Impact of Climate Smart Resilient Practices on Enhancing Sustainable Agricultural Productivity. Case study of Rice, Cocoa and Oil Palm Value Chains Development

by Jana Publication & Research

Impact of Climate Smart Resilient Practices on Enhancing Sustainable Agricultural Productivity. Case study of Rice, Cocoa and Oil Palm Value Chains Development

Abstract:
The goal of the study was to evaluate the impacts of agricultural productivity through climate smart agricultural practices for selected value chains (IVS-Rice, Cocoa and Oil Palm) in a bid to boost resilience and enhance livelihood opportunities for rural farmers in Bo District. The objectives were to determine the effectiveness of climate-smart agricultural practices in increasing crop yields and productivity, and identify barriers to the adoption of climate-smart practices among rural farmers. The study adopted a mixed method approach using both quantitative and qualitative research method approaches

The findings revealed that climate smart agriculture (CSA) practices led to improved yields across all value chains with cocoa and IVS rice farmers achieving higher yields (above 25%) compared to moderate gains (10-25%) among Oil Palm farmers.

The study concludes that Climate Smart Agricultural (CSA) practices have significantly enhanced agricultural productivity of farmers dealing with the IVS rice, cocoa, and oil palm value chains in Bo District.

Although farmers continue to face challenges such as financial constraints, limited training opportunities, uncertain weather conditions, and restricted access to inputs, the evidence demonstrates that CSA practices consistently improve yields, with rice and cocoa farmers recording the highest gains and adoption rates are encouraging.

Moreover, stakeholders acknowledge that CSA awareness is steadily increasing, particularly among younger male farmers, and that practices like intercropping are becoming more common.

Overall, the findings affirm that CSA is a viable pathway to strengthen resilience, boost rural livelihoods, and support sustainable agricultural development in the district, provided that financial, institutional, and policy support systems are strengthened to scale adoption.

Key Words: Value chain development, climate smart agriculture (CSA), climate change, crop yield, sustainable agriculture.

1. INTRODUCTION

Among the world's most pressing environmental issues is climate change. Coastal ecosystems, biodiversity, agriculture, water resources, and forests are all negatively impacted by climate change.

Although agriculture plays a significant role in the economy and the creation of jobs worldwide, especially in Sierra Leone, 20% of the population is food insecure (FAO, 2013). Global hunger and food insecurity have risen in the past few years following a lengthy period of decline. Approximately 75 per cent of the world's poor reside in rural areas and depend heavily on agriculture for their livelihood (Lipper et al. (2014),

Globally, agriculture sector generates 19–29 per cent of total greenhouse gas emissions (GHG) which is a crucial drawback to accomplish the ecological and climatic related sustainable development goals; particularly in the less developed and developing countries (Smith, 2014). Climate change is one of the foremost environmental challenges of the world. Climate change is related with various adverse impacts on agriculture, water resources, forest, biodiversity and coastal ecosystems (Balasubramanian, 2012).

Hence, to address this issue, priorities should be given to integrated climate-smart agriculture (CSA) initiatives for enhanced production, adaptation and resilience with reduced emissions through the farming system approach for addressing food and nutrition security in one dimension and climate vulnerabilities in another dimensions (Vincent, 2021). Moreover, several CSA initiatives and schemes in various developing countries increased agricultural productivity and build resilience on climate-change risks in smallholder farming systems (Victor, 2022). It is possible with the support of the innovative farmer leaders of the social systems for making a desirable social change through sustainable adoption of CSA practices in the respective social systems.

The climate-smart agriculture approach advocates incorporating climate change into the preparation and execution of sustainable agricultural strategies, thereby recognizing synergies and trade-offs inside the three pillars of CSA (food security, adaptation, and mitigation) in favour of climate change related decisions and policies (Nagothu et al., 2016). According to its definition, CSA strives to assist activities that increase food and nutrition security, therefore absorbing critical adaptation and mitigation strategies (Chandra et al., 2018). It offers enabled methods for evaluating the consequences of various technologies and practices, particularly national development and food safety goals under changing climate conditions. Furthermore, CSA incorporates environmentally friendly agricultural expertise and participatory community-driven approaches (Ongoma et al., 2017), with effective intensification as the fundamental of on-farm income and productivity, in addition to existing agricultural land protection strategies. CSA also emphasizes the adoption of low-income farming methods such as conservation agriculture, agroecology, ecosystem services, small-scale irrigation, aquaculture and agroforestry systems, soil/water conservation and nutrient management, integrated crops, livestock, landscape approaches, grassland and forestry management, best practices for reducing tillage and breeds, all in order to improve food productivity, adaptation, and mitigation measures.

The need for a more sustainable approach to agriculture has led to suggestions that agriculture is the key and holds enormous potential to contribute to any strategy to adapt to climate change and reduce emissions particularly in an African context (Garrity et al., 2010; Beddington et al., 2011).

1.1 Problem Analysis

Sierra Leone is among the 10% of countries most vulnerable to climate impacts globally (Notre Dame, 2019). Regional climate models predict increased temperatures and highly variable rainfall levels, both of which require adaptation in agriculture practices and production. Farmers face challenges of tragic crop failures, reduced agricultural productivity, increased hunger, malnutrition and diseases due to climate change related issues.

The declining agricultural productivity in Sierra Leone is worrisome and a real challenge for government with a population of approximately 8.61 million people to feed. Climate change affects agriculture in several ways, one of which is its direct impact on food production that is mainly affecting food security for its population.

Rice production and farmer livelihoods are especially vulnerable to changes in precipitation levels, given that rice is a staple food crop and grown mainly on smallholder farms under rain-fed conditions. This vulnerability is against a background of persistent rural poverty and impacts farmers who do not hold insurance to protect against severe weather events or possess resources to invest in irrigation and other agricultural technologies to adapt to varying rainfall levels. Climate impacts are also expected to increase incidence of pest and animal disease outbreaks that will need to be managed.

Extreme weather events are expected to increase. Warm spells will increase crop water requirements and constrain crop and livestock production in water-limited areas of the country. Increased high rainfall events will potentially lead to flooding. Rainfed agriculture, which dominates in the country, faces risk of crop and livestock losses that could significantly worsen already low levels of food security.

Water quality and availability are highly vulnerable to climate impacts, yet reliable access to clean water is essential for multiple uses, and shortages can exacerbate social vulnerability and poverty for parts of the population. Major water uses in Sierra Leone include domestic (drinking, cooking, hygiene), agriculture (irrigation), industrial (beer, spirits, soft drink, cooling, and waste disposal), and hydroelectric power production. Urban water resources are especially under strain, as rural migration to the capital of Freetown during and since the civil conflict has placed increased pressure on these resources. Shifting rainfall patterns have led to reduced flow of rivers and streams and decreased access to water, as well as a lower supply of energy that relies on water flow to meet cooling, lighting, and heating needs.

Despite the growing interest in CSA, there are significant gaps in research, especially in relation to region-specific practices, technological integration, and adaptation strategies. In many regions, particularly in developing countries, there is insufficient data on local climate patterns, soil health, and the socioeconomic factors that influence agricultural practices. Effective implementation of CSA requires not only knowledge dissemination but also ongoing support for farmers to adopt new practices. Many agricultural extension services, especially in low-income countries, lack the capacity to educate farmers about CSA practices or provide continuous support. Farmers' willingness to adopt CSA practices is influenced by social and cultural factors, such as traditional farming methods, community norms, and risk perception. Research that does not take into account these cultural dimensions can fail to engage local communities, resulting in resistance to new practices. The success of CSA depends heavily on supportive policies and regulatory frameworks. In many countries, there are policy gaps or weak governance structures around climate adaptation, agricultural development, and environmental protection.

1.2 Aim and Objectives of the Study

This study aims at contributing to the promotion of sustainable farming systems by identifying CSA best practices, barriers to adoption, and their socioeconomic impacts on farming communities in Bo District and Sierra Leone as a whole.

