Strategies for Extension and Advisory Services to Promote Climate Smart Agriculture Among Smallholder Farmers in Sub Saharan Africa

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Abstract
Africa is one of the most vulnerable and least adapted continent to climate change. The increasing climate variability as well as extreme weather events such as droughts or floods hit the economy hard, reduce food production, increase food prices, and contribute to an already vulnerable food security situation. This scenario is specifically extensive among small holder farmers in sub saharan Africa who typically work at a subsistence level with inadequate financial resources, access to infrastructure, information, and knowledge, further exposing them to climate and market-related risks. Even though a range of Climate Smart Agriculture (CSA) technologies including Sustainable Land Management (SLM) have been promoted, the rate of adoption is less than 30 percent. This is attributed to limited capacity in extension and advisory services to enhance CSA compliance. The objective of this paper is to share strategies for strengthening extension and advisory services to promote CSA among small holder farmers. These strategies were generated through undertaking bench marking exercise with National Agricultural Research Institutes through peer to peer learning and exchange of information and high-level policy dialogue. As a result, there was increased skills and knowledge of participants in different innovation areas, promoted knowledge sharing and exchange of innovations and technologies. The envisaged strategies to improve adoption included; (i) invest in strengthening institutions to promote mindset change among policy makers and communities regarding the benefits of promoting CSA innovations in value chains, (ii) provide appropriate incentives or instruments to enhance adoption of CSA (iii) improve and strengthen knowledge management and; (iv) invest in early warning systems, surveillance and forecasting.

Development of CSA innovations alone is not enough but using strategies to strengthen capacity to ensure wide spread adoption among small holder farmers is pertinent to enhance community resilience to climatic shocks.

Key words: Climate Change, extension and advisory services, knowledge management.

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1. Introduction

Climate-Smart Agriculture (CSA) reflects the motivation to advance the integration of agriculture development and climate responsiveness (Arun Khatri-Chhetri, et al., 2020). It aims to achieve food security and broader development goals under a changing climate and increasing food demand. CSA investments sustainably increase production and productivity, enhance resilience, and reduce or remove greenhouse gases (GHGs), and require planning to address trade-offs and synergies between productivity, adaptation, and mitigation (Ashango & Mesene., 2019).

Africa is one of the most vulnerable and least adapted countries to climate change. The increasing climate variability as well as extreme weather events such as droughts or floods hit the economy hard, reduce food production, increase food prices, and contribute to an already vulnerable food security situation. This scenario is specifically extensive among small holder farmers in Sub Saharan Africa who typically work at a subsistence level with inadequate financial resources, access to infrastructure, information, and knowledge, further exposing them to climate and market-related risks.

Even though a range of CSA technologies including Sustainable Land Management (SLM) have been promoted, the rate of adoption is less than 30 percent. This is attributed to limited capacity in extension and advisory services to enhance CSA compliance. There is need to support initiatives that promote extension and advisory services in CSA. Extension and advisory services can bridge the knowledge gap by providing clarity on CSA components and its relevant issues. They also play a vital role in helping farmers to cope with the diverse impacts of climate change by creating awareness by using appropriate tools to make them aware about different adaptation and mitigation strategies. (Raj & Garlapati, 2020).

Therefore; the purpose of this write up is to share strategies for improving adoption of CSA technologies and innovations.

2. Materials and Methods

Bench marking exercise

A bench marking exercise was conducted to address capacity gaps identified in a previously conducted Capacity Gaps Assessment (CGA) for ASARECA member countries. This exercise aimed at strengthening capacity, spur exchange of technologies and improve technical knowledge where participants have knowledge gaps. The benchmarking exercise was hosted in Uganda's National Agricultural Research Organization (NARO) physically and it involved country based presentations coupled with feedback session, field visits and peer to peer learning. The presentations and field visits were facilitated by scientists from NARO and Agromax Uganda Ltd (an agricultural private sector player.

The participants were key scientists from the National Agricultural Research Institutions (NARIs) from selected 8 ASARECA member countries of Burundi, Cameroon, Central African Republic, Democratic Republic of Congo, Eritrea, Republic of Congo, South Sudan, and Sudan. The exercise was held from 18 to 22 October 2021. The participants were taken through the different technologies and innovations developd using modern biotechnology in the biosciences laboratory at the National Crop Resources Research Institute (NaCCRI) as a team of scientists demostrated the processes of conventional and modern plant breeding. NaCRRI handles research on 10 of the 15 national priority commodities that NARO conducts research on. Some of the 10 commodities include cereals, legumes, root crops and horticultural crops. Participants visited the nutritional and bioanalytical laboratory where they were taken through diagnosis of food contaminants, physical and chemical inspection items. They were also taken through simple tests for food contaminants, trained in detection of illegal food additives and inferior food, inspection in food production, processing, and storage, diagnosis, and detection of plant diseases with emphasis on the available diagnostic tools in NaCRRI including Real Time Polymerase Chain Reaction (RTPCR), rapid whole genome sequencing, spectroscopy-based methods among others. They were taken through the traditional and modern methods of farming that have been developed in response to several agricultural challenges like climate change. Some of the advanced methods that are being used to grow plants and manage biotic and abiotic stresses were shared.

3. Results

3.1. Comparison of technologies and innovations

The technologies and innovations compared included; Biotechnology (biosafety & regulatory frame work), Integrated pest management, Livestock resources and agricultural mechanization.

A list of Genetically Modified (GM) crops that have been commercialized and the genetic traits that have been engineered into those crops was shared and participants were encouraged to embrace the technology. This involved comparison of technologies and innovations at the research institutes across different countries.

3.1.1. Biotechnology and innovations

The biotechnology and innovations observed and shared included; processes of conventional and modern plant breeding for crops like: cereals, legumes, root crops and horticultural crops, diagnosis of food contaminants, physical and chemical inspection items, detection of illegal food additives and inferior food, inspection in food production, processing, and storage, diagnosis, and detection of plant diseases with emphasis on the available diagnostic tools at NaCRRI including; Real Time Polymerase Chain Reaction (RTPCR), rapid whole genome sequencing, spectroscopy-based methods.

Participants were able to compare technologies and innovations across countries (Table. 1). As a result, some of the participants were able to request for sweet potato planting materials. For instance, participants from the Institute of Agricultural Research for Development (IRAD) requested for sweet potato planting materials and pasture seed (Bracharia spp) for testing in the moist Savanna zone of Cameroon.

3.1.2. Integrated Pest Management

Integrated Pest Management (IPM) is a multidisciplinary endeavour that goes beyond pest management and encompasses economics, agricultural engineering among other sectors. The first known pesticide was discovered in 2500 BC and over the years the practices have evolved however, the selection of a method depends on a comparison between cost and benefit.

It was noted that over the years NARO has developed several disease resistant varieties through conventional breeding. These varieties have been released to farmers. On the other hand, varieties developed through genetic engineering have not yet been distributed due to lack of an enabling policy environment. This scenario is not only in Uganda but also in other countries with the extreme that such varieties are not acceptable for example in Central African Republic (Table 1). Some of the technologies shared are being applied without use of pesticides include; pheromone traps, sanitation, cultural control and biological methods. It was noted that pheromone traps can be locally fabricated by the farmers with the only thing they need to buy being a 'lure' that attracts insects to the trap.

3.1.3 Agricultural Mechanization technologies and innovations

The broader areas of focus for mechanization included; (i) Farm Power and Mechanization systems (ii) Water harnessing and utilization (iii) Agro-processing engineering and farm structures (iv)Renewable energy systems. The key production Technologies highlighted include: (a) Farm Implements: Animal drawn inter-row weeder and power tiller mould boards plough (b). Small-scale Irrigation: treadle pump and NARORAMP, (c) Post-harvest Technologies: Maize motorized maize sheller, NARO hand cranked maize sheller Rice, NARO Lightweight Rice Thresher, Improved sun drying method for paddy livestock feed, motorized forage chopper, Cassava: food grade cassava chipper, cottage food processing- Fish NARO PAH-Safe Fish Smoking Kiln (NAROFIK).

Table 1: Comparison of technologies and innovations in Uganda and other countries

No.	Technologies	Technologies/innovations in Uganda	Technologies/ innovations in other countries

1.	Biotechnology (biosafety & regulatory framework)	No export of GM products because we do not have GM crops in farmers' fields. All GM crops are still only at the stage of research due to absence of an enabling law for commercial release.	Don't allow GMOs because of the associated high risk of loss of sovereignty e.g., Central African Republic
2.	Integrated Pest Management	The push pull system has a great effect on striga. It is multi-purpose in the sense that it helps in the maintenance of soil fertility, helps control pests, attracts natural enemies to pests, and when desmodium spp is included, it helps in the management of striga. This is also happening in other country other than Uganda Grafting has been used to address bacterial wilt in tomatoes in greenhouses.	Seasonal timing to control the fall armyworm by advising farmers to grow maize in the rainy seasons to control the armyworm is used in DRC
3.	**Agricultural mechanization of value chains**	Several technologies and innovations have been developed that can be replicated in different countries	Other countries were able to learn from the different technologies and are willing to replicate them in their respective counties

1. Discussion

Biotechnology, Integrated pest management and Agricultural Mechanization technologies and innovation

It is pertinent to recognize that biotechnology is important and that it is a tool that can contribute to development. There are different applications of biotechnology that are not necessarily GM technology that countries can take advantage of like tissue culture. However, some countries may realize that some cases can only be addressed through genetic engineering for example Uganda's case with cassava brown streak disease that can only be addressed by introducing resistance through genetic engineering. Countries must not lock down themselves against biotechnologies. They can only choose what applies to their situation and what does not apply. GMOs have largely been interpreted as to only apply to crops. However, there is a need to understand that genetic engineering has been applied to other fields as well like vaccine development for human diseases. It is therefore up to a country to weigh the benefits and cost of utilizing the various aspects of biotechnology. The importance of biotechnology in agriculture, environment and food processing cannot be underestimated in terms of contributing to CSA advancements (Target study, 2018).

Integrated Pest Management (IPM) technologies and innovations solve pest problems while minimizing risks to people and the environment. As the population in Africa continues to expand, utilizing an integrated approach to pest management will be critically important for food security, agricultural sustainability, and environmental protection (Anderson et al., 2019). Biological and cultural methods complement the integrated approach. However, despite the advantages in using IPM technologies and innovations for several crops, there are still challenges in disseminating and wide scale adoption of the proven methods.

Implements and powered machinery are important inputs to agriculture because they have a direct effect on land productivity, labour productivity and profitability of farming. Several technologies and innovations have been developed with some customized to countries. It is important to note that although mechanization increases agricultural productivity, this should be coupled with use of quality, disease resistant seed, fertilizers among other agro inputs (Clarke, 2019). The adoption of mechanized technology is hampered by limited extension and advisory services, limited funds to afford the technologies among others.

Mindset change among policy makers and communities regarding the benefits of promoting CSA

Change of mentality to support the diffusion of technologies that are implemented in CSA is a silent factor in attaining sustainable global development. It helps improve resilience to weather conditions, climate change adaptation and reduction in agricultural based greenhouse emissions (Fusco et tal, 2020)

Appropriate incentives or instruments to enhance adoption of CSA

Sain et al., (2017) studied CSA adoptation of maize and beans small holder farmers in Guatemala by using a cost-benefit analysis. The analysis covered mulching, agroforestry, crop rotation, contours, ponds and drip irrigation, pest- and disease-tolerant crop variety for frequency. The profitability indicators showed that least applied practices achived high return and lowest payback period. Whiel the two most popular practices also had positive financial outcomes, but their payback period is more than 8 years long. This highlights the importance of more complex analysis, e.g., considering non-financial issues such as adoption risks, labor intensity, and ecosystem services.

CSA adoption is difficulty to attain especially in areas whose topography is slope and may not allow conservation technologies like barriers since they deter production. On labour aspects field burning is more affordable than conservative agriculture and so farmers prefer techniques that save their time and cost (Hellin et al, 2019).

Mutenje et al. (2019) used cost benefit analysis to asess CSA practices in Malawi among farmers growing improved varieties, while conserving water and soil with cereal – legume mix. The blend of the CSA practices yielded the highest economic and environmental benefits for the farmers. Diversfication of the CSA practices improves the output for both profitability and environmental conservation. Combining Medium Soil Disturbance (MSD) with other CSA practices has produced positive outcomes too. They also highlighted the importance of accessibility and affordability of the different inputs (herbicides, fertilizers, and seeds) for small-scale farms. (Mizik, 2021)

Improve and strengthen knowledge management.

Sharing CSA knowledge and pracitces among African countries is pertinent in promoting uptake and scaling up of agricultural technologies. Production of targeted agricultural knowledge delivered through appropriate communication channels bridges the gap between generation and use of research information. Improving and strengthening knowledge management in Agriculture can be done through; (i) Improving access to available agricultural information, (ii) Improving the generation of new agricultural information content, (iii) Harmonising the strategies and the policy environment for agricultural information, (iv) Scaling up/out proven technologies, (v) Enhanced skills and capacities in ICT.

Invest in early warning systems, surveillance, and forecasting.

The use of climate and soil data for agricultural task planning can reduce the uncertainties caused by climate change, for example by developing early warning systems for extreme weather (e.g., drought and flood), as well as for pest and disease occurrence, thus increasing the ability of farmers to take early action, allocate resources effectively, and reduce associated risks (Adamides, 2020).

5. Conclusions

It is important that different countries identify adoptable and cost-effective technologies they have come across and transfer them to farmers in their countries. Technology and Innovation is meant to aid transfer of such identified technologies and knowledge across countries between scientists. Scientists ought to advocate for proper standards, policies, and regulations in their countries to enable easy transfer of knowledge and technologies with other countries. There are more tangible benefits when CSA information is shared through face-to-face interaction between farmers and scientists and other agricultural stakeholders.

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