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Research Article

Effects of Climate-Smart Agriculture on Smallholder Farmers in the Eastern Province of Zambia

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Abstract

Climate change is one of the distressful environmental challenges the world has been grappling with in recent times as it affects crop production, among other economic activities. The Eastern Province of Zambia has not been spared by crop failure resulting from climate-induced effects. As a result, the Zambia Integrated Forest Landscape Project (ZIFLP) implemented climate-smart agriculture (CSA) in the Eastern Province, from the first quarter of 2018 to the first quarter of 2024, which aimed to improve smallholder farmers' resilience to the effects of climate change on crop productivity. However, the effects of the CSA techniques on crop productivity were scientifically unclear. Therefore, this study used a mixed-methods approach to investigate the effects of CSA on crop productivity of the 106 smallholder farmers as questionnaire respondents and five District Agriculture Co-ordinators as key informants for interviews. The results revealed that all the respondents (100%) were aware of CSA in their communities, and about two-fifths (42%) of them, who formed the majority, practised crop rotation the most. Almost all the respondents (96%) viewed CSA as an important agricultural intervention in their communities in light of the adverse effects of climate change. Two-thirds (66%) of the respondents, who were the majority, acknowledge that the CSA techniques increased crop yield. The maize crop tonnage *Mean* $(M = 7.70)$ after the respondents' implementation of CSA was statistically significantly higher than the maize crop tonnage *Mean* $(M = 3.82)$ before the respondents implemented CSA, signifying that the respondents produced more tonnage of maize crops after they implemented CSA than before. The study concludes that CSA in the Eastern Province of Zambia is an intervention through which smallholder farmers were helped to enhance their crop productivity in light of the devastating effects of climate change. Therefore, the study recommends continuity of financial and technical support of CSA by the Zambian government or cooperating partners or both; refresher training for smallholder farmers in CSA; and improvement in the agricultural extension system.

Keywords

Smallholder Farmers, Climate Adaptation, Climate-Smart Agriculture, Climate Change

1. Introduction

Climate change is a global phenomenon that has adverse effects on various aspects of life including agriculture [1]. The agriculture sector is vulnerable to the effects of climate change, as it depends on weather patterns and temperature conditions. The International Panel on Climate Change (IPCC) has warned that the increase in temperature will lead to fre-

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quent and severe droughts, floods, and heatwaves, which will increase the risk of crop failure, reduction in crop yields and affect food security [1]. Climate change has become a major challenge for agriculture, worldwide, where smallholder farmers are the most vulnerable. According to the United Nations Development Programme (UNDP), climate change is expected to reduce crop yields in Africa by up to 30% by 2050 [2].

Africa is one of the continents in the world that has been severely affected by climate change, which presents with an increase in temperatures and changing precipitation patterns that affect economic sectors such as energy and agriculture [2]. Zambia is one of the countries in southern Africa whose agriculture sector has severely been hit by the effects of climate change such as rising temperatures and changing weather patterns resulting in drought, heatwaves and flooding [3]. The yearly drought, heatwaves and flooding, in Zambia, cause low crop yields, crop failures, crop pests, and plant diseases, among others [3]. Zambia's economy is heavily dependent on agriculture, which employs over 70% of the population and contributes about 20% to the country's Gross Domestic Product [4]. The agriculture sector is vulnerable to climate change due to its reliance on rain-fed crop farming and low adaptation capacity [3]. Zambia is a lower-middle-income country with an estimated 19.6 million inhabitants with the Eastern Province accounting for 12% [5]. The Eastern Province covers an area of approximately 51,476 km^2 and lies between the Luangwa River and borders Malawi to the east and Mozambique to the south [5].

The main economic activity of the Eastern Province of Zambia is agriculture. In an ideal weather condition, the Eastern Province receives about 800 – 1,000 millimetres of rainfall, which in most cases is evenly distributed throughout the crop growing season [6]. The plateau areas of the province, under normal circumstances, have productive soils that allow cultivation of maize, groundnuts, sorghum, and a range of cash crops including tobacco, sunflower, irrigated wheat, soybeans, rice, and horticultural crops [7]. Despite the agricultural potential of the Eastern Province, the province faces several agricultural challenges. In recent times, many challenges that constrain smallholder farmers' efforts to increase crop productivity are becoming evident every farming season. Crop failures resulting from climate-induced challenges such as dry spells, late onset of rains and the emergence of new crop pests have affected crop productivity [7]. For instance, the 2022 crop-focused survey report revealed that the crop yields for the most produced crops in the province which are maize and sunflower for the 2021/2022 rain season were 1.78 tons/ha and 0.53 tons/ha, respectively, which is below the expected yields of 5 to 10 tons/ha for Maize and 1.2 to 2.8 tons for sunflower [5].

In response to the devastating effects of climate change on the environment that affects agriculture, the Zambian government through the Ministry of Green Economy and Environment under the auspices of the World Bank launched the Zambia Integrated Forest Landscape Project (ZIFLP) in the fourth quarter of 2017 which came into effect in the first quarter of 2018. The project which ran for about seven years closed in the first quarter of 2024. The ZIFLP aimed to provide support to rural communities in the Eastern Province of Zambia to enable them to better manage their landscape resources, reduce deforestation, and curb unsustainable agricultural practices [2]. However, the interest of this study was on the aspect of curbing unsustainable agricultural practices. To curtail unsustainable agricultural practices in the wake of climate change, the ZIFLP implemented CSA targeting smallholder farmers in the Eastern Province of Zambia to help them embrace a host of techniques that sustainably increase crop production, improve resilience (adaptation), decrease greenhouse gas emissions (mitigation), and enhance household food security [8]. The CSA under the ZIFLP supported smallholder farmers to grow crops such as groundnuts, soya beans, maize, beans, sunflower, cassava, sorghum and cotton [8].

Although the ZIFLP is said to have helped to increase crop yields through the implementation of CSA practices, the effectiveness of the techniques in improving crop production and productivity for the smallholder farmers in the Eastern Province is not clear. There are very few empirical studies to support isolated testimonies from some smallholder farmers who practised CSA in the Eastern Province of Zambia. This necessitated this study to provide an independent picture of what was obtained on the ground through interaction with the smallholder farmers who practised CSA under the ZIFLP and the technocrats in the field of agriculture in the province. This study sought to investigate the effects of CSA techniques on smallholder farmers' agricultural productivity in the Eastern Province of Zambia targeting five districts namely; Chipata, Katete, Sinda, Petauke, and Nyimba. Specifically, the study sought to establish the categories of smallholder farmers that practised CSA; smallholder farmers' awareness of CSA; smallholder farmers' perceptions of CSA; and maize crop tonnage produced before and after smallholder farmers' participation in the implementation of CSA.