The following objectives are pertinent to this study: (a) To determine the effectiveness of climate-smart agricultural practices in increasing crop yields and productivity of rice, cacoa and oil palm. (b) To determine the effect of climate-smart agricultural practices on rural household income levels. (c) To identify barriers to the adoption of climate-smart practices amongst rural farmers. (d) To develop a scheme for enhancing the adoption and scaling of climate-smart agricultural practices.

2. LITERATURE REVIEW

Among the many issues that governments in Sub-Saharan Africa deal with are reducing poverty and enhancing food security. These governments must continuously choose between mitigating climate change, which calls for a reduction in some agricultural operations, and producing food, which produces large volumes of greenhouse gases (World Bank, 2011).

2.1 Crop yields and Productivity of Climate-Smart Agricultural practices

Agriculture is the primary source of income for the majority of smallholder farmers in Sierra Leone. To help people safeguard their livelihoods and guarantee their food security, it is essential to increase their resilience and adaptation capacity to climate change. The resilience of the household, or its ability to withstand the effects of and recover from a shock, is a key factor in determining its ability to deal with the effects of weather shocks and natural catastrophes brought on by the effects of climate change.

There is broad scientific agreement that extreme weather occurrences including droughts, strong rains, and high temperatures have an impact on agricultural production (Lesk et. al, 2016). According to the present climate change scenario, food output is predicted to decline by 1% to 5% every decade and crop yield is predicted to decline by 30 to 82% by the end of the twenty-first century (Hatfield et. el, 2011), and a 1–5% decline in food production is anticipated every ten years (Ramírez and Thornton, 2020). A popular tactic to boost agricultural yields in a changing environment, guarantee farmers' climate change resilience, and lower greenhouse gas emissions is climate-smart agriculture (CSA).

In order to maximize the advantages and encourage smallholder farmers to embrace CSA techniques, integrated CSA approaches have been promoted due to the intricate socioeconomic structure of agricultural systems in Sub-Saharan Africa. Based on this idea, the CGIAR Research Program on Climate Change, Agriculture, and Food Security (CCAFS) applied integrated CSA techniques in severely degraded areas in several developing nations (Tadesse et. al, 2021).

Farmers need to determine what, in light of their biophysical, agricultural, and socioeconomic circumstances, qualifies as climate-smart. The application of the CSA technique is therefore knowledge-intensive and may necessitate significant institutional support (Neufeldt et. al, 2013).

Pinto et. al, 2020 demonstrates that widespread adoption of CSA practices can increase production and lower world prices of wheat, maize, and rice under future unfavorable climatic conditions. These gains can be obtained while improving soil fertility and with a reduction in GHG emissions.

By reducing nutrient leaching and on-farm erosion, as well as grain losses from pest assaults, the use of cover crops is said to increase yields. For instance, Kaumbutho et al. (2007) demonstrated that the use of mucuna (velvet bean) as a cover crop enhanced maize output in Kenya from 1.2 to 1.8-2.0 t/ha. Pretty (2000) demonstrated that farmers who used mucuna cover crops achieved greater maize yields with less labor input for weeding (maize after mucuna yields 3–4 t/ha without nitrogen fertilizer application, comparable to yields typically obtained with recommended levels of fertilization at 130 kgN/ha). Crop rotation and intercropping that guarantee different nutrient uptake and use (for example, between nitrogen-fixing crops like groundnuts, beans, and cowpeas and crops like millet and sorghum) will improve soil fertility, lessen the need for chemical fertilizers, and enrich the nutrient supply for succeeding crops (Conant 2010), all of which will increase crop yields (Woodfine 2009). Because enhanced crop varieties have more seed diversity, it is anticipated that using them will raise average yields. Pretty (2000) demonstrated, for instance, that new tree (fruit) and crop (vegetable) varieties enhance yields in Ethiopia by 60%.2.2

2.2 Adoption and Scaling of Climate-Smart Agricultural Practices

In order to adapt agriculture to a changing climate, Climate-Smart Agriculture (CSA) is being actively pushed (FAO, 2013; Hansen et al., 2018; Nkonya et al., 2018).

Stress-adapted crop and livestock breeds, enhanced water management techniques (like small-scale irrigation), agroforestry and conservation agriculture, crop diversification, index-based insurance, integrated soil fertility management techniques (like mulching and rotations), and other methods are all included in the category of CSA (FAO, 2013).

Makate (2019) expressed that under growing climate stress, the benefits of different CSA techniques are a welcome development for agricultural advancement. However, widespread adoption of related practices is necessary for CSA to have a meaningful overall impact on society. The lack of proof or success stories on the viability of integrating the various CSA methodologies and technology into agricultural systems is one of the main reasons given in the developing literature for the low adoption rates (Aggarwal et al., 2018).

Scaling of agricultural innovations is also impacted by a number of variables, including donor dependency (the collapse of CSA efforts after donor financing stops), a lack of supportive legislation and policy strategies for CSA, and a weak institutional setup (such as extension systems). According to Steenwerth et al. (2014), an integrated strategy involving the interaction of research, technology, and decision-making with regional socioeconomic circumstances and cultures is necessary for the successful scaling of CSA.

According to Pacico and Fujisaka (2004), scaling agricultural innovations is less a scientific matter and more a management concern. In this way, managing projects to guarantee that benefits are maximized and that effects are equitable and sustainable is the focus of scaling agricultural innovations. Swallow et al. (2002) state that there are two common fallacies in the conceptualization of scale: the composition fallacy, which is essentially predicated on the idea that what benefits one person also benefits everyone, and the ecological fallacy, which presupposes that what works at one scale

Makate (2019) discussed various possible approaches/strategies for scaling CSA in smallholder farming inclusive of value chain development approach, innovation platform approach, social movement approach, climate smart village approach, cooperatives, market driven approaches, and other participatory approaches (i.e. community based scaling approaches).

3. RESEARCH METHODOLOGY

3.1 Description of the Study Area

The study was conducted at three communities (Njeikohun, Kambawama, Kalia) in Bo district in the Southern Region, which is the second most populated district in Sierra Leone based on the 2021 Mid-Term Population and Housing Census.

Figure 1: Map of Bo District showing study areas

3.2 Design of the Study

This study adopted a mixed method approach using both quantitative and qualitative research method approaches to evaluate the impacts of agricultural productivity through climate smart agricultural practices for selected value chains (IVS-rice, Cocoa and Oil Palm) among rural farmers in Bo District. The approach enables a comprehensive analysis, incorporating statistical data with insights from targeted respondents, whilst also exploring in-depth phenomena to understand and interpret the meanings, experiences, and perspectives of individuals and selected groups.

3.3 Sample Size and Sampling Technique

A representative sample of the population in the different communities was collected using stratified random sampling to capture diverse perspectives. The sampling method adopted for this study is the probability sampling method; a method in which participants of the research are selected based on criteria (for this purpose, rural farmers who are currently engaged in Climate-Smart Agricultural Practices in Njeikohun- Cocoa, Kambawama- IVS Rice and Kalia- Oil Palm).

A sample size of 110 respondents were selected for the quantitative aspect of the study as presented in Table 1. In the qualitative study, 10 participants (agricultural extension officers, and policymakers) within the Agricultural Sector in Bo District were selected.

Table1: Sample size distribution

No	Region/Province	District	Chiefdom	Community	Sample
1	Southern	Bo	Komboya	Njeikohun	35
2	Southern	Bo	Wonde	Kambawama	40
3	Southern	Bo	Kakua	Kalia	35
			Total		**110**

3.4 Data Collection Methods

Both quantitative and qualitative data collection methods were adopted for this study.

Quantitative Data Collection

A Questionnaire was developed and administered to the 110 respondents using Kobo Collect software.

Qualitative Data Collection

Structured interviews were conducted and insightful conversations held aimed at gathering in-depth information about the research topic. Key informants interviews were conducted during the field visit in the studied communities. 10 selected participants ranging from agricultural extension officers, master farmers, target beneficiaries of the intervention, community elders, traditional leaders, development partners and policymakers) were interviewed to gather diverse views on the research topic.

Data Analysis Techniques and Instrument

Quantitative data analysis was done using SPSS and MS Excel while the Qualitative data analysis adopted the thematic analysis method wherein themes and patterns identified in the data were interpreted and reported.

4. DISCUSSION OF RESULTS

4.1 Demography

Demographic information is relevant because it provides data regarding research participants and is necessary for the determination of whether the individuals in a particular study are a representative sample of the target population for generalization purposes. To understand the population dynamics of the participants identified for this research, demographic questions about age, gender, level of education attained and marital status were asked and the results interpreted.

4.1.1 Age

The survey result indicates that about 50% of the interviewed participants are within the age bracket of 35-44 years; highlighting that the majority of the participants are young adults. 28% of the participants account for youths who are within the age bracket of 25-34 years as presented in Figure 2.

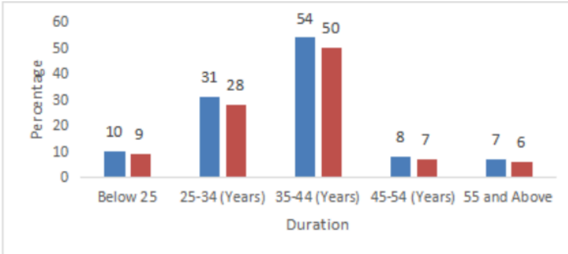

Figure 1: Age of participants

4.1.2 Gender

Since the technique adapted for this research involves probability sampling technique, both male and female participants were consented for participation in this study. The survey result indicates that about 57% of the interviewed participants are male, whilst 43% of the participants are female.

4.1.3 Level of Education

The survey result indicates that majority (36%) of the participants interviewed attained a secondary level of education, about 26% of the participants claimed that they attained a primary level of education and another 26% also affirmed that they had no formal education at the time of interview. About 11% of the participants interviewed mentioned that they attained Quranic education, and none of the participants indicated that they attained a tertiary level of education as shown in Figure 3.

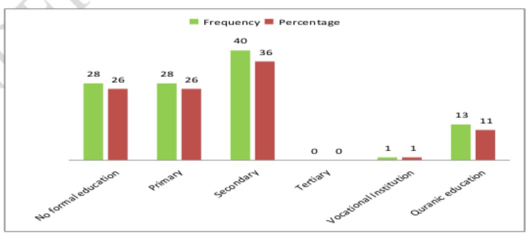

Figure 3: Level of education attained by participants

4.1.4 Marital Status

Figure 4 indicates that 88% of the participants interviewed stated that they are currently in a legally recognized marital union while 9% of the participants interviewed are single and 3% separated.

Figure 4: Marital status of participants

4.2 Climate Smart Agricultural Practices adopted by Farmers

The survey result indicates that 36% of the farmers interviewed practice IVS rice value chain while 32% each cocoa and oil palmvalue chains as indicated in Figure 4.

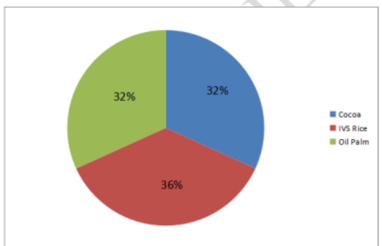

Figure 5: Value chain distribution of participants

An assessment on the climate-smart agricultural practices on the IVS rice, cacoa and oil palm value chains studied reveals that these value chains farmers practice organic farming, conservation tillage, crop rotation and mulching as an essential components of their climate-smart agriculture as presented in Figure 6. Furthermore, water harvesting techniques are only practiced by IVS rice farmers, whilst agroforestry is predominantly practiced by oil palm and cacoa farmers in Sierra Leone, More need to be done to encourage farmers to adopt improved irrigation systems, especially for IVS rice, and the use of drought resistant varieties for cacoa and oil palm value chain .The practice of integrated pest management is not common among cocoa farmers as evident from the results presented in Figure 6.

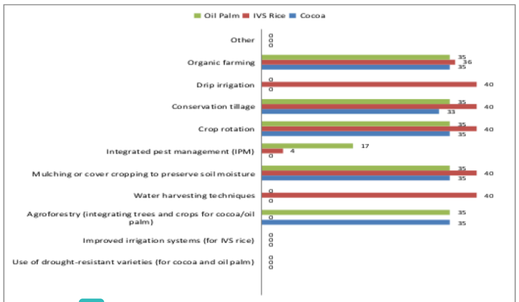

Figure 6: Climate-smart agricultural practices adopted by farmers

4.3 Source of CSA Knowledge and Practices

The study revealed that farmers obtained the climate smart agricultural (CSA) knowledge mainly from trainings provided by the Sierra Leone Government through the Ministry of Agriculture and Forestry and Food Security (MAFFS)'s extension services, non-governmental organizations (NGO) and colleague farmers as shown in Figure 7.

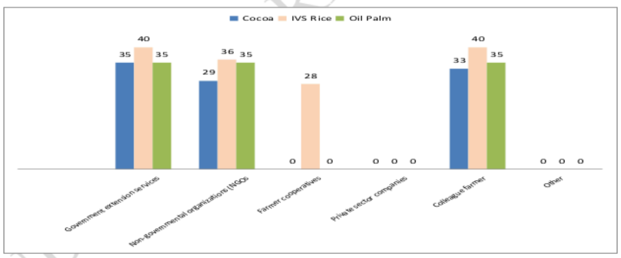

Figure 7: Farmers' source of CSA Knowledge and Practices

4.4 Training and Extension Services on CSA Practices

The study seeks to understand whether or not the targeted farmers have received any training or extension services on climate-smart agricultural practices for growing their crops.

The results presented in Figure 8 indicate that farmers of these three value chains investigated affirmed that they have all received training and extension services on climate-smart agricultural practices for growing their crops. This highlights both Governmental and Non-Governmental strides in ensuring that farmers in rural communities, especially female farmers, benefit from capacity building interventions that are critical to human capital index and national development.

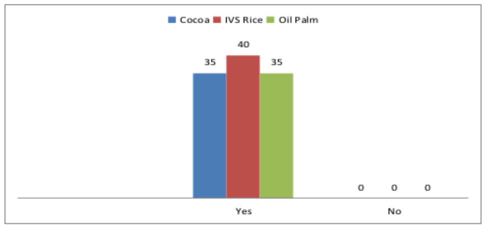

Figure 2: Status of farmers on CSA training and extension services

4.5 Environmental Challenges of CSA practices

The survey sought to understand the different types of environmental challenges that have impacted farmers who adopted the CSA practices within the last five years. Three key challenges faced by farmers in implementing climate-smart agriculture were identified namely flooding for the IVS rice, soil erosion and pest and diseases which adversely impact productivity of climate smart agriculture as revealed in Figure 9.

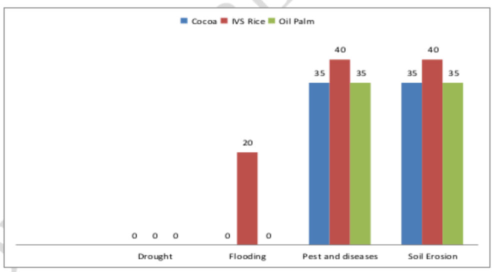

Figure 9: Environmental challenges faced by the three value chains farmers

4.6 Impact of CSA Adoption

The survey result indicates that each participant belonging to the different value chains indicated that they all observed improvements in crop yield after adopting climate smart agricultural practices. In terms of soil fertility, improvements were observed among participants belonging to the different value chains, except for four (4) participants belonging to the Cocoa value chain. The results show that water conservation technique is far more common amongst participants who engage in IVS rice farming system, as each of them observed improvements in water conservation than the other participants belonging to the Cocoa and Oil Palm value chains. In terms of resistance to pests and diseases, improvements were observed amongst participants belonging to the different value chains, except for seven (7) participants belonging to the Cocoa value chain. Also, improvements were observed amongst participants belonging to the different value chains in relation post-harvest losses except for five (5) participants belonging to the Cocoa value chain.

