al. 2014).

Apart from these practices, farmers are organizing themselves into associations to pool resources and form savings groups. However, it was observed that these CSA practices are common especially among farmers who have been exposed to government and private extension organizations which provide them with agricultural extension services, giving considerable attention to climate change mitigation (CIAT and BFS/USAID 2016). This implies that a large percentage of farmers especially those who have not received extension services are still not practising CSA.

#### 13.6.1.2 The Extension Services and Climate Information Services in Senegal

In Senegal, the extension agents are at the centre of the entire dissemination systems to ensure the accuracy and reliability of climate information. Before the dissemination of any climate message to farmers, they make sure that it is well defined and has been interpreted to suit the local context of a particular farming system. However, Sala et al. (2016) observed that several factors limit the performance of extension services in Senegal: there is a dearth of extension workers (multidisciplinary working groups) at the local level to translate climate information to farmers, inadequate funding for operationalizing plans, capacity building of extension workers and journalists, and improving communication between actors.

#### 13.6.1.3 Extension Initiatives to Tackle Climate Change in Senegal

The government with the support of the Research Program on Climate Change Agriculture and Food Security (CCAFS) has initiated climate information services (CIS) which provide weather forecasts helping farmers to improve their decisions about agriculture management in an environment of climate change (CCAFS 2015b; Sala et al. 2016). Another initiative for CIS which works primarily during the beginning of the rainy season was established by the national meteorological agency, Agence Nationale de l'Aviation Civile et de la Météorologie (ANACIM). It has been using some different methods such as radio broadcasting (which use local languages), direct contact with farmers, collaboration with the rural development departmental services (SDDR) and also by conducting seminars to inform farmers about the trends and projections of weather (CCAFS 2015b; Sala et al. 2016).

However, different studies in other developing countries (including Sub-Saharan Africa) have pointed out some weaknesses that could undermine the long-term sustainability of delivery and uptake of CIS. These include (i) the production of information is not locally relevant, fit for purpose and available in a timely manner (Lackstrom et al. 2014; Nidumolu et al. 2016; Singh et al. 2017); (ii) the lack of appropriate governance and institutional structures for the provision of climate information (Vaughan and Dessai, 2014); (iii) inadequate emphasis on socio-economic value in the uptake of climate information provided and subsequent decision-making; and (iv) the lack of appropriate boundary organizations to effectively communicate between information providers and users (Ouedraogo et al. 2018). This suggests a need for a determined effort to check these weaknesses to ensure effective CIS delivery particularly in developing countries like Senegal.

Furthermore, to facilitate the flow of CSA information in Senegal, a multidisciplinary working group has been established to play an essential role in disseminating climate information and advisories which significantly influences farm management decisions and other livelihood activities (Partey et al. 2018). However, Sala et al. (2016) found that there was insufficient coverage of local working groups (GTPs) across the country due to lack of funds to cover their operational costs such as meetings, transport and capacity building of GTPs, journalists and communication among actors.

#### 13.6.1.4 Extension Methods

The studies of Lynagh et al. (2014) and D'Auria and McKune (2014) observed the existence of farmers' social networks within their communities which also play a vital role in climate information dissemination. Also, the same reports found that individuals who have active social networks were likely to get climate information which helps them to take proactive measures to minimize the risks of climate change. Settle et al. (2014) argued that creating social networks among farmers is an important strategy which helps to cluster small farmer groups (e.g. FFS groups) in which they can easily access information and also consider the adoption of new practices through farmer-to-farmer diffusion.

The report of Sala et al. (2016) on CSA and extension shows that in Senegal, apart from other extension methods, mobile phones are widely used to disseminate climate information to farmers by using short message service (SMS). Partey et al. (2018) reported that while the ICT-based extension methods have increased the availability of CIS, farmers are well informed about rainfall distribution patterns, intensity and frequency, wind storms and extreme events like droughts which enable them to plan their agricultural activities effectively and efficiently. Rapidly growing mobile phone services in Senegal have increased the access of people to climate information.

The reports of ANSD (2013) and CCAFS (2015a, b) revealed that a total of 7.4 million rural people, representing about 740,000 agricultural households, were potentially reached with climate information across all 14 administrative regions of Senegal via 82 rural community radios and SMS. Sanga et al. (2014) claimed that ICT is the best method for bridging the information gap for rural farmers concerning information related to innovative practices and technologies. For instance, the study by Veeraraghavan et al. (2009) reported that in India, mobile phone communications had been preferred as an effective means of reaching many smallholder farmers in the rural areas, transferring relevant agricultural information via SMS. However, according to Sala et al. (2016), the impact of ICT-based methods can be limited by several circumstances. They argued that despite its potential in reaching many farmers promptly, two problems arise: first, a risk of exclusion of specific population groups whose accessibility to a particular information channel is not guaranteed, and second, since ICT is a supply-based approach, it might not respond to real farmers' needs.

Another extension approach which is being used to disseminate climate messages to farmers in Senegal is field demonstrations where extension workers facilitate the emergence of innovations among farmers through participatory and interactive learning. The study of Ouedraogo et al. (2018) explains that in Senegal the demonstration approach emphasizes problem-solving and discovery-based learning which increase farmers' capability to deal with challenges of climate change, and according to the authors, this approach ensures farmers with the adoption of innovative practices which are best suited to their local farming environments. Despite the potential of this approach, the study of Franzel et al. (2018) found that in Senegal, demonstration plots are particularly useful when managed by farmers rather than extension staff; they observed that farmer-led demonstrations were better received than those presented by technical staff.