The study provides insights into the potential of implementing CSA practices in mitigating the effects of climate change on crop yields, enhancing food security, and promoting sustainable farming. The findings of the study have significant practical implications for the successful implementation of CSA, as they may contribute to policymaking and provide valuable information to the Zambian government and the Ministry of Green Economy and Environment, in particular. The recommendations from this study can inform policy decisions and guide the development of programmes that promote sustainable agricultural practices to improve the food security and livelihoods of rural communities. Furthermore, the study adds to the body of literature on the agricultural sector.

2. Literature Review and Theory

2.1. Climate-Smart Agriculture

CSA is a system that assists in guiding actions required to transform and reorient agricultural practices to support agricultural productivity in a changing climate [9]. It is a set of agricultural technologies which all together enhance productivity, boost resilience and lessen greenhouse gas emissions [10]. The CSA practices are designed to help farmers adapt to changing weather patterns; conserve soil and water resources; and reduce greenhouse gas emissions from agricultural activities [11].

Types of Climate-Smart Agricultural Practises

There are many forms of CSA practices of which the common ones are; cover crops, crop diversification, crop residue, crop rotation, intercropping, mulching, organic manure, and zero tillage. Each of the practices has a unique way of implementation and benefits to smallholder farmers. Below are summarised explanations of each of them.

1. Cover crops: these are plants planted to cover the soil rather than to be harvested. This technique helps to capture carbon dioxide into soils, by removing it from the atmosphere, making the soil healthier and crops more resilient to a changing climate [12].
2. Crop diversification: this involves growing more than one crop in a field, for instance, maize, groundnuts and sunflower [13]. Several studies have shown that crop diversification is strongly associated with increased agricultural income due to pest suppression, increased production and climate change buffing [3].
3. Crop residue: this is the materials left on cultivated land after the crop has been harvested. This technique aims to improve and increase soil quality and nutrition cycling, hence improving crop quality [14]. Crop residue reduces soil erosion, promotes moisture retaining, and mitigates soil temperatures among other benefits [14].
4. Crop rotation: this is a technique of growing different crops yearly. Crop rotation is a long-term soil management technique that adds value to the soil [15]. It refers to the sequence of crops grown in a specific field, including cash crops, cover crops and green manures [15]. Well-planned rotation schedules improve soil fertility and aid in pest management.
5. Intercropping: this is the practice of growing two or more crops in the same field during the same farming season [16]. This technique aims at bettering yields by repelling pests, reducing weeds, and increasing soil fertility to help save crops [16].
6. Mulching: this is the spreading of various covering materials on the surface of the soil to minimise moisture loss and weed population for the healthy growth of crops [17]. It helps to stop the growth of weeds while conserving soil moisture and reducing soil erosion.
7. Organic manure: this is a technique that helps to improve soil structure and water capacity with minimum leaching while reducing emissions of greenhouse gases and the need for synthetic fertilisers [18].
8. Zero tillage: this is a farming practice with little or no soil surface disturbance, apart from the disturbance during planting [19]. It reduces soil erosion and increases soil organic matter.

The CSA practices have been promoted for over two decades as a way to conserve soils and increase agricultural productivity in sub-Saharan Africa, including Zambia [7]. The CSA practices are pivotal to poverty reduction efforts since most rural households in sub-Saharan Africa depend on rain-fed agriculture [20]. These practices enable agricultural system managers to respond to climate change more effectively.

2.2. Review of Selected Studies on Climate-Smart Agriculture

In recent years, CSA has gained global attention, with many countries promoting it as a solution to the challenges posed by climate change. Below are a few selected studies on farmers' awareness and perceptions of CSA.

2.2.1. Studies on Farmers' Awareness of Climate-Smart Agriculture

In Africa, awareness of CSA has been increasing, with many countries developing policies and programmes to promote its adoption. A study in sub-Saharan Africa on CSA awareness found that awareness of CSA was high among farmers [9]. Further, some studies revealed that farmers in Kenya were aware of CSA practices that included conservation agriculture and water harvesting [9]. Some studies have established that several factors influence farmers' awareness of CSA adaptation strategies. A review of CSA practices in Ethiopia found that awareness of CSA was high among farmers in Ethiopia, with many farmers adopting practices such as crop rotation and adoption of improved crop varieties [21]. Similarly, a study in Malawi on CSA awareness revealed that farmers in Malawi were aware of CSA practices such as crop diversification, soil conservation, and rainwater harvesting [22].

In Zambia, awareness of CSA is relatively low, despite the country being vulnerable to the effects of climate change. According to a study by Arslan et al., (2015), most farmers in Zambia were not aware of CSA practices. The study found that about 32% of the surveyed farmers had heard of CSA, and less than 10% were implementing CSA practices [23]. There have been efforts by the Zambian government and non-governmental organisations to promote CSA awareness and adoption. For instance, the government developed the CSA framework to guide the implementation of CSA practices [24]. Additionally, non-governmental organisations such as World Vision have been implementing projects to promote CSA practices in Zambia [7]. The introduction of Zambia's national climate change learning strategy which followed the national climate change policy of 2016 has contributed to an increase in awareness of climate change and the integration of climate change learning into national priority sector policies and systems [13].

2.2.2. Studies on Smallholder Farmers' Perceptions of Climate-Smart Agriculture

Several studies have highlighted the positive perceptions of farmers towards CSA practices. For instance, a study conducted in the Eastern Province of Zambia found that farmers perceived CSA practices as beneficial in mitigating the effects of climate change on crop production [25]. Farmers acknowledged that CSA practices such as crop diversification, cover crops, crop residue, crop rotation, intercropping, mulching, zero tillage, and organic manure helped in improving soil health, increasing crop yields, and reducing the vulnerability of their crops to extreme weather events. Further, the study revealed that the majority of farmers who adopted CSA reported an increase in crop yields after practising CSA techniques [25]. The results are in line with a review study conducted in sub-Saharan Africa which highlighted similar perceptions. For instance, the study found that the majority of farmers perceived CSA practices as beneficial for enhancing productivity and increasing resilience to climate change [26]. The study also reported positive outcomes such as improved soil fertility, increased crop yields, and reduced vulnerability to drought and pests [26].

An assessment of perceptions towards CSA conducted in four Tanzanian Villages revealed that farmers perceived CSA practices as effective measures for climate-risk mitigation and adaptation [27]. These practices were associated with increased farm productivity, improved household income, and enhanced ecological sustainability [27]. Statistics from another study conducted by Umar and others in the Eastern Province of Zambia showed that farmers practising CSA techniques experienced a 20% increase in maize yields compared to conventional farming methods [25]. Similarly, other studies and the 2022 baseline report on CSA practices and adoption in Zambia reported that farmers who adopted CSA practices witnessed an average increase of 30% in crop yields, leading to a 25% rise in income [28].