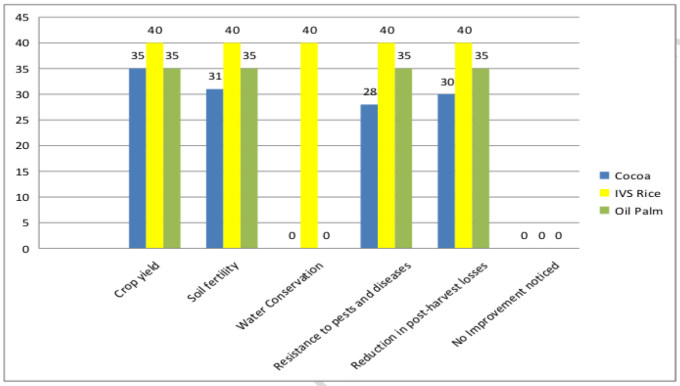

Figure 10: Impact of CSA adoption on farm productivity

Adoption of CSA in agriculture as played a significant role in increasing agricultural productivity of farmers of the three value chains investigated as presented in Figure 10. Key among the benefits identified in the study are increased in crop yield, improvement in soil fertility, resistance to pests and diseases and reduction in post harvest losses.

4.7 Improvement in Crop Yield

The survey results indicate that each participant belonging to the different value chains affirmed that they have all experienced improvement in crop yields of the various crops they grow as a result of adopting the techniques related to climate smart agricultural practices as presented in Figure 11.

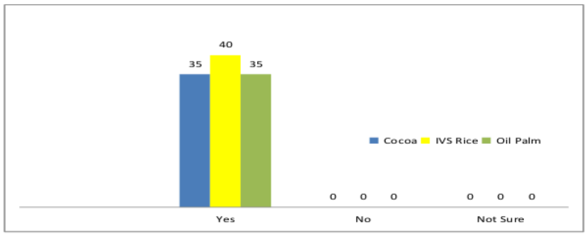

Figure 11: Participants responses on improvement of crop yield

Participants were asked to rate the percentage of increase observed in their various farms. Figure 12 presents the result of participants' responses.

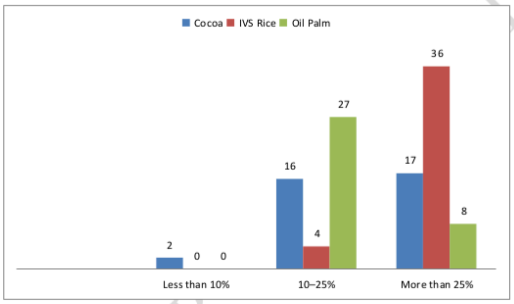

Figure 12: Statistics showing percentage increase in yield observed by participants

From these results, there is a significant increase in crop yields in all the three value chains investigated with the IVS rice value chain ranked the highest (>25%). This could be attributed to the effective and efficient utilization of key climate smart agricultural practices such as water conservation/irrigation, use of improved varieties that are resistant to pests and diseases, soil fertility and reduction in post harvest losses (Figure 10).

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The study concludes that Climate Smart Agricultural (CSA) practices have significantly enhanced agricultural productivity of farmers dealing with the IVS rice, cocoa, and oil palm value chains in Bo District.

Although farmers continue to face challenges such as financial constraints, limited training opportunities, uncertain weather conditions, and restricted access to inputs, the evidence demonstrates that CSA practices consistently improve yields, with rice and cocoa farmers recording the highest gains and adoption rates are encouraging.

Moreover, stakeholders acknowledge that CSA awareness is steadily increasing, particularly among younger male farmers, and that practices like intercropping are becoming more common.

Overall, the findings affirm that CSA is a viable pathway to strengthen resilience, boost rural livelihoods, and support sustainable agricultural development in the district, provided that financial, institutional, and policy support systems are strengthened to scale adoption.

5.2 Recommendation

From the results of this study the following recommendations could be made:

1. To expand financial access through affordable credit facilities, subsidies, and insurance schemes to ease adoption constraints.