### 13.6.2 Malawi

In Malawi, extension has been proposed to play a centre role in dealing with climate change problems by significantly expanding farmers' awareness of the adverse impacts of the changing climatic conditions on agricultural productivity, and thus of the need for farmers to adjust agriculture management practices to adapt to climate change (Nhemachena and Hassan 2007). According to the authors, Malawian farmers who have access to climate change information have shown resilience to shocks of climate change. However, in some areas, the adoption of CSA measures by farmers seems to be low. Mkisi (2014) argued that this situation might be attributable to the lack of awareness of many smallholder farmers on the available CSA technologies and practices or lack of information overlaps with the other point about lack of awareness.

#### 13.6.2.1 Adaptation to Climate Change

According to Mkisi (2014), there are about nine common adaptive practices used by farmers in Malawi to reduce the impacts of climate change on agricultural production. The most common practice is intercropping. It is done to reduce the threat of food shortage in case of climate variability and to maximize output as well, whereby two or more crops are grown in one field. The common combinations are maize and beans, maize and cassava, maize and pigeon peas and maize and ground nuts. The second common practice is the use of drought- and disease-resistant crops such as cassava and sorghum. The third most common practice is the use of hybrid crop varieties (mainly maize varieties) which are high yielding and early maturing. Other adaptation practices include the use of organic matter or manure, box ridging, crop diversification, crop processing, soil and water conservation measures and adoption of agroforestry practices (Magombo et al. 2012). Various studies found similar adaptation practices are being applied by smallholder farmers in other developing countries (Deressa et al. 2011; Chanika et al. 2011; Ozor and Cynthia 2011).

#### 13.6.2.2 Limitations to Adaptation Efforts

In 2002, the Government of Malawi introduced a pluralistic extension approach to expand farmer access to extension services. However, Kakota et al. (2017) observed that this approach brought other new challenges to the agricultural communities during the implementation of programmes and projects. Lack of proper coordination and organization among extension providers led to poorly harmonized information, approaches and methods. This has further contributed to information overload on smallholder farmers and hampered their capacity to deal with farming challenges including climate change.

Additionally, lack of certified CSA training manuals by the government has resulted in contradictory information on CSA technologies and practices among extension providers and, in turn, led to the poor adoption of those practices among farmers (Kakota et al. 2017). In addition, household characteristics such as size of the households, landholding, per annum total income of household, input access and output market were also found to affect the adoption of different combinations of climate change adaptation strategies in Malawi (Magombo et al. 2012).

### 13.6.3 Kenya

Kenya like many other countries especially in the developing world is facing the impacts of climate change which affects its economic sectors particularly agriculture. The severity of these effects is attributed to the high dependence of Kenyan agriculture on rain-fed production systems which accounts for about 75% of the entire agricultural land (Stefanovic et al. 2017). Projections of climate change suggest that agricultural production in Kenya, especially for the critical staple crops of maize and wheat, is likely to experience declines due to increased evapotranspiration caused by increasing temperature (Bryan et al. 2012).

#### 13.6.3.1 CSA Practices in Kenya

The results from the household survey by Deressa et al. (2011) showed that farmers in Kenya have started to use different kinds of practices in response to perceived climate change. The most common CSA practices adopted in Kenya include changing crop variety (33%), changing planting dates (20%) and changing crop type (18%). Other responses included planting trees (9%), reducing livestock numbers (7%), diversifying, improving, or supplementing livestock feeds (7%), changing fertilizer application (7%) and soil and water conservation practices (SWC) (5%).

However, the results from another household survey conducted by Bryan et al. (2012) revealed about 19% of farmer households in Kenya were not using climate change adaptive measures. Meanwhile, lack of resources, limited water access and insufficient information are mentioned to be the significant barriers to the adoption of CSA technologies and practices (Bryan et al. 2013). In contrast to these findings, a similar survey conducted in Ethiopia and South Africa found 37 and 62% of smallholder farmers, respectively, were not using any CSA measure (Bryan et al. 2013). This comparison implies that Kenya was doing better than many other African countries although the percentage of farmer households which did not adopt seemed to be high.

#### 13.6.3.2 Extension and Adaptation to Mitigate Climate Change

The study of Silvestri et al. (2012) in the seven districts of agro-pastoral communities in Kenya has mentioned extension services as a primary determinant for implementing a successful strategy to mitigate the effects of climate change. Similarly, Stefanovic et al. (2017) cited the same factors in influencing the uptake of appropriate mitigation strategies in crop production with few exceptions such as farmers' access to non-agricultural income, the availability of farmers' groups and cooperatives and the future risk perception in case of late planting among food crop farmers.