While some studies reveal farmers' positive perceptions of CSA, it is important to acknowledge the negative perceptions and challenges that farmers may have towards CSA practices. A study conducted in the Eastern Province of Zambia identified some of the negative perceptions of CSA expressed by farmers [25] in the province. From the study, there was a common concern about the initial investment required to adopt CSA practices. Farmers perceived the upfront costs of implementing CSA technologies and acquiring necessary inputs as barriers to adopting CSA [25]. The study also revealed that limited access to credit and financial resources further compounded these challenges. Additionally, some farmers expressed scepticism about the effectiveness of CSA practices, particularly due to a lack of long-term evidence or success stories in their local context [25]. Additionally, a study conducted to explore farmers' perceptions of CSA practices in the Eastern Province of Zambia revealed some farmers' scepticism about the effectiveness of CSA citing inconsistent rainfall patterns and inadequate technical support as barriers to the successful implementation of CSA in the province [25]. Lack of information and training opportunities also contributed to negative perceptions, as farmers felt uncertain about the potential benefits of CSA practices [25].

Generally, in as much as there are some negative perceptions of CSA practices by some smallholder farmers as revealed by some studies, the benefits of practising them outweigh the negative perceptions.

2.3. Theory

This study used the theory of social-ecological resilience. This theory suggests that social and ecological systems are interdependent and that resilience is needed to sustain them in the face of climate change [29]. A social and ecological system is a coherent system of biophysical and social factors that regularly interact in a resilient and sustained manner [29]. These systems are linked systems of people and nature, emphasising that humans must be seen as a part of, not apart from, nature [29]. The theory emphasises the importance of taking an adaptive and collaborative approach to managing both social and ecological systems. This involves collaboration across sectors and requires input from stakeholders in a participatory approach. It also highlights the need to consider various stakeholders involved in the system and how they interact to identify and address key challenges [29]. The social-ecological resilience theory helped this study, to understand the complexities of smallholder farmers and their ability to adapt and thrive in the face of climate and social change. It provided a holistic way of looking at the interactions between different elements such as smallholder farmers, project implementers, extension workers and the government on one hand, and the resilience of ecological systems to external shocks, on the other hand.

3. Methods

3.1. Study Area

The Eastern Province, which is one of Zambia's ten provinces, is the area where the study was conducted. The Eastern province covers an area of approximately 51,476 km ^{2} and has a population of about 2.4 million people [5]. It lies between the Luangwa River and borders Malawi to the east and Mozambique to the south. The Eastern Province was chosen for this study because agriculture, which is threatened by the effects of climate change, is the economic mainstay of the province, and that is where the Zambia Integrated Forest

Landscape Project (ZIFLP) implemented CSA to enhance smallholder farmers' crop productivity.

3.2. Research Design and Sampling

A mixed-methods design was used to systematically collect the data and present it descriptively to give a clear picture of the effects of CSA on the sampled smallholder farmers. The study opted for a mixed-methods design because it allowed the collection of information by interviewing and administering a questionnaire to selected samples [30]. Non-probability sampling, employing a purposive technique, was used to select districts in Eastern Province namely; Chipata; Katete; Sinda; Petauke; and Nyimba, as areas of study because of their proximity to the Great East Road and easy accessibility to the agricultural camps. This sampling technique was relevant for selecting the districts in Eastern Province as well as selecting the five District Agricultural Coordinators as key informants in their respective districts because it allowed purposeful sampling [31]. The study purposely selected 106 smallholder lead farmers in CSA, as questionnaire respondents, from the 53 agriculture camps (two per camp) that were selected using a 50 percent of 106 agriculture camps across the five districts as shown in Table 1.

Table 1. *Samples and sampling criteria.*

S/n	Districts sampled	Key informants (DACOs)	Total agri. camps	Agric-camps sampled	Agric-camps reached out	Total lead farmers per district
1	Chipata	1	18	9	9	18
2	Katete	1	24	12	12	24
3	Sinda	1	16	8	8	16
4	Petauke	1	26	13	13	26
5	Nyimba	1	22	11	11	22
Total		5	106	53	53	106

Source: Survey results
Notes: DACOs = District Agriculture Coordinators

3.3. Data-Gathering and Analysis

The researcher-administered questionnaire was used to gather quantitative and qualitative data from the 106 smallholder farmers (Appendix I). This type of questionnaire was used because of the relatively high illiteracy levels in the rural communities of the five sampled districts of Eastern Province, while an interview guide was used to collect information from the five District Agriculture Coordinators as key informants (Appendix II). The key informants were purposely selected because of them being in charge of agriculture in their respective districts.

Quantitative data was analysed using the Statistical Package for Social Sciences version 20 software which enabled computations of a wide range of descriptive data in the form of frequency distributions, percentages, arithmetic mean, and standard deviations for various variables/thematic areas of interest. Qualitative data was analysed using a content analysis model through the development of a classification system which assisted in generating categorical variables and themes that were subjected to analysis using Statistical Package for Social Sciences software (Flick, 2014).

4. Results and Discussions

4.1. Biographic and Demographic Data

In a bid to understand the human characteristics of smallholder farmers who participated in implementing CSA under the auspices of the Zambia Integrated Forest Landscape Project in the Eastern Province, the study analysed data on the following variables 1) Sex and age range; and 2) education levels of the respondents.

4.1.1. Sex and Age Group of the Respondents

Slightly more than half (54%) of the respondents were males, while 46% were females (Table 2). It was, also, established that about half (51%) representing 54 respondents broken down as 28 males and 26 females fell in the age group of 35 to 49 years, while the minority (7%) fell in the age group of 65 years and above (Table 2). These findings were supported by the interview outcomes with key informants who comprised five key agriculture staff drawn from the five districts. The majority of four out of the five key informants interviewed explained that the male smallholder farmers who participated in the implementation of CSA in the Eastern Province of Zambia were slightly more than the females.

Table 2. *Sex and age group cross-tabulation.*

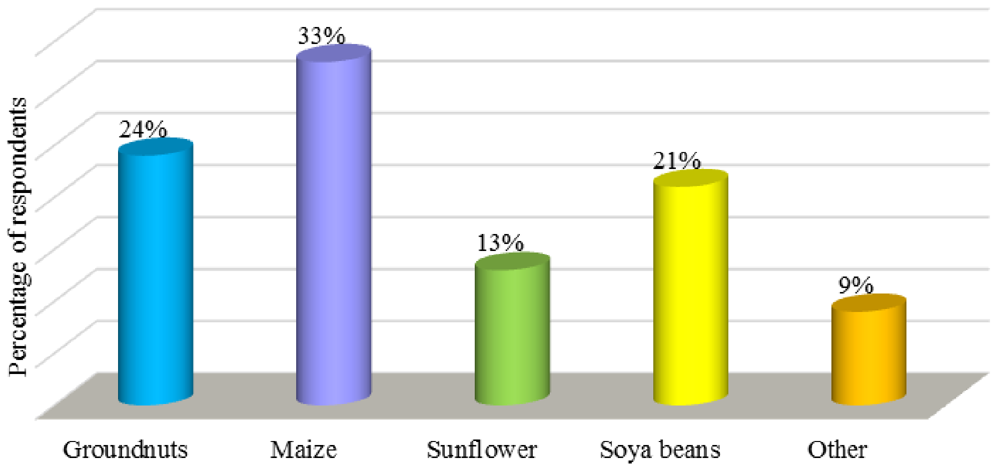
	Age range (years)	Sex of respondents				Total	
		Male		Female			
		n	%	n	%	n	%
Age of respondents	18 to 34	10	10	10	10	20	20
	35 to 49	28	26	26	25	54	51
	50 to 64	18	16	6	6	24	22
	65 & above	2	2	6	5	8	7
Total		58	54	48	46	106	100

Source: Survey result
Notes: n = Number of respondents

With about half (51%) of the smallholder farmers who participated in this study falling within the age group of 35 to 49 years and the minority (7%) in the age group of 65 years, it can be argued that the former age group was energetic enough while the latter had diminishing strength and energy to implement the CSA practices. The finding agrees with the argument that the active population that can work tirelessly and withstand harsh conditions in most rural communities in sub-Saharan Africa are young adults [32]. The age group of 50 to 64 years came second in terms of percentage points, meaning that in this age group, strength and energy were progressively declining. This reasoning resonates with the argument that, in agricultural production, the productivity of smallholder farmers improves and then declines with advancing age in communities that have not adopted high farm mechanisation [25].

4.1.2. Education Levels of the Respondents

Educational levels were considered in this study because they influence smallholder farmers' farming activities. The study established that two-fifths (41%) of the respondents did not go beyond primary education, and a quarter (25%) never had any formal education, while those who received tertiary education were the minority (7%) as shown in Figure 1. Therefore, the results show low literacy levels among respondent smallholder farmers.



Source: Survey result

Figure 1. *Respondents' educational levels.*

Education is one of the resources that smallholder farmers use to fulfil their livelihood strategies. Household members combine their skills, knowledge and capabilities with the different resources at their disposal to undertake agricultural activities to realise their most favourable livelihood. With little or no education, smallholder farmers can hardly comprehend the latest agricultural technologies thereby increasing the resistance to adopting the latest technologies such as CSA. Resistance to new agricultural technologies can reduce agricultural productivity in the wake of climate change. A study conducted in Tanzania that used food consumption as an indicator of food security to establish factors influencing household food security discovered that households with family heads with higher education levels had improved crop productivity than those without or with lower education levels [33].

Therefore, education levels have effects on agricultural production and productivity and ultimately household food security. The livelihood strategies and food security linkages component of the Sustainable Livelihood Framework support this conclusion, and further add that rural households' livelihoods depend on various factors, such as levels of education and local knowledge [34]. This is the reason that, even within the same locality, there are differences in household crop productivity because of variances in educational levels.

4.2. Respondents' Awareness of CSA

The study sought to establish respondents' awareness of CSA, the type of CSA technique most practised, and the frequency of receipt of sensitisation information on CSA.

All the respondents (100%) were aware of CSA in their localities and understood what it was all about (Table 3). Further, about two-fifths (42%) of the respondents, who were the majority, practised the crop rotation technique, while closer to a third (28%) practised the organic manure technique. Less than a fifth (13%) of the respondents, who were the minority, practised the minimum tillage technique.

Table 3. *Respondents' awareness of CSA.*

s/n	Variable characteristics	CSA beneficiaries	
		n = 106	**(%)**
	Awareness of CSA		
1	Yes	106	100
	Total	106	100
	CSA technique mostly practised		
2	Crop rotation	44	42
	Organic manure	30	28
	Mulching	18	17
	Minimum tillage	14	13
	Total	106	100

Source: Survey result
Notes: CSA = Climate-Smart Agriculture n = Number of respondents

Farmers' awareness of agricultural projects/programmes being implemented in their communities is important to increase enthusiasm and stimulate self-mobilisation and action. It allows farmers to understand things from multiple perspectives and frees them from their assumptions and biases [25]. Awareness of projects/programmes also helps farmers build better relationships and gives them a greater ability to regulate their emotions. Therefore, the study established that smallholder farmers in the Eastern Province of Zambia were aware of CSA techniques, and the majority of them practised crop rotation (Table 3).

The finding mentioned above is contrary to the results of the study conducted in Zambia, whose findings showed relatively low levels of awareness of CSA despite the country being vulnerable to climate change [23]. The study found that only 32% of the surveyed farmers had heard of CSA, and less than 10% were implementing CSA [23]. On the contrary, the findings of this study agree with several results of the studies conducted in other African countries, such as Ethiopia and Malawi, whose results showed that awareness of CSA was high among farmers. In Ethiopia, for instance, the study found that awareness of CSA was high among farmers, with many of them practising crop rotation and adopting improved crop varieties [21]. Similarly, a study in Malawi revealed that farmers were aware of CSA practices such as crop diversification and soil conservation, among others [22].

4.3. Smallholder farmers' Perceptions of CSA

Smallholder farmers' perceptions of the importance of CSA and the benefits of practising it were sought from the respondents.

4.3.1. Respondents' Views on the Importance of CSA

Almost all the respondents (96%) explained that CSA practices were important to implement in their communities because they enhance crop production and productivity in light of the adverse effects of climate change on the agriculture sector, while very few (4%) viewed it as unimportant because they did not see any benefits from it as shown in Table 4.

Table 4. *Respondents' views on the importance of CSA.*

s/n	Variable characteristics	Respondents n = 106	(%)
1	Beneficiaries' views on CSA		
	Not important	4	4
	Important	102	96
	Total	106	100
2	Do CSA techniques increase crop yield?		
	Strongly agree	70	66
	Agree	24	23
	Neutral	8	7
	Disagree	2	2
	Strongly disagree	2	2
	Total	106	100

Source: Survey results
Notes: CSA = Climate-Smart Agriculture n = Number of respondents

Therefore, the study established that the majority of the respondents appreciated the importance of practising CSA implemented by the Ministry of Green Economy and Environment under the Zambia Integrated Forest Landscape Project supported by the World Bank in the Eastern Province of Zambia. This finding is supported by the study conducted in Ghana, Kenya, and Tanzania on the assessment of perceptions of farmers towards CSA which revealed that farmers perceived CSA practices as effective measures for climate risk mitigation and adaptation [27]. According to the studies mentioned above, CSA practices were associated with increased farm productivity, improved household income, and enhanced ecological sustainability [27].

Further, the respondents were asked to indicate, on a scale of agreement and disagreement intensity, if the CSA techniques espoused under the project increased crop yields on crops supported by the project. Two-thirds (66%) of the respondents, who were the majority, strongly agreed that CSA techniques increased crop yield, and about one-fifth (23%) merely agreed, while very few (2%) strongly disagreed (Table 4). The study, therefore, established that CSA contributed to the enhancement of crop productivity of smallholder farmers in the Eastern Province of Zambia. This finding agrees with the study conducted in the Eastern Province of Zambia on the perceptions of farmers towards CSA, whose results revealed that farmers acknowledged that CSA practices such as crop rotation, crop diversification and intercropping increased crop yields and reduced the vulnerability of their crops to extreme weather events [25].

4.3.2. Respondents' Views on the Benefits of Implementing CSA Techniques

Three-fifths (61%) of the respondents said that the CSA techniques which were implemented in their respective localities helped in increasing crop yields, while slightly less than one-fifth (17%) said they helped in improving soil fertility (Figure 2).

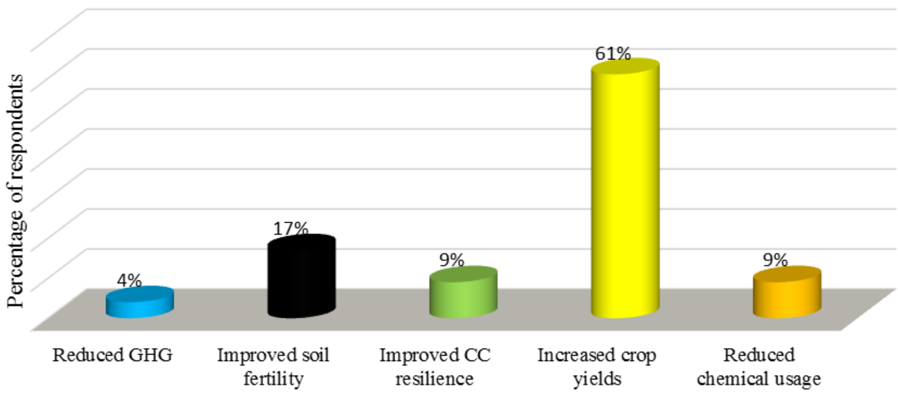


Figure 2. *Respondents' views on the benefits of CSA practices.*

Source: Survey result
Notes: GHG = Greenhouse gas CC=Climate Change
CSA= Climate-Smart Agriculture

Two groups of less than one-fifth (9%) mentioned that CSA techniques contributed to improved climate change resilience and reduction in the use of chemical fertiliser and pesticides, respectively, while the minority (4%) mentioned the reduction in greenhouse gas emissions as a major benefit (Figure 2).

Therefore, increased crop production and productivity were found to be the major benefit derived from the effective implementation of CSA techniques by the majority of smallholder farmers in the Eastern Province of Zambia. The finding is in line with the study conducted in multiple African countries, including Zambia, which found that the majority of farmers perceived CSA practices as beneficial for enhancing crop productivity, increasing resilience to climate change, and improving household food security [26].

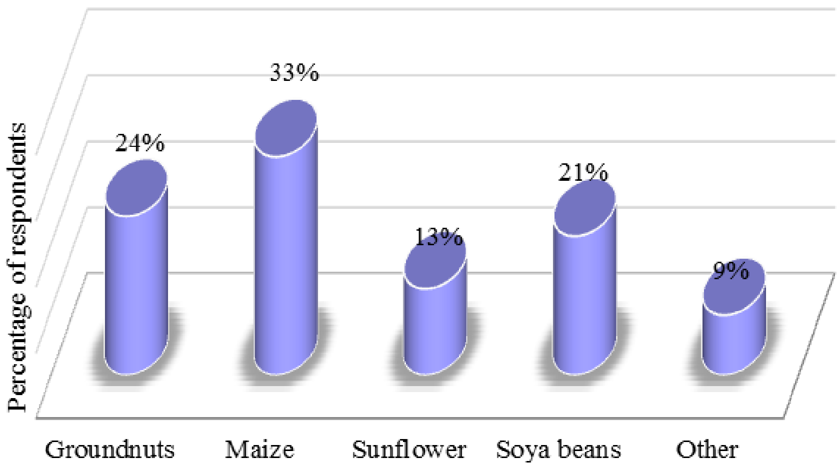
4.4. Effects of CSA Techniques on Crop Yields

To establish the effects of CSA practices on crop productivity, the study solicited information from the respondents on the following; crops that were mostly grown, number of years of implementing CSA versus farm size, maize crop tonnage produced before and after the implementation of CSA, and income realised from sales of crops grown.

4.4.1. Crops Grown by Respondents Under CSA

One-third (33%) of the respondents grew maize crops, while about a quarter (24%) cultivated groundnuts (Figure 3). Others, less than one-fifth (21% and 13%) grew soya beans and sunflower, respectively, with the minority (9%) cultivating other crops such as cassava, beans, sorghum and cotton (Figure 3). Therefore, the majority of the respondents grew maize crops under CSA. This finding is supported by the outcome of the interview with one of the technocrats who appreciated the project for the support to smallholder farmers in the province to grow maize crops which is a staple food crop. The interviewee explained:

"Since Eastern Province is predominantly a smallholder farming region with farmers growing maize crop as a staple food crop, we commend the project for including maize crop under the CSA technological initiatives to cushion the effects of climate variabilities."



Source: Survey results

Figure 3. *Most grown crops under CSA.*

The findings on the most grown crop in Eastern Province that points at maize crop in this study are supported by the outcome of the Crop Focussed Survey Report for the 2021/2022 farming season which singled out maize crop and sunflower as major crops grown in Eastern Province with the estimation of 1.78 tons per hectare and 0.53 tons per hectare, respectively [5].

Further, when respondents were asked about the period they practised CSA techniques and their farm size, it was established that two-fifths (40%) of the respondents practised CSA techniques for 6 years and above, while slightly over one-third (36%) of them had been practising CSA for the period spanning 4 to 5 years as shown in Table 5. Very few (4%) respondents practised CSA for less than a year (Table 5). It was, also, established that about two-fifths (39%), who formed the majority cultivated between 4 to 5 acres of land to grow crops under CSA, and a third (33%), second topmost, cultivated between 1 to 3 acres of land, while those that cultivated 9 acres and above were the minority at 6% as indicated in Table 5). These results imply that the majority of the respondents cultivated reasonably big amounts of land to warrant high crop productivity. The results confirm the argument that, depending on agro-climatic conditions, smallholder farmers would farm between three to six acres [35]. With favourable weather conditions and adherence to good farming practices, the smallholder farmers cultivating big amounts of land were likely to increase their yields compared to those cultivating small amounts of land [35].

Table 5. *Respondents' years of practising CSA versus farm.*

	Years of practising CSA	Farm size (Acres) 1 to 3		4 to 5		6 to 8		= > 9		Total	
		n	%	n	%	n	%	n	%	n	%
Period of practising CSA	< a year	0	0	0	0	4	4	0	0	4	4
	1 to 3	8	7	10	9	2	2	2	2	22	20
	4 to 5	14	13	14	13	6	6	4	4	38	36
	= > 6	14	13	18	17	10	10	0	0	42	40
Total		36	33	42	39	22	22	6	6	106	100

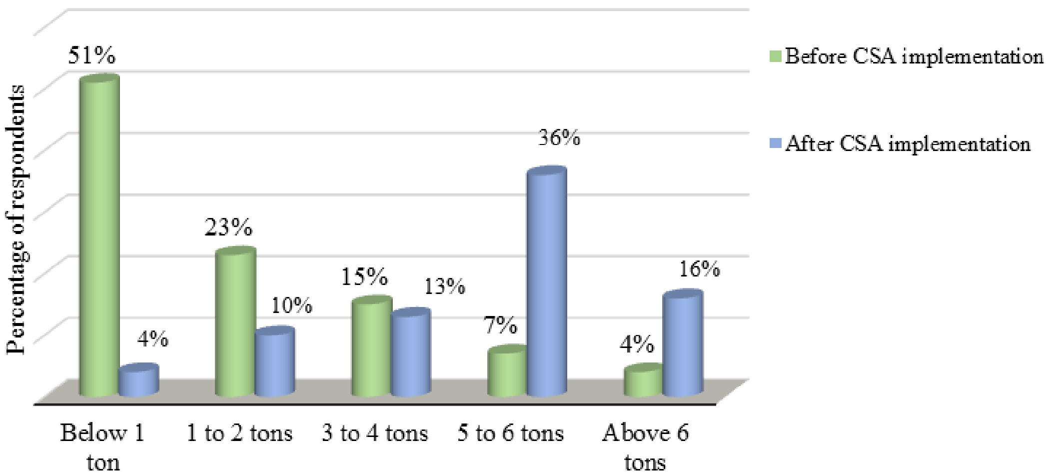
Source: Survey result

The aforesaid argument is supported by a study conducted in sub-Saharan Africa which revealed that the size of the farm is a determining factor of productivity [36]. The correlation in the above study is that an increase in farm size increases the likelihood of farming households to enhance crop productivity. On the contrary, the investigation into the connection between farm size and productivity in Ethiopia established a contrary negative correlation between farm size and yield per hectare [37].

4.4.2. Maize Crop Tonnage Produced by Respondents Before and After Implementation of CSA

For the past three farming seasons reviewed, the study sought to compare the average tonnage of maize crops produced by the respondents before and after implementing CSA. Among the crops supported under CSA, the study focussed on maize crop production because it is the staple food in the Eastern Province of Zambia.

Slightly over half (51%) of the respondents produced an average of less than one ton of maize crop before they started practising CSA compared to 4% who produced the same tonnage of maize crop after they implemented CSA (Figure 4). However, after they commenced implementing CSA, over a third (36%) of the respondents produced an average maize crop of between 5 to 6 tons compared to 7% who produced the same tonnage maize crop before they commenced implementing CSA (Figure 4). The above results show that the respondents yielded more tonnage of maize crops after practising CSA than before. This implies that the implementation of CSA significantly contributed to high maize crop productivity which ultimately increased maize crop tonnage realised after the respondents practised CSA.



Source: Survey result

Figure 4. *Maize crop tonnage produced: before and after CSA.*

To confirm the results generated from the analysis of the data portrayed in Figure 4 above which suggest that CSA significantly contributed to increased tonnage of maize crop produced by the respondents, a paired samples *t*-test was conducted focussing on the period before and after respondents' implementation of CSA by comparing the *Mean* tonnage as shown in Table 6.

Table 6. *Maize crop tonnage produced before and after respondents' implementation of CSA.*

	Period of maize Crop tonnage production	Mean	N	Std. Deviation	Std. Error Mean
Pair 1	before CSA	3.82	106	2.126	.292
	after CSA	7.70	106	2.296	.316

Source: Survey result
Notes: CSA = Climate-smart agriculture N = Number of respondents Std. = Standard

The paired samples *t*-test in Table 6 reveals that the maize crop tonnage produced before respondents' access to CSA (*N* = 106) had a lower *Mean* (*M* = 3.82) than the maize crop tonnage after respondents' access (*M* = 7.70). The *Mean* difference was (M_1-M_2) = -3.88. The variation of the standard deviation in the data was wider for the maize crop tonnage after access to CSA (*SD* = 2.296) than the maize crop tonnage before (*SD* = 2.126). The maize crop tonnage *Mean* after the respondents' implementation of CSA practices was statistically significantly higher than the maize crop tonnage *Mean* before the respondents implemented CSA practices.

The results above signify that the respondents produced more tonnage of maize crops after practising CSA than before. Therefore, the effective practice of CSA increased the maize crop tonnage of the majority of smallholder farmers in the Eastern Province of Zambia. The aforementioned finding supports the outcome of the study conducted in the Eastern Province of Zambia whose statistics showed that farmers practising CSA techniques experienced a 20% increase in maize yields compared to conventional farming methods [25]. Similarly, the Ministry of Agriculture crop focus survey of 2018 in Zambia reported that farmers who adopted CSA practices witnessed an average increase of 30% in crop yields, leading to a 25% rise in income [28].

4.4.3. Respondents' Recommendations on the Implementation of CSA

The study used a bottom-up approach to planning processes to solicit recommendations from the respondents on how CSA can increase crop yields more than the existing harvest status. Slightly over one-third (34%), who made the majority, of the respondents recommended an increase in the frequency of conducting refresher pieces of training, followed by slightly over a fifth (22%) who submitted that there was a need for the project to increase the package of farming inputs (Table 7). The other 19% and 14% of the respondents submitted that there was a need for improvement in agricultural extension services and encouragement for exposure visits, respectively. However, the minority 11% of the respondents supported the status quo as shown in Table 7. Slightly over one-third (34%), who were the majority, of the respondents recommended an increase in the frequency of conducting refresher pieces of training.

Table 7. *Respondent's recommendations on how CSA can be enhanced.*

Respondents' recommendation	Respondents	%
Improved extension services	20	19
Increased frequency of training	36	34
Increase inputs packages	24	22
Encourage exposure visits	14	14
Satisfied with the status quo	12	11
Total	106	100

Source: Survey result

The recommendation shows that refresher pieces of training in CSA practices were rarely conducted by the implementing agency and line government ministries. The recommendation for refresher pieces of training is supported by the outcome of the study conducted in Zambia on farmers' perceptions towards CSA in Zambia whose findings revealed that a lack of information and training opportunities contributed to negative perceptions towards CSA practices [25]. According to the results of the above-mentioned study, farmers felt uncertain about the potential benefits of CSA practices due to a lack of refresher training for them and the agriculture extension workers [25].

However, the recommendation, by some respondents, on the need for the project to increase the input package was disputed during interviews by the technocrats with one saying:

"The current inputs package is enough to enable the

project beneficiaries to grow, harvest, and store crops for home consumption up to the next farming season. The only problem with beneficiary farmers is that they want to sell almost everything after harvests."

Nevertheless, the recommendations made by the respondents in Table 7 are all important and have policy connotations that require the attention of the project managers. The recommendations presented give options for agricultural transformation which advocate for putting fundamentals in place to strengthen the agricultural production systems and to motivate farmers' commitment to agricultural production and productivity.

5. Conclusions

Climate change is one of the devastating environmental challenges the world is facing today. Combating the effects of climate change is a significant topic of discussion worldwide particularly in Africa, Zambia inclusive, as it relates to poor agriculture production and productivity among smallholder farmers. Every responsible government must work with cooperating partners to design feasible and sustainable projects, like the one implemented in the Eastern Province, which targeted smallholder farmers to adopt and implement CSA to enhance crop yields amid the effects of climate change. Given the statement above, the study's main focus was to investigate the effects of CSA techniques on smallholder farmers who participated in the Zambia Integrated Forest Landscape Project in the Eastern Province of Zambia.

Smallholder farmers in the Eastern Province of Zambia were aware of CSA largely through sensitisation. The majority of the respondents received CSA information through monthly sensitisation meetings. Others received the same information weekly, quarterly, and annually, while the minority never received such information. Those who received CSA sensitisation information monthly were satisfied with the frequency of information dissemination compared to others. The introduction of CSA was appreciated by the smallholder farmers in the province. The majority of smallholder farmers viewed CSA as a great contributor to the improvement of their crop productivity, with the majority of them considering an increase in crop productivity as a major benefit that came with implementing CSA techniques.

Most smallholder farmers grew maize crops under CSA because it is a staple food crop, while the minority grew sunflowers and others grew soya beans and groundnuts. The smallholder farmers produced more maize crop tonnage after practising CSA than before, implying that the implementation of CSA significantly contributed to high maize crop productivity. It was evident that smallholder farmers had embraced CSA in the province going by the majority number of them who had been practising CSA techniques for 6 years and above.

Therefore, CSA techniques implemented by smallholder farmers in the Eastern Province through the Zambia Integrated Forest Landscape Project can, confidently, be said to be a force behind improved crop productivity and enhanced household food security. With the closing of the project in the first quarter of 2024, the study recommends continuity of the project by the Zambian government through either government coffers or cooperating partners or both; consistent and regular pieces of refresher training for smallholder farmers in areas of interest; an improvement in technical and administrative support in the agricultural extension system aimed at bridging the gap in the area of extension worker-farmer ratio.

Since the study purposely focussed on five districts out of the fourteen in the province on account of easy accessibility, it is recommended that future research focus on all the districts in the province be conducted to have a holistic picture of the effect of CSA on maize crop productivity of smallholder farmers. Equally, since the study concentrated on maize crop productivity to analyse the effect of CSA, it is recommended that a study that would also look at other food crops such as sunflower, soya beans, groundnuts, cassava, and sorghum that were supported under CSA be conducted. This proposed study should go beyond to look at the nutritional and dietary value because these determine the activeness and health life of families.

Abbreviations

CSA	Climate-Smart Agriculture
DACOs	District Agriculture Co-ordinators
IPCC	International Panel on Climate Change
UNDP	United Nations Development Programme
ZIFLP	Zambia Integrated Forest Landscape Project

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Author Contributions

Veronica Nanyangwe: Conceptualisation, Methodology, Investigations, Writing – review & editing, Validation

Royd Tembo: Writing- original draft, Methodology, Software, Formal analysis, Writing – review & editing, Data curation

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The data is available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflicts of interest.

Appendix

Appendix I. Questionnaire for Lead-Farmers Implementing CSA in the Eastern Province of Zambia

Questionnaire for Lead-Farmers implementing CSA under the Zambia Integrated Forest Landscape Project, Eastern Province, Zambia

Respondent number: [ ]

Place of questionnaire administration:

....

Date for questionnaire administration:

....

Is the Questionnaire Self-Administered?

Yes [ ]

No [ ]

Instructions: Answer questions by ticking the right answer in the box provided.

Section 1: Biographic and demographic data of the respondents

1. What is your sex?
   a) Male [ ]
   b) Female [ ]
2. What is your age?
   a) 18 to 34 years [ ]
   b) 35 to 49 years [ ]
   c) 50 to 64 years [ ]
   d) 65 years and above [ ]
3. What is your highest level of educational attainment?
   a) Mute [ ]
   b) No formal education [ ]
   c) Primary education [ ]
   d) Secondary education [ ]
   e) Tertiary [ ]

Section 2: Respondents' awareness of CSA

4. Do you know what Climate Smart Agriculture is?
   a) Yes [ ]
   b) No [ ]
   c) Have an idea [ ]
5. Which of the following Climate Smart Agricultural Techniques do you know most?
   a) Crop rotation [ ]
   b) Organic manure [ ]
   c) Mulching [ ]
   d) Minimum tillage [ ]
   e) Composting [ ]
6. How frequently do you receive information on Climate-Smart Agriculture from the District Agriculture Office/Extension Office?
   a) Weekly [ ]
   b) Monthly [ ]
   c) Quarterly [ ]
   d) Annually [ ]
   e) Never [ ]
7. How satisfied are you with the awareness being provided by the District Agriculture Coordinating Office or any other organization on climate-smart agriculture?
   a) Very dissatisfied [ ]
   b) Somewhat dissatisfied [ ]
   c) Neutral [ ]
   d) Somewhat satisfied [ ]
   e) Very satisfied [ ]

Section 3: Perceptions of smallholder farmers on CSA

8. In your opinion, how do you perceive Climate-Smart Agriculture?
   a) Not important [ ]
   b) Important [ ]
9. In your opinion, what is the top-most benefit of implementing climate-smart agricultural practices?
   a) Increased crop yield [ ]
   b) Improved soil health [ ]
   c) Reduced greenhouse gas emissions [ ]
   d) Reduced use of chemical fertilizers and pesticides [ ]
   e) Improved resilience to climate change [ ]
10. Do you agree that the Climate-Smart Agricultural techniques being implemented by ZIFLP have the potential to increase crop yield for most Farmers in the region?
    a) Strongly Agree [ ]
    b) Agree [ ]
    c) Neutral [ ]
    d) Disagree [ ]
    e) Strongly disagree [ ]
11. How likely are you to continue using Climate-Smart Agricultural practices that are being promoted by ZIFLP in the future?
    a) Very likely [ ]
    b) Somewhat likely [ ]
    c) Neutral [ ]
    d) Somewhat unlikely [ ]
    e) Very unlikely [ ]

Section 4: Effects of CSA techniques on crop yields

12. Are you practicing any Climate-Smart Agriculture?
    a) No [ ]

b) Yes [ ]