2. Strengthening capacity building by scaling up extension services, training programs, and farmer demonstrations to address knowledge gaps.

3. It also highlights the need to promote localized climate and weather information services to help farmers adapt to unpredictable conditions and to support inclusive adoption by encouraging participation of women, youth, and marginalized groups through targeted interventions that reduce labour and cultural barriers.

4. To enhance market linkages, storage, and processing facilities to ensure that productivity gains translate into sustainable income for farmers.

5. There is the need to integrating CSA into district agricultural policies and institutional frameworks.

6. The concept of the CSA Scaling Framework, should be built around awareness, access to inputs, policy support, finance, market development, and monitoring and learning, in order to achieve sustainable and widespread adoption of CSA practices.

References

1. Balasubramanian, M. B. (2012): Climate Change and its impact on India. *The IUP Journal of Environmental Sciences*, 32-46.

2. Chandra, A. M. (2018): *Climate-Smart Agriculture: Perspectives and Framings*.

3. Climate Policy. Volume 18. DOI:10.1080/14693062.2017.1316968

4. Conant, R. (2010): Rebuilding resilience: Sustainable land management for climate mitigation and adaptation, Technical Report on Land and Climate Change for the Natural Resources Management and Environment Department.

5. FAO, F. a. (2013): Coping with the food and agriculture challenges: Smallholder's agenda. Preparations and outcomes of the 2012 United Nations Conference on Sustainable Development (Rio+20).

6. FAO, F. a. (2015): Smallholder productivity under climatic variability: adoption and impact of widely promoted,agricultural practices in Tanzania.

7. Garrity, D. A. (2010): Evergreen Agriculture: a robust approach to sustainble food security in Africa. Food Security. 2 (3): 197-214.

8. Hatfield, J., Boote, K., Kimball, B., Ziska, L., Izaurralde, R., Ort, D., . . . Wolfe, D. (2011). *Climate impacts on Agriculture: Implications for Crop production*. Agronomy Journal. Volume103, Issue2. https://doi.org/10.2134/agronj2010.0303.

9. Hine, R., & Pretty, J. (2008). Organic agriculture and food security in Africa. *United Nations Conference on Trade and Development (UNCTAD)*. Geneva and New York: United Nations Environment Programme (UNEP).

10. Lesk, C., Rowhani, P., & Ramankutty, N. (2016). *Influence of Extreme Weather disasters on global crop production*. *Nature*. Volume 529, pages 84–87

11. Lipper, L., Thornton, P., Campbell, B., Baedeker, T., Braimoh, A., Bwalya, M., Tibu, A. (2014): Climate-Smart Agriculture for Food Security. *Nature Climate Change*. https://openknowledge.fao.org/server/api/core/bitstreams/83ce8fff-f030-436e-aee3-b8d85ca4e492/content

12. Nagothu, S., & Kolberg, S. S. (2016): *Climate-smart agriculture. Is this the new paradigm of agricultural development?* DOI:10.1080/13549839.2024.2390467

13. Neufeldt H, J. M. (2013): *Beyond Climate-Smart Agriculture:toward safe operating spaces for globa food systems*. August, Agriculture & Food Security 2:12. DOI:10.1186/2048-7010-2-12.

14. Ongoma, V. C. (2017): *Projected Changes in Mean Rainfall and Temperature over East Africa based on CMIP5 models*. International Journal of Climatology 38(3):1375-1392. DOI:10.1002/joc.5252

15. Ramírez Villegas, J., & Thornton, P. (2020). *Climate Change Impacts on African Crop Production*. *Climate Change Impacts on African Crop Production*. Working Paper No. 119. CGIAR Research Program on Climate Change,

16. Smith, P., Bustamante, M., Ahammad, H., Clark, H., Elsiddig, E., Haberl, H., . . . House, J. (2014): *Agriculture, Forestry and Other Land Use (AFOLU)*. http://www.ipcc.ch/pdf/assessment-report/ar5/wg3/

17. World Bank, 2011: World development report 2011 : Conflict, Security, and Development.

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