According to Silvestri et al. (2012), poor climate change adaptation by smallholder farmers is attributed to insufficient extension services which are characterized by limited contacts between extension agents and farmer households and lack of appropriate climate change information. Furthermore, the same survey by Silvestri et al. (2012) revealed that only about 20% of farmer households in the study area had received extension visits and for about 66% of those visits, the number of the visits was limited to three times or fewer within the year. This problem may be caused by a limited number of extension workers and lack of climate change knowledge among them. However, generally, the impact of extension services was observed on changed farming practices such as selection of livestock breeds that are more resistant to new climate conditions and switching to alternative feed sources during prolonged drought (Silvestri et al. 2012).

In his study, Roncoli et al. (2010) argued that adaptation is concerned with making decisions in a situation that involves uncertainty; however, regardless of the availability of high-quality information from meteorological data, forecasts of climate or local observations, farmers will still work under a certain degree of uncertainty due to the nature of climate change. This condition adds complications in delivering extension messages. Moreover, a study into the effects of government extension services on farmers' adaptation in response to climate change reveals limited success, given climatic variability advice to farmers needs to be continuously revised in the light of changing weather conditions (Crane et al. 2011).

#### 13.6.3.3 Extension Services Reformations to Suit CSA in Kenya

Various studies in Kenya have shown the importance of having an effective extension delivery system that will facilitate the adoption of climate change practices, a situation of strengthening farmer resilience and maintenance of agricultural productivity (Lopokoiyit et al. 2012; Silvestri et al. 2012; Stefanovic et al. 2017). Additionally, Sala et al. (2016) explain a successful CSA implementation involves effective and efficient extension providers and systems; this suggests the need for significant organization and institutional reform and capacity building at the organizational and individual levels.

With regards to these calls, the Government of Kenya has been implementing some strategies to deal with these challenges as they have been stipulated in the Kenya climate-smart agriculture strategy 2017–2026. According to GoK (2017), the first strategy is to mainstream CSA in formal training institutions at certificate, diploma, graduate and postgraduate levels to increase the capacity of extension staffs to undertake CSA. The second strategy is to enhance the ability of institutions to conduct mitigation and adaptation research. This entails availing adequate infrastructure for research; providing sufficient skilled research personnel; adopting indigenous knowledge and culture; enhancing capacity to carry out adequate measurement, reporting, and verification (MRV); and increasing operational resources for CSA research. A third strategy is to ensure the availability of data and information on CSA by establishing and maintaining a data and information management system, build capacities in data collection and information management and promote data generation and dissemination during planning, implementation, monitoring and evaluation at both national and county levels.

Recently, Kenya started to use an agro-weather tool which incorporates internationally available decision support system (DSS) devices such as crop simulation models into its system to understand and demonstrate impacts of climate change and crop management practices on specific crop yields and subsequently generate climate-smart agro-advisory. It collects, organizes and integrates all the different information required for producing a particular crop and then analyses and interprets the data and finally gives recommendations on appropriate action to maintain maximum productivity. ICT-based (mass media) communication methods/channels (such as SMS, radio messages and newsletters) have been used by extension agents to disseminate these kinds of CSA technologies in Kenya and Ethiopia for their adoption and utilization (Oladele et al. 2018).

According to Rupan et al. (2018), ICT-based communication is the best extensive covering method in the environments of developing countries where the significant constraints of national extension systems are the shortage of field extension personnel and limited resources to reach large numbers of farmers spread widely across geographical areas. In contrast, Okwu (2011) argued that ICT-based communication cannot effectively reach all groups of farmers because farmers who use mass media are those who have a reasonable level of education, belong to a relatively high-income bracket and are typically male and of a relatively high socio-economic status, that is, not the profile of a typical smallholder farmer. Therefore, farmers' socioeconomic characteristics should be considered in planning mass media usage in agricultural information dissemination (Oladele et al. 2018).

This analysis shows that adaptation to the projected impacts of climate change is being increasingly prioritized among many African countries because of the serious threat that climate change poses for the sustainability of economic sectors, particularly, the agriculture sector. The proposed measures to mitigate climate change are similar across many developing countries with few variations depending on particular local context. There are significant relationships between socio-economic factors and the kinds of adaptation recommended while the availability and quality of extension services play a prominent role in determining the adoption of CSA technologies and practices among smallholder farmers. It is observed that lack of efforts to empower agricultural extension services to take emerging climate change issues seriously remains a critical obstacle to effective climate change action among farmers across the region.

## 13.7 Extension Model for Improved Action on Climate Change

### 13.7.1 Need for Reforming Agricultural Extension Provision in Tanzania

A successful CSA blueprint requires a well-organized extension system competent to address the urgency of climate change issues. Despite playing a role in dealing with climate change within the farming environment, the current extension model in Tanzania does not offer sufficient services which could effectively address climate change challenges. The purpose of this chapter is to suggest an extension model that may suit the current need for extension services under climate change challenges.

### 13.7.2 Pluralistic System

The current state of extension services, characterized by limited financial and human resources (particularly for public sector agencies), requires combined efforts of both public and private extension service providers to reduce the impact of these challenges. Also, the pluralistic systems have the potential to deal with the diversity of conditions, needs, audiences and farming systems that make up the agricultural landscape by providing an equally diverse arrangement of services and service providers. However, coordination by government departments (Fig. 13.2) will be needed to help extension actors to deliver services that utilize the relative strengths of each entity.

### 13.7.3 Group-Based Approaches

To build the sustainable resilience of farmers to climate change and variability requires innovations that are drawn from farmers' knowledge and experiences. Besides, to build resilience needs strong farmers' associations and networks to improve their bargaining power at the markets, to increase access to relevant information, to widen sources of finances and to have a loud voice in advocating policy and strategies that affect their activities. The group-based extension approaches have a high potential to allow farmers to self-organize to build their resilience in confronting this issue of climate change.

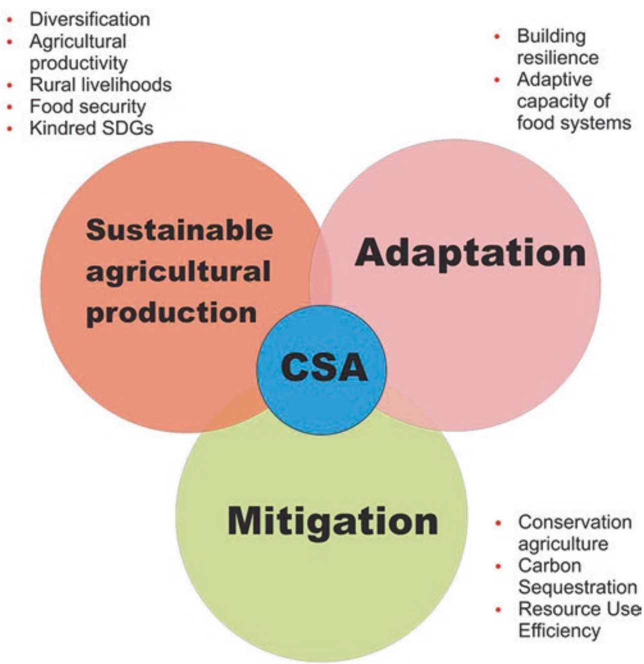


**Fig. 13.2** Goals of climate-smart agriculture. (Source: Venkatramanan and Shah (2019)

## 13.7.4 Extension Methods

There is no single extension approach/method which is adequate to address agricultural challenges including the climate change issues effectively. This implies that to deal with the complex impacts of climate change requires more than one approach/method. There is a need for a complementary extension approach that can trap the advantages from each available approach/method to adequately address climate change. According to Sala et al. (2016), extension approaches/methods differ regarding their reach and impact potential, "the higher the reach, the smaller the impact and vice-versa".

## 13.7.5 Traditional Extension (ToT)

This approach suits the motive of increasing agricultural productivity by transferring farming technologies from outside of the farmers' environment. Successful CSA technologies and practices from outside sources can be effectively disseminated by using this approach and help to reduce the effects of climate change. However, implementation of this approach will require some modifications to make it more participatory to ensure the sustainability of those technologies and practices in the new environment.

### 13.7.6 Participatory Approaches

This approach to extension is essential due to its potential in facilitating the emergence of innovations among farmers. Addressing climate change and variability needs more specific and realistic solutions based on local conditions. Indigenous knowledge and experiences are highly recommended to facilitate the emergence of innovations which are more appropriate and practical to solve a specific climate change challenge at a local level. Also, a sense of ownership which is ensured by this approach helps to facilitate the adoption, promoting the sustainability of those innovations.

### 13.7.7 Innovation Platforms

One of the roles of agricultural extension is a "bridging" function. Finding solutions for most of the farming challenges including climate change requires a kind of collective effort of all rural stakeholders and service providers. More recently, in many countries, extension agents have been emphasizing agricultural innovation systems (AIS) by playing various roles in establishing and strengthening of multi-stakeholder innovation platforms. In the platforms, the extension worker is the leading innovation broker for catalysing the process and bringing other stakeholders together and facilitating interaction between them, coordinating and creating networks, ensuring the flow of information among actors and providing technical assistance.

## 13.8 Conclusion

The agriculture sector in Tanzania is detrimentally affected by the persisting impacts of climate change due to its high proportion of rain-fed production systems. In recent years, noticeable effects, including seasonal fluctuation of agricultural productivity, have become common in different parts of the country. Studies predict severe consequences in the future which will, in turn, affect the country's economic status due to its dependence on the agriculture sector. This suggests deliberate efforts are needed by the government in collaboration with other development partners to reduce the impacts of climate change on this sector.

At the farmer's level, one of the recommended efforts for reducing impacts of climate change is the adaptation of CSA technologies and practices in farming activities. Several field observations in Tanzania reveal that there are various CSA technologies and practices which are being used by smallholder farmers although the rate of adoption is still low due to many reasons, particularly, poor rural extension services. However, in Tanzania, CSA is still a new notion among many extension agents and smallholder farmers. This suggests efforts are needed by the extension services to build the capacity of extension agents and smallholder farmers on CSA.

The current extension services in Tanzania are faced with many challenges which affect their performance in bringing desirable outcomes in the sector. Despite the obstacles, extension remains a crucial catalyst in enhancing agricultural development due to its significant potential in dealing with farming challenges including cross-cutting issues like climate change. Among many other difficulties in extension provision, poor utilization of available approaches and methods has been affecting its performance. Many studies suggest the need for, among other things, a carefully chosen combination of approaches and methods that suit the need of a specific farming situation such as the adaptation of CSA to suit the local context.

In reforming and strengthening agricultural extension services for promoting CSA in Tanzania, there is a need to implement immediate priority actions alongside the long-term action plans. These include establishment of mechanisms at the local level for better alignment and cooperation/collaboration between public sector agricultural extension and other sectors (such as livestock, water, environment, forestry and fisheries) to strengthen the capacities of agricultural service provision and other rural stakeholders to enhance processes of innovation at organizational and individual levels and to improve the ability of service providers to identify and use a range of extension methods and approaches appropriately for sharing CSA technologies and practices with farmers.

In the long term, the government should increase investment in research, extension and training including the introduction of specialized courses in climate change, particularly CSA technologies and practices. This review also recommends short-term training of smallholder farmers on climate change and CSA technologies and practices; training and deployment of more public extension workers and short-term retraining of existing extension workers, policymakers and policy implementers in climate change and CSA thinking.

## References

Ahmed SA, Diffenbaugh NS, Hertel TW, Lobell DB, Ramankutty N, Rios AR (2011) Climate volatility and poverty vulnerability in Tanzania. Glob Environ Chang 21:46–55. https://doi.org/10.1016/j.gloenvcha.2010.10.003

ANSD (2013) Rapport Definitif RGPHAE 2013. Agence Nationale de la Statistique et de la Démographie (ANSD). http://bit.ly/1NrlekU

Arndt C, Farmer W, Strzepek K, Thurlow J (2011) Climate change, agriculture, and food security in Tanzania. Helsinki, United Nations University: UNU-WIDER

Barakabitze AA, Kitindi EJ, Sanga C, Shabani A, Philipo J, Kibirige G (2015) New technologies for disseminating and communicating agriculture knowledge and information: challenges for agricultural research institutes in Tanzania. Electron J Inf Syst Dev Countries 70(2):1–22

Bie SW, Mkwambisi D, Gomani M (2008) Climate change and rural livelihoods in Malawi. Review study report of Norwegian support to FAO and SCC in Malawi, with a note on some regional implications. The Royal Norwegian Embassy, Lilongwe, Malawi

Braun A, Duveskog D (2008) The farmer field school approach-history, global assessment and success stories. Background paper for the IFAD rural poverty report

Bryan E, Ringler C, Okoba B, Koo J, Herrero M, Silvestri S (2012) Can agriculture support climate change adaptation, greenhouse gas mitigation, and rural livelihoods? Insights from Kenya. Clim Chang 118:151–116. https://doi.org/10.1007/s10584-012-0640-0

Bryan E, Ringler C, Okoba B, Roncoli C, Silvestri S, Herrero M (2013) Adapting agriculture to climate change in Kenya: household strategies and determinants. J Environ Manag 114:26–35. https://doi.org/10.1016/j.jenvman.2012.10.036

CCAFS (2015a) Annual report 2014: climate-smart agriculture – acting locally, informing globally. CGIAR research program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark. Available online at: bit.ly/CCAFSAR2014

CCAFS (2015b) Scaling up climate advisories in Senegal and Colombia. https://cgspace.cgiar.org/bitstream/handle/10568/67903/05outcomecase.pdf?sequence=3

Chang'a LB, Kijazi AL, Luhunga PM, Ng'ongolo HK, Mtongori HI (2017) Spatial and temporal analysis of rainfall and temperature extreme indices in Tanzania. Atmos Clim Sci 7:525–539. https://doi.org/10.4236/acs.2017.74038

Chanika D, Hamazakaza P, Joubert A, Macome E, Mutonhodza C (2011) Overcoming the barriers: how to ensure future food production under climate change in Southern Africa. Oxfam International, Oxford

CIAT; BFS/USAID (2016) Climate-smart agriculture in Senegal. CSA country profiles for Africa series. International Center for Tropical Agriculture (CIAT). Bureau for Food Security, United States Agency for International Development (BFS/USAID), Washington, DC, p 20

CIAT; World Bank (2017) Climate-smart agriculture in Tanzania. CSA country profiles for Africa series. International Center for Tropical Agriculture (CIAT); World Bank: Washington, DC. p 25. https://ccafs.cgiar.org/publications/climate-smart-agriculture-tanzania#.XBx90FwzbIU. Accessed 21 Dec 2018

Coulibaly YJ, Kundhlande G, Amosi N, Tall A, Kaur H, Hansen J (2015) What climate services do farmers and pastoralists need in Tanzania? Baseline study for the GFCS Adaptation Program in Africa. CCAFS working paper no. 110. CGIAR research program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark. Available online at: www.ccafs.cgiar.org

Crane TA, Roncoli C, Hoogenboom G (2011) Adaptation to climate change and climate variability: the importance of understanding agriculture as performance. NJAS Wagen J Life Sci 57(3–4):179–185

D'Auria Ryley T, McKune S (2014) Climate change and social networks in Senegal's peanut basin. CCAFS. http://bit.ly/1Kc3nvL

Daniel E (2013) Assessment of agricultural extension services in Tanzania. A case study of Kyela, Songea Rural and Morogoro Rural Districts. Internship report in Plant Sciences CSA. Wageningen University, Netherlands

Deressa T, Hassan R, Ringler C (2011) Perception of and adaptation to climate change by farmers in the Nile basin of Ethiopia. J Agric Sci 149(01):23–31. https://doi.org/10.1017/S0021859610000687

Diouf B, Lo HM, Dieye B, Sane O, Sarr OF (2014) Pour une agriculture intelligente face au changement climatique au Sénégal: Recueil de bonnes pratiques d'adaptation et d'atténuation. Document de travail no 85. Copenhagen, Denmark: Programme de Recherche du CGIAR sur le Changement Climatique, l'Agriculture et la Sécurité Alimentaire (CCAFS)

Ehrhart C, Twena M (2006) Climate change and poverty in Tanzania: realities and response options for CARE. Background report. CARE international poverty-climate change initiative. http://www.care.dk/multimedia/pdf/web_english/Climate%20Change%20and %20Poverty%20in%20Tanzania%20-%20Country%20Profile.pdf

Enfors E, Gordon L (2008) Dealing with drought: the challenge of using water system technologies to break dry-land poverty traps. Glob Environ Chang 18:607–616. https://doi.org/10.1016/j.gloenvcha.2008.07.006

FAO (2010) "Climate-smart" agriculture policies, practices and financing for food security, adaptation and mitigation. FAO, Rome

FAO (2013) Climate-smart agriculture: a sourcebook. Food and Agriculture Organization of the United Nations (FAO), Rome

FAO (2014) Success stories on CSA. Rome, Italy, FAO. http://www.fao.org/3/a-i3817e.pdf

FAO (2016) FAOSTAT Database, Food and Agriculture Organization of the United Nations

FAO (2017) Climate-smart agriculture guideline for the United Republic of Tanzania: a country–driven response to climate change, food and nutrition insecurity. Rome, Italy. http://www.fao.org/3/a-i7157e.pdf

Franzel S, Ndiaye A, Tata JS (2018) Senegal: in-depth assessment of extension and advisory services. In: Developing local extension capacity project. USAID, Washington, DC

GoK. (Government of the Republic of Kenya) (2017) Kenya climate-smart agriculture strategy-2017-2026. Ministry of Agriculture, Livestock, and Fisheries. Nairobi, Kenya. Retrieved from https://canafrica.com/wp-content/uploads/2017/05/MINISTRY-OF-AGRICULTURE-LIVESTOCK-AND-FISHERIES-3.pdf

Gwambene B, Saria JA, Jiwaji NT, Pauline NM, Msofe NK, Shija SMY (2015) Smallholder farmers' practices and understanding of climate change and climate-smart agriculture in the Southern Highlands of Tanzania. J Resour Dev Manag 13:37–47

Harris-Coble L (2016) Tanzania. Landscape analysis. Working document: United States Agency for International Development (USAID) and US Government Feed the Future project "Integrating Gender and Nutrition within Extension and Advisory Services"(INGENAES), p 30. https://www.agrilinks.org/sites/default/files/resource/files/ING%20Landscape%20Study%20%282016%29%20Tanzania%20-%20published%202016_05_10.pdf. Accessed 26 Dec 2018

IPCC (2007) In: Parry ML, Canziani OF, Palutikof JP, van der Linden PJ, Hanson CE (eds) Climate change 2007: impacts, adaptation and vulnerability. Contribution of Working Group II to the fourth assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, 976pp

IPCC (2013) Summary for policymakers. In: Stocker TF, Qin D, Plattner G-K, Tignor M, Allen SK, Boschung J, Nauels A, Xia Y, Bex V, Midgley PM (eds) Climate Change 2013: the physical science basis. Contribution of Working Group I to the fifth assessment report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge/New York

Kaaria S, Sanginga P, Njuki J, Delve R, Chitsike C, Best R (2007) Enabling rural innovation in Africa: an approach for empowering smallholder farmers to access market opportunities for improved livelihoods. In: Farmer first revisited conference, future agricultures consortium. Institute of Development Studies (IDS), Sussex

Kakota TV, Maonga BB, Synnevag G, Chonde C, Mainje M (2017) Harmonisation of extension messages on climate-smart agriculture in Malawi: do we speak with one voice, and to whom? J Agric Ext Rural Dev 9(11):255–261. https://doi.org/10.5897/JAERD2017.0905

Kangalawe RYM, Mung'ong'o CG, Mwakaje AG, Kalumanga E, Yanda PZ (2017) Climate change and variability impacts on agricultural production and livelihood systems in Western Tanzania. Clim Dev 9(3):202–216. https://doi.org/10.1080/17565529.2016.1146119

Khan A, Pervaiz U, Khan NM, Ahmad S, Nigar S (2009) The effectiveness of demonstration plots as extension method adopted by AKRSP for agricultural technology dissemination in District Chitral. Sarhad J Agric 25(2):313–320

Khatam A, Muhammad S, Chaudhry KM, Mann AA, Haq I, Amin H (2010) Strengths and weaknesses of farmers field schools approach as perceived by farmers. Sarhad J Agric 26(4):685–688

Khouma M, Jalloh A, Thomas TS, Nelson GC (2013) Senegal: In International Food Policy Research Institute (IFPRI). Discussion paper, pp 291–322

Kisusu R (2003) The impact of dairy and rice production in dairy-based and irrigated rice farming systems in Dodoma region. The Sokoine University of Agriculture

Lackstrom K, Kettle NP, Haywood B, Dow K (2014) Climate-sensitive decisions and time frames: a cross-sectoral analysis of information pathways in the Carolinas. Weather Clim Soc 6:238–252

Lopokoiyit MC, Onyango C, Kibett JK, Langat BK (2012) Human resource development in agriculture extension and advisory services in Kenya. The 8th Africa Farm Management Association (AFMA), Congress peer-reviewed papers. Moi University, Kenya

Lynagh S, Tall A, Jay A (2014) One size does not fit all: considering gender, equity, and power in climate information services. CCAFS. http://bit.ly/1Q3blaG

MAC (2000) The need for agricultural extension reform in Tanzania: review of the literature. Ministry of Agriculture and Cooperatives MAC-Extension facilitation unit, Dar es Salaam

Magombo TM, Kanthiti G, Phiri G, Kachulu M (2012) The incidence of indigenous, emerging and innovative climate change adaptation practices for smallholder farmers' livelihood security in Chikhwawa district, Southern Malawi. Working paper series no. 63. The African Technology Policy Studies Network. Nairobi, Kenya

Mandleni B, Anim FDK (2011) Climate change awareness and decision on adaptation measures by livestock farmers in South Africa. J Agric Sci 3(3):258–268. https://doi.org/10.5539/jas.v3n3p258

Mkisi RB (2014) The role of agricultural extension in smallholder farmer adaptation to climate change in Blantyre district, Malawi. Open access theses. 353. https://docs.lib.purdue.edu/open_access_theses/353

Mnenwa R, Maliti E (2010) A comparative analysis of poverty incidence in farming systems of Tanzania. Special paper 10/4 Dar-es-salaam: REPOA

Msuya CP, Annor-Frempong FK, Magheni MN, Agunga R, Igodan CO, Ndiaye A (2017) The role of agricultural extension in Africa's development: the importance of extension workers and the need for change. Int J Entomol Res 5(1):59–70. ISSN:2311-6110

Müller C, Cramer W, Hare WL, Lotze-Campen H (2011) Climate change risks for African agriculture. Proc Natl Acad Sci U S A 108:4313. https://doi.org/10.1073/pnas.1015078108

Mvuna JK (2010) Agricultural extension services delivery in Tanzania. In Kimaro WH, Mukandiwa L, Mario EZJ (eds) Towards improving agricultural extension service delivery in the SADC region. Proceedings of the workshop on information. Sharing among extension players in the SADC region, 26–28 July 2010, Dar es Salaam, Tanzania

Mwamakimbula AM (2014) Assessment of the factors impacting agricultural extension training programs in Tanzania: a descriptive study. Graduate theses and dissertations. 14227. http://lib.dr.iastate.edu/etd/14227

Nederlof ES, Pyburn R (2012) One finger cannot lift a rock: facilitating innovation platforms to trigger an institutional change in West Africa. Royal Tropical Institute, Amsterdam

Nhemachena C, Hassan R (2007) Micro-level analysis of farmers' adaptation to climate change in Southern Africa. IFPRI Discussion paper 00714 August 2007. International Food Policy Research Institute, Environment, and Production Technology Division

Nidumolu UB, Lubbers M, Kanellopoulos A, van Ittersum MK, Kadiyala DM, Sreenivas G (2016) Engaging farmers on climate risk through targeted integration of bioeconomic modeling and seasonal climate forecasts. Agric Syst 149:175–184

Nyanga PH, Johnsen FH, Aune JB, Kalinda TH (2011) Smallholder farmers' perceptions of climate change and conservation agriculture: evidence from Zambia. J Sustain Dev 4(4):73–85. http://tinyurl.com/nhokvkq

Nyasimi M, Kimeli P, Sayula G, Radeny M, Kinyangi J, Mungai C (2017) Adoption and dissemination pathways for climate-smart agriculture technologies and practices for climate-resilient livelihoods in Lushoto, Northeast Tanzania. Climate 5(63):1–22. https://doi.org/10.3390/cli5030063

Okunade E (2007) The effectiveness of extension teaching methods in acquiring knowledge, skill, and attitude by women farmers in Osun state. J Appl Sci Res 3(4):282–286

Okwu OJ (2011) Characterizing farmer users and nonusers of mass media as channels of agricultural information in Benue state, Nigeria. J Agric Food Inf 12(3–4):315–328

Oladele OI, Gitika MP, Ngari F, Shimeles A, Mamo G, Olorunfemi OD (2018) Adoption of agro-weather information sources for climate-smart agriculture among farmers in Embu and Ada'a districts of Kenya and Ethiopia. Inf Dev:1–16. https://doi.org/10.1177/0266666918779639

Ouedraogo I, Diouf NS, Ouédraogo M, Ndiaye O, Zougmoré R (2018) Closing the gap between climate information producers and users: assessment of needs and uptake in Senegal. Climate 6(13):1–16. https://doi.org/10.3390/cli6010013

Ozor N, Cynthia N (2011) The role of extension in agricultural adaptation to climate change in Enugu State, Nigeria. J Agric Ext Rural Dev 3(3):42–50

Partey ST, Zougmore RB, Ouedraogo M, Campbell BM (2018) Developing climate-smart agriculture to face climate variability in West Africa: challenges and lessons learnt. J Clean Prod 187:285–295

Roncoli C, Okoba B, Gathaara V, Ngugi J, Nganga T (2010) Adaptation to climate change for smallholder agriculture in Kenya: community-based perspectives from five districts. Report to the World Bank of the project. Adaptation of smallholder agriculture to climate change in Kenya
Rowhani P, Lobell DD, Linderman M, Ramankutty N (2011) Climate variability and crop production in Tanzania. Agric For Meteorol 151(4):449–460
Rupan R, Saravanan R, Suchiradipta B (2018) Climate-smart agriculture and advisory services: approaches and implication for future. MANAGE discussion paper 1, MANAGE- Centre for Agricultural Extension Innovations, Reforms and Agripreneurship (CAEIRA), National Institute of Agricultural Extension Management. Hyderabad, India
Rutatora DF, Mattee AZ (2001) Major agricultural extension providers in Tanzania. Afr Stud Monogr 22(4):155–173
Sala S, Rossi F, David S (2016) Supporting agricultural extension towards climate-smart agriculture: an overview of existing tools. Global Alliance for Climate Smart Agriculture (GASCA)/FAO, Italy
Sanga C, Mussa M, Tumbo S, Mlozi MRS, Muhiche L, Haug R (2014) On the development of the mobile-based agricultural extension system in Tanzania: a technological perspective. Int J Comput ICT Res 8(1):49–67. http://www.ijcir.org/volume8-issue1/article 5.pdf
Settle W, Soumaré M, Sarr M, Garba MH, Poisot AS (2014) Reducing pesticide risks to farming communities: cotton farmer field schools in Mali. Philos Trans R Soc Lond B Biol Sci 369:20120277
Silvestri S, Bryan E, Ringler C, Herrero M, Okob B (2012) Climate change perception and adaptation of agro-pastoral communities in Kenya. Reg Environ Chang 12:791–802. https://doi.org/10.1007/s10113-012-0293-6
Singh C, Daron J, Bazaz A, Ziervogel G, Spear D, Kituyi E (2017) The utility of weather and climate information for adaptation decision-making: current uses and prospects in Africa and India. Clim Dev 10(5):389–405. https://doi.org/10.1080/17565529.2017.1318744
Stefanovic JO, Yang H, Zhou Y, Kamali B, Ogalleh SA (2017) Adaptation to climate change: a case study of two agricultural systems from Kenya. Clim Dev:1–20. https://doi.org/10.1080/17565529.2017.141124
Stigter K, Winarto YT, Ofori E, Zuma-Netshiukhwi G, Nanja D, Walker S (2013) Extension agrometeorology as the answer to stakeholder realities: response farming and the consequences of climate change. Special issue on Agrometeorology: from scientific analysis to operational application. Atmosphere 4(3):237–253
Swanson BE (2010) Strengthening agricultural extension and advisory systems: procedures for assessing, transforming, and evaluating extension systems. Agriculture and rural development discussion paper 45. World Bank, Washington, DC
Taneja G, Pal BD, Joshi PK, Aggarwal PK, Tyagi NK (2014) Farmers' preferences for climate-smart agriculture: an assessment in the Indo-Gangetic Plain. IFPRI discussion paper 01337. International Food Policy Research Institute, Washington DC, USA
URT (2005) Singida region socio-economic profile. Second eds, printed with the cooperation of National Bureau of Statistics and Singida Regional Commissioner's office, United Republic of Tanzania
URT (2014) Agriculture climate resilience plan 2014–2019. Ministry of Agriculture. Livestock and Fisheries. United Republic of Tanzania, Dar-es-salaam
URT (2017) Climate-smart agriculture guideline. Ministry of Agriculture. Livestock and Fisheries. United Republic of Tanzania, Dar-es-salaam
Vaughan C, Dessai S (2014) Climate services for society: origins, institutional arrangements, and design elements for an evaluation framework. Climate Change 5:587–603. https://doi.org/10.1002/wcc.290
Veeraraghavan R, Yasodhar N, Toyama K (2009) Warana unwired: replacing PCs with mobile phones in a rural sugarcane cooperative. Inf Technol Int Dev 5(1):81–95

Venkatramanan V, Shah S (2019) Climate smart agriculture technologies for environmental management: the intersection of sustainability, resilience, wellbeing and development. In: Shah S et al (eds) Sustainable green technologies for environmental management. Springer, Singapore, pp 29–51. https://doi.org/10.1007/978-981-13-2772-8_2

Williams TO, Mul M, Cofie O, Kinyangi J, Zougmore R, Wamukoya G, Nyasimi M, Mapfumo P, Speranza CI, Amwata D, Frid-Nielsen S, Partey S, Girvetz E, Rosenstock T, Campbell BM (2015) Climate smart agriculture in the African context. Background paper. Feeding Africa conference, 21–23 October 2015. https://hdl.handle.net/10568/68944

World Bank (2007) World congress on communication for development: lessons, challenges and the way forward. The World Bank published jointly with the Food and Agriculture Organization of the United Nations and the Communications Initiative, Washington, DC

World Bank (2016) World development indicators. http://data.worldbank.org/indicator/NV.AGR.TOTL.ZS