13. How many years have you been practising Climate-Smart Agricultural practices?
 a) Less than 1 year [ ]
 b) 1-3 years [ ]
 c) 4-5 years [ ]
 d) 6 years and above [ ]
14. What is the size of your farm in acres?
 a) Below 1 acre [ ]
 b) 1 to 3 acres [ ]
 c) 4 to 5 acres [ ]
 d) 6 to 8 acres [ ]
 e) 9 acres and above [ ]
15. Which Climate-Smart Agricultural technique do you practice most on your farm?
 a) Minimum Tillage [ ]
 b) Mulching [ ]
 c) Crop rotation [ ]
 d) Organic manure [ ]
 e) Composting [ ]
16. What is the most positive outcome you have recorded as a result of implementing Climate-Smart Agricultural techniques?
 a) Increased crop yield [ ]
 b) Improved soil fertility [ ]
 c) Reduced crop production costs [ ]
 d) Reduced usage of chemical fertilisers and pesticides [ ]
 e) Improved climate change resilience [ ]
17. How would you rate each of the following Climate-Smart Agricultural techniques in increasing crop yields i) minimum tillage [ ], ii) mulching [ ], iii) crop rotation [ ], iv) organic manure [ ], and v) composting [ ], using the following measures:-
 a) Not effective
 b) Less effective
 c) Effective
 d) Very effective
 e) Extremely effective
18. Have you noticed any changes in crop yield since implementing Climate-Smart Agricultural practices?
 a) Yes, significant increase [ ]
 b) Yes, slight increase [ ]
 c) No noticeable change [ ]
 d) Slight decrease [ ]
 e) Significant decrease [ ]
19. How would you rate the infestations of pests on the following crops after the implementation of Climate-Smart Agricultural techniques i) Soya beans [ ], ii) Maize [ ], iii) Sunflower [ ], iv) Groundnuts [ ], and v) Other [ ], using the following measures:-
 a) Yes, significantly reduced
 b) Yes, slightly reduced
 c) No noticeable change
 d) No, but slightly increased
 e) No, but significantly increased
20. Before you started implementing Climate-Smart Agriculture, what was your average harvest tonnage per acre in the past three farming seasons for each of the following crops i) Soya beans [ ], ii) Maize [ ], iii) Sunflower [ ], iv) Groundnuts [ ], and v) Other [ ]
 a) Below 1 ton
 b) 1 to 2 tons
 c) 3 to 4 tons
 d) 5 to 6 tons
 e) Above 6 tons
21. 21. For the past three farming seasons, after implementing Climate-smart agricultural techniques, what is your average harvest tonnage per acre for each of the following crops i) Soya beans [ ], ii) Maize [ ], iii) Sunflower [ ], iv) Groundnuts [ ], and v) Other [ ]
 a) Below 1 ton
 b) 1 to 2 tons
 c) 3 to 4 tons
 d) 5 to 6 tons
 e) Above 6 tons
22. What is your average profit in kwacha per harvest?
 a) 0 to 5000 ZMW [ ]
 b) 5001 to 10000 ZMW [ ]
 c) 10001 to 15000 ZMW [ ]
 d) 15001 to 20000 ZMW [ ]
 e) Above 20001 ZMW [ ]
23. Do you think that the trainings you are receiving have the potential to contribute to increasing crop yield?
 a) Yes [ ]
 b) No [ ]
24. In your view, what recommendation can you give to make CSA more effective?……………………

Thank you for your time and valuable input. Your insights will contribute to a better understanding of Climate-Smart Agricultural practices in the region and help inform future strategies and initiatives.

Appendix II. Interview Guide for District Agriculture Coordinators in the Eastern Province of Zambia

Interview guide for District Agriculture Coordinators, Eastern Province, Zambia

Interviewee number: [ ]

The place for the Interview:

....

Date for Interview:

....

Section 1: Background Information

1. Sex?
 a) Male [ ]
 b) Female [ ]
2. What is your age?...
3. What is your current job position? …………………

4. What is your qualification? ………………………...
5. What are your years of experience in the agricultural sector? ....

Section 2: Awareness by Farmers in Climate Smart Agriculture

6. Which climate-smart agricultural techniques are being implemented under the ZIFLP project in your district?..
7. Approximately, how many farmers are currently practicing climate-smart agriculture in your district under the ZIFLP project? ....
8. Are farmers in your area aware of Climate-Smart Agriculture?..
9. Are you offering any awareness on Climate-Smart Agriculture to the farmers?..
10. If so how often? ……………………………………
11. Are there other organisations conducting awareness programmes on Climate-Smart Agriculture in your area?........................... If there are, kindly mention them………..
12. In your opinion, do you think the awareness being offered to farmers on Climate-Smart Agriculture is adequate?... In your opinion, do you think farmer's awareness of Climate-Smart Agriculture can influence crop yield?...........................
    Give reasons for your answer………………………

Section 3: Perception of Climate Smart Agriculture

13. Do farmers and other stakeholders in your area have negative or positive perceptions of Climate-Smart Agriculture? Give reason(s) for your answer.................
14. From your perspective, which Climate-Smart Agricultural technique is most relevant and effective in your area?………………Give Reasons……………
15. Do you agree with the statement that the implementation of ZIFLP has led to the enhancement of household food security among the beneficiary farmers?.........Give reason(s) for your answer..

Section 4: Effects of Climate-Smart Agricultural Techniques on Crop Yields

16. Which climate-smart agricultural techniques are being implemented under the ZIFLP project in your district?...
17. How effective do you think the Climate-Smart Agricultural techniques being implemented in your district are in improving crop yields? ………………………
18. Have the crop yields for the farmers increased after implementing Climate-Smart Agricultural techniques promoted by ZIFLP?................................
19. Has the pest infestation reduced on crops of the ZIFLP beneficiaries after the implementation of Climate-Smart Agricultural techniques? ………….
20. Before farmers started implementing Climate-smart agriculture, what was the average harvest tonnage per acre for each of the following crops promoted by ZIFLP? i) soya beans, ii) maize, iii) sunflower, and iv) groundnuts?………………………………….
21. After farmers started implementing Climate-Smart Agriculture, what is the average harvest tonnage per acre for each of the following crops promoted by ZIFLP? i) soya beans, ii) maize, iii) sunflower, and iv) groundnuts?……………………………
22. How would you rate the overall adoption of Climate-Smart Agriculture being implemented by ZIFLP among farmers in your area?………………………
23. How would you rate the following based on their level of importance towards the success of increasing crop yield under the ZIFLP: i) technical support and extension services [ ], ii) financial support [ ], iii) farmers' knowledge and awareness of Climate-Smart Practices [ ], iv) Climate-Smart Inputs [ ], and v) Policy and institutional support [ ] using these measures?
    a) Very Important
    b) Important
    c) Neutral
    d) Unimportant
    e) Very Unimportant
24. To what extent do you believe that the ZIFLP has successfully increased crop yield in your district?
    a) Strongly disagree [ ]
    b) Disagree [ ]
    c) Neither agree nor disagree [ ]
    d) Agree [ ]
    e) Strongly agree [ ]
25. Based on your experience, what recommendations would you give to improve the adoption and effectiveness of Climate-Smart Agriculture in your region?
    ……………………………………………………………

Thank you for your time and valuable input. Your insights will contribute to a better understanding of Climate-Smart Agricultural practices in the region and help inform future strategies and initiatives.

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Biography

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Research Field

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Royd Tembo: Food Security, Climate Change, Agriculture Extension Services, Climate-Smart Agriculture, Social Welfare Programmes, Social Protection, Vulnerability & Systems of Cover