Smallholder Farmers Perspective of Climate-Smart Agriculturural Practices in Uzo-Uwani Local Government Area, Enugu State

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Abstract: Background of the Study: Agriculture remains a critical driver of Nigeria's economy. However, conventional farming practices have contributed significantly to environmental degradation, including deforestation, soil erosion, declining biodiversity, and greenhouse gas emissions. With climate change accelerating and environmental sustainability becoming increasingly urgent, there is a growing need to transition toward more sustainable and climate-resilient farming systems. These practices not only improve farm yields but also reduce environmental harm, making agriculture a tool for environmental sustainability. However, the adoption and effective implementation of CSA practices in Nigeria including Uzo-Uwani remain limited, especially among farmers. **Aim and Objectives:** The aim of this study is to assess smallholder farmers' perception of climate-smart agriculture in Uzo-Uwani Local Government Area, Enugu State. Specifically, the study assessed the awareness and level of utilization of CSA practices and the challenges limiting the utilization of CSA. **Methodology:** Descriptive survey research design was employed for the study. Simple random sampling technique was adopted to select 15 smallholder farmers from each community in Uzo-Uwani making a sample size of 240. A well-developed structured questionnaire, validated and subjected to reliability test was used for data collection. On the spot mode of data collection was used. However, only the adequately filled ones (225) were used for the study. The remaining 15 questionnaires were discarded due to wrong filling or unreturned. The data collected were analyzed using frequency, percentage, mean and standard deviation in answering the research questions. **Results:** the result of the study showed the smallholder farmers in Uzo-Uwani Local Government Area, Enugu State have high awareness of the CSA practices with varying degree but utilizes them at a low extent. The study also shows that the challenges limiting the farmer's level of adoption include capital intensiveness of CSA practices, inadequate knowledge and understanding of CSA and its practices, unavailability of improved crop varieties, limited government support with farm inputs among others. **Conclusion:**The level of Climate-smart practice utilization in Uzo-Uwani seems inadequate to meet the challenges of climate change. Therefore, the strategies that will encourage smallholder farmers to fully utilize the CSA practices be put in place in order to achieve the set objectives of CSA.

Keywords: Climate-Smart Agriculture, Environmental Sustainability, Smallholder Farmers

1. Introduction

Agriculture is a key sector of the world's economy contributing to about 4 % of the global Gross Domestic Product (GDP) and in some developing nations, accounting for at least 25 % of the GDP (The World Bank, Agriculture and Food, 2022). Agricultural development elevates incomes, minimize poverty, and enhance food security for about 80 % of the world's poor who inhabit rural communities and work mostly in farming (FAO, 2022). According to Pawlak and Kołodziejczak, (2020) and Jarzebski, Ahmed, Karanja, Boafo, Balde and Chinangwa, (2020), agriculture plays a crucial role by providing sustenance and income for millions, contributes to GDP and export earnings.

Despite the role of agriculture, agricultural production and food security is being threatened and also poverty rate, incidences of diseases and pests as well as climate variability is being increased, particularly in Uzo-Uwani (Ibe, Okoh &Arua, 2022). This threat is due to the high dependence on rain-fed agricultural systems (Isiwu&Adejoh, 2023). Farmers in Uzo-Uwani depend heavily on rain-fed agriculture which makes the area vulnerable to climate disruptions and the socio-economic development of the area under threat (Nwangwu, Ume, Onah &Omeje, 2024). Agricultural developments are not only victims but also a driver of climate change through the emissions of agricultural GHGs by the use of resources (Chandra, McNamara &Dargusch, 2017).

As drivers of Climate change, the utilization of poor agricultural practices exacerbates climate change. Through deforestation and conversion of grassland to cropland, emissions of agricultural GHGs occur. These actions also induce higher carbon dioxide (CO_2) emissions, and reduce capacity for carbon sequestration. Also, in order to provide nutrients for crop production through the use of synthetic fertilizers, CO_2 is generated in the production of synthetic fertilizers and nitrous oxides are emitted when nitrogen is added to the soil through the use of synthetic fertilizers. Another significant source of agricultural GHGs emissions is livestock agriculture which produces methane (CH_4) (its impact is more than 25 times greater than CO_2) and nitrous oxide (N_2O) and indirectly through the production of fodder used for livestock.

As victims of climate change, agricultural production is affected by climate change directly and indirectly. Directly, increase in mean temperatures accelerates crop development and shorten the crop cycle and phenological stages, thus reducing crop production and indirectly, variations in the amount of seasonal precipitation and increase in evaporation lead to drought stress for crops (Kalu &Mbanasor, 2023). Furthermore, changes in precipitation pattern affect water availability for crops leading to less crop yield. Therefore, global climate change has a severe impact on crop production and inflicts varied constraints on agricultural systems, particularly in water constrained environments (Onyeneke, Amadi, Njoku & Osuji, 2021). Climate change adversely affects food production through water shortages, pest outbreaks, and soil degradation, leading to significant crop yield losses and posing significant challenges to global food security (Thomas &Eforuoku, 2020).

Although, the agricultural sector in Uzo-Uwani employs at least 50 % of the areas labor force, smallholder farmers encounter numerous barriers such as high post-harvest losses as well as low productivity levels caused by increasing climate variability (Isiwu&Adejoh, 2023). Therefore, without significant adaptation measures, agricultural productivity could decline by up to 30% by 2050 (Trisos, Adelekan, Totin, Ayanlade, Efitre, Gemeda, 2022), with some areas potentially facing up to 90% decline in net farm revenues by 2,100 (Nhemachena Nhamo, Matchaya, Nhemachena, Muchara, Karuaihe, 2020).

The adverse impact of climate change on agricultural production calls for a need to enhance the adaptability of small-scale farmers in order to sustain the desired level of food security and income to cope with the growing population’s needs. One of the multiple steps to mitigate adverse climate change impacts and invariably food insecurity is the commitment to transition the agricultural sector to be climate-smart by 2030 (Zheng, Ma & He, 2024). The need for more resilient systems, where agriculture is part of the solution to climate change and food crises led the Food and Agriculture Organization of the United Nations (FAO) and World Bank to formally develop Climate-Smart Agriculture (CSA) in 2010 as an approach to guide the transformation of commercial and subsistence agricultural systems in developing countries (Awoke, Löhr, Kimaro, Matavel, Lana, Hafner & Sieber, 2025). Therefore, for farmers to cope with those challenges associated with climate change, climate-smart agriculture (CSA) has been recommended (Bongole, Kitundu& Hella, 2020).

2. Literature Review

The Food and Agricultural Organization of the United Nations (FAO) provided the most commonly definition of CSA as agriculture that sustainably increases productivity, enhances resilience (adaptation), reduces/removes Greenhouse Gases (GHGs) (mitigation) where possible, and enhances achievement of national food security and development goals (Onugo& Onyeneke, 2022). Consequently, the sustainable development goals 2 (Zero Hunger) and 13 (Climate action) could be achieved through the CSA practices. In Nigeria, 70% of its population are engaged in farming with a largely subsistence-based agricultural sector (88.4% are small holders) with a very rapidly growing population (Onyeneke, Amadi, Njoku & Osuji (2021) resulting in further pressure on the farming sector and natural resources, therefore the FAO developed the concept of Climate Smart Agriculture (CSA) to increase food security as a result of increasingly population growth without degrading the quality of the environment quality (FAO, 2022).

The 2030 Agenda is to make agriculture including crops, livestock, fisheries and forestry and food systems more efficient and sustainable, and also to shift from crude agricultural practices to more sustainable consumption and production approaches

(Gabriel, Olajuwon, Klauser, Michael & Renn, 2023). CSA is a response to the growing need for a clear and coherent strategy for managing agriculture and food systems under climate change to reach food security and development objectives (Osuafor& Ude, 2021). Climate-smart agriculture aims to transform and reorient agricultural productivity in the face of the realities of climate change (Onyeneke, Igberi, Uwadoka&Aligbe (2018). Climate-smart agriculture involves agricultural techniques or methods that sustainably increase agricultural productivity while reducing or removing greenhouse gases (GHGs), and enhancing the attainment of sustainable development goals 2 and 13. Consequently, through CSA, problems of food insecurity, climate change, and ecosystem management are addressed concurrently. The core objective of CSA is to help farmers maintain agricultural output increasingly while adapting to shifting climate patterns and improving economic sustainability (Schmidhuber&Tubiello, 2022).

According to Agyekum & Stringer (2024), Climate-smart agriculture (CSA) is based on three pillars/goals which includes Productivity (Improving agricultural productivity).Adaptation (Enhanced resilience) and mitigation (Reduced emissions or cutting back on emissions of greenhouse gases (GHGs). The extent to which the three pillars of CSA are present and the recognition of triple benefits of the CSA practices is one of the key means of determining whether an agricultural technique or practice is climate-smart (Ariom, Dimon, Nambeye, Diof, Adelusi& Boudalia, 2022). Farmers who adopt climatically smart agriculture practices see a rise in income while also helping to combat climate change and strengthen global food security. Through CSA, agricultural productivity could be increased sustainably without having a negative impact on the environment, thereby raising food security. Furthermore, CSA could help to reduce and remove greenhouse gas (GHG) emissions.

CSA practices in Nigeria include high levels of adoption of early maturing and drought tolerant varieties (Wahab, Abubakar, Angara, Qsim&Yukubu, 2020), changing of planting dates, and diversification of crops (Onoja, Abraha, Gima & Achike, 2019). According to Kpadonou, Owiyo& Barbier, (2017); Zakaria, Azumah, Appiah-Twumaji&Dagunga, (2020); Khatri-Chhetri, Regmi, Chanana & Aggarwal, (2020); Aryal, Farnworth & Khurana (2020); Waaswa, OywayaNkurumwa, MwangiKibe&NgenoKipkemoi, (2022); Vatsa, Ma & Zheng, (2023), smallholder farmers worldwide have adopted various CSA practices and technologies such as integrated crop systems, drop diversification, inter-cropping, improved pest, water, and nutrient management, improved grassland management, reduced tillage and use of diverse varieties and breeds, restoring degraded lands, and improved the efficiency of input use in order to attain to reach the objectives of CSA. For Djido, Zougmoré, Houessionon, Ouédraogo, Ouédraogo & Diouf, (2021), CSA practices include also cultivating climate-resilient crop varieties i.e. growing crops that are more resistant to temperature and precipitation extremes, conservation agriculture such as no-till and reduced-tillage cultivation, mulching to enhance water retention and soil health, employing crop leftovers and cover crops and rotating crops, agroforestry i.e. growing trees alongside crops or livestock (to incorporate trees and shrubs into farmland) in order to yield several gains including fodder, shade, fuel wood, and the sequestration of carbon; enhanced irrigation and water harvesting technologies, which can expand the availability of water and crop productivity; and climate information services, which provide timely and reliable access to forecasts and advisories to aid smallholder farmers plan their farming activities and cope with climate risks, precision irrigation, drip irrigation, and collecting rainwater.

According to Agyekum, Antwi-Agyei, Dougill and Stringer (2024), there are categories of climate-smart agriculture (CSA) practices. The categories include: Nitrogen-smart; Weather-smart; Carbon-smart; Energy-smart; Knowledge-smart and Water-smart Therefore, any CSA practice is based on or is addressing one or more of these categories.

CSA has and is being promoted as a laudable approach that can help farmers maximize the potential of the farming sector and enhance food security, despite the challenges posed by climate change (Agyekum, Anti-Agyei, Dougill & Stringer, 2024). However, CSA uptake among farmers in Uzo-Uwani is still relatively low despite its proven potential for one reason or another (Isiwu&Adejoh, 2023). Most smallholders in Uzo-Uwani continue to follow the environmentally harmful practices, like cutting down trees, slash and burn flood irrigation, and forest degradation (Ibe, Okoh &Arua, 2022). Despite the widespread adoption of CSA approaches across West Africa, many countries have still not been able to resolve the problems of food insecurity and rural poverty (Onugo& Onyeneke, 2022). Most farmers encounter challenges and difficulties in utilizing these CSA practices. Such challenges and difficulties include lack of education and awareness. Even farmers enthusiastic about making the switch to climate smart agriculture may have trouble doing so due to a lack of information and access to established approaches, limited financial resources and High costs at the outset (Nyasimi, Kimeli, Sayula, Radeny, Kinyangi& Mungai, 2017). Climatically smart agriculture practices may call for expensive agricultural technology or infrastructure, which are out of reach for many farmers, especially smallholders, inadequate infrastructure, insufficient technical expertise, and unsuitable farming models for small landholdings (Kabato, Getnet, Sinore, Nemeth, Molnár, 2025). Smallholder farmers may face obstacles from policy and regulation in utilizing CSA practices. According to Onugo and Onyeneke, (2022), farmers may find it challenging to embrace climatically smart agriculture practices due to governmental and regulatory obstacles. There may be outright bans on some climate smart agriculture technologies and activities and insufficient funding or technical support from government agencies. Cultural and social resistance is another factor limiting the utilization of CSA Practices. Farmers may hesitate to utilize these practices if it conflicts with their established farming norms. Farmers attempting to implement contentious approaches to climate smart agriculture may also encounter pushback from locals (Ma &Rahut, 2024).

3. Research Methodology/Materials and Methods

The study was carried out in Uzo-Uwani Local Government Area of Enugu State, Nigeria. The area lies o between latitude 6 55'N and 7˚15'N, and longitude 6˚30' o and 7 00'E (Isiwu&Adejoh, 2023. It has an area of 855 2 km and a population of 124,480 (NPC, 2006). The study area has 16 communities namely: The major occupation of the people in the study area is farming with each community specializing in one crop or the other. Simple random sampling technique was adopted to select 15 smallholder farmers from each community in Uzo-Uwani making a sample size of 240. A well-developed structured questionnaire, validated and subjected to reliability test was used for data collection. On the spot mode of data collection was used. However, only the adequately filled ones (225) were used for the study. The remaining 15 questionnaires were discarded due to wrong filling or unreturned. The data collected were analyzed using frequency, percentage, mean and standard deviation.

4. Results and Discussion

Fig 1: Simple percentage analysis on the awareness of smallholder farmers of CSA practices

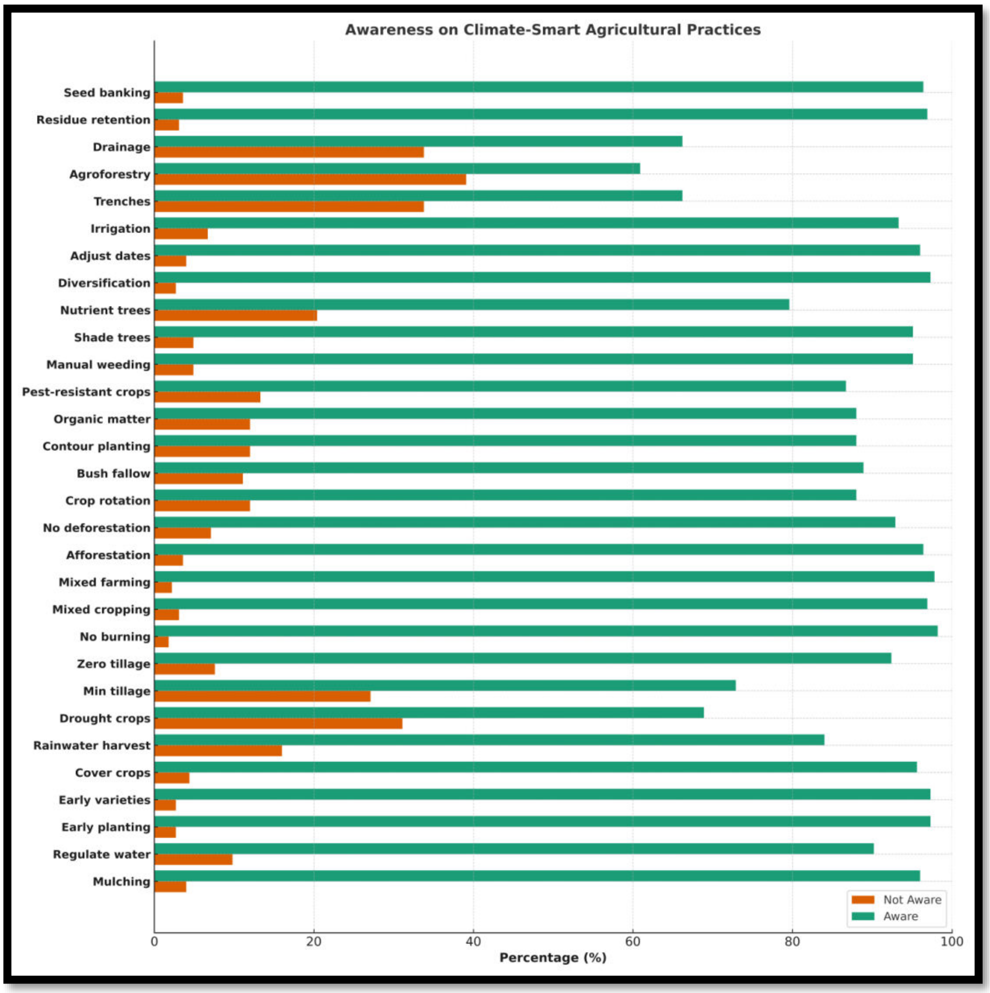

Figure 1 above reveals a generally high level of awareness among respondents regarding various climate-smart and environmentally sustainable agricultural practices. Specifically, a vast majority of respondent's demonstrated strong awareness of adaptive strategies aimed at water conservation and sustainable land management. For instance, 96% of respondents were aware of the need to engage in mulching to reduce excessive water use, while 90.2% recognized the importance of regulating water used in irrigation. Similarly, 97.3% each indicated awareness of planting in the early season to utilize rainwater and planting early maturing crop varieties, and 95.6% were aware of the value of planting cover crops to maintain soil moisture. In terms of more specialized adaptation measures, 84% of the respondents reported awareness of rainwater harvesting, while 68.9% and 72.9% were aware of planting drought-resistant crops and minimum tillage respectively. Awareness was even higher for zero tillage (92.4%) and zero bush burning (98.2%). Additionally, sustainable agricultural methods such as mixed cropping (96.9%), mixed farming (97.8%), afforestation (96.4%), and zero deforestation (92.9%) were well recognized among farmers. Awareness of crop rotation (88%) and bush fallowing (88.9%) also reflected substantial understanding of soil fertility maintenance techniques. Furthermore, farmers were also largely informed about planting on contours (88%), intensive use of organic matter (88%), and investing in pest-resistant crops (86.7%). They are also aware of the practices that limit the use of chemicals, such as manual weeding instead of herbicides (95.1%), were widely adopted. Other measures such as planting shade trees (95.1%) and planting nutrient-building tree species (79.6%) also recorded significant awareness. High awareness levels were maintained in crop diversification (97.3%), adjusting planting dates (96%), and use of sprinkler and drip irrigation (93.3%). However, only 66.2% of respondents were aware of constructing trenches or building drainage systems, and 60.9% recognized agroforestry integration. From the result in Table 1, the awareness of CSA practices among farmers is high, this finding is in line with the Singh, Mehta and Kashyap (2025) who recorded high awareness of CSA practices in smallholder communities. Also, the finding of Mbanasor, Kalu, Okpokiri, Onwusiribe, Nto, Agwu, &Ndukwu, (2024) highlighted a high awareness of CSA among crop farmers in South-east Nigeria which aligns with the findings of the present work. This high awareness recorded among smallholder farmers could be as a result of information about these practices disseminated through cooperative societies, extension workers and friends.

Table 1: Mean and standard deviation analysis on the responses of smallholder farmers on their level of utilization of CSA practices

S/N	Item Statement	N	Mean	SD	Dec
1	Engage in mulching to reduce excessive use of water	225	3.26	0.98	MU
2	Regulate/control the water used in watering crops	225	2.20	0.94	FU
3	Plant in the early season to make use of rainwater	225	2.59	0.96	MU
4	Planting early maturing crop varieties	225	3.15	0.93	MU
5	Plant cover crops to maintain soil moisture	225	2.10	0.87	FU
6	Harvest and store rain water to be used in my farm (Rainwater harvesting)	225	3.56	0.72	HU
7	Planting drought resistant crops	225	2.26	0.92	FU
8	Minimum tillage	225	2.02	0.83	FU
9	Zero tillage	225	1.15	0.57	LU
10	Zero bush burning	225	2.44	1.03	FU
11	Mixed cropping	225	3.09	0.90	MU
12	Mixed farming	225	2.52	0.91	MU
13	Afforestation	225	2.35	1.10	FU
14	Zero deforestation	225	1.34	0.82	LU
15	Crop rotation	225	2.24	1.27	FU
16	Bush fallowing	225	2.05	1.14	FU
17	Planting on contours	225	1.93	1.07	FU
18	Intensified use of organic matter	225	1.95	1.09	FU
19	Investing in pest-resistant crops	225	1.99	1.12	FU
20	Use manual weeding instead of herbicides	225	2.21	1.24	FU
21	Planting shade trees	225	2.10	1.21	FU
22	Planting nutrients building species of trees	225	2.21	1.19	FU
23	Crop diversification	225	3.13	0.77	MU
24	Adjusting planting dates	225	3.09	0.81	MU
25	Use of sprinkler and drip irrigation	225	2.46	1.29	FU
26	Construction of trenches	225	2.33	1.26	FU
27	Agroforestry integration	225	2.26	1.19	FU
28	Build drainage systems	225	2.31	1.21	FU
29	Residue retention	225	2.90	0.84	MU
30	Store seeds for next season/emergency (seed banking)	225	2.64	1.10	MU
	Grand Mean	**225**	**2.39**		**FU**

Key: HU-Highly Utilized; MU-Moderately Utilized; FU-Fairly Utilized; LU-Less Utilized

Table 1 presents the mean and standard deviation analysis of smallholder farmers' responses on their level of utilization of Climate-Smart Agriculture (CSA) practices. Specifically, only one practice harvesting and storing rainwater for farm use (rainwater harvesting) was rated as highly utilized (Mean = 3.56, SD = 0.72). A number of practices were found to be moderately utilized (MU). These include engaging in mulching to reduce water use (Mean = 3.26), planting early maturing crop varieties (Mean = 3.15), mixed cropping (Mean = 3.09), crop diversification (Mean = 3.13), adjusting planting dates (Mean = 3.09), store seeds for next season/emergency (Mean = 2.64), and residue retention (Mean = 2.90).

Conversely, the majority of the CSA practices were rated as fairly utilized (FU). This category includes techniques such as regulating water use (Mean = 2.20), planting drought-resistant crops (Mean = 2.26), minimum tillage (Mean = 2.02), zero bush burning (Mean = 2.44), afforestation (Mean = 2.35), crop rotation (Mean = 2.24), manual weeding (Mean = 2.21), use of sprinkler/drip irrigation (Mean = 2.46), construction of trenches (Mean = 2.33), and agroforestry integration (Mean = 2.26), among others. A few practices recorded low utilization (LU) levels, including zero tillage (Mean = 1.15) and zero deforestation (Mean = 1.34). The prevalence of fair utilization suggests that while farmers are aware of these practices, their utilization is limited, likely due to factors such as resource constraints, inadequate technical support, or limited access to equipment. The overall grand mean of 2.39 indicated that the practices are fairly utilized among respondents. This finding validated the finding of Isiwu&Adejoh, (2023) who posited that CSA uptake among farmers in Uzo-Uwani is still relatively low despite its proven potential.Similarly, Zanmassou, Al-Hassan, Mensah-Bonsu, Osei-Asare &Igue, (2020) reported that the practice of climate-smart agriculture among smallholder farmers is still relatively low in sub-Saharan African countries, Nigeria inclusive.

Table 2: Mean and standard deviation analysis on the responses of smallholder farmers on the factors impeding their utilization of CSA practices

S/N	Item Statement	N	Mean	SD	Dec
1	It is capital intensive	225	3.31	0.75	Agree
2	Lack of awareness	225	2.36	1.16	Disagree
3	Inadequate knowledge and understanding of CSA and its practices	225	3.31	0.72	Agree
4	Unavailability of improved crop varieties	225	3.27	0.78	Agree
5	High illiteracy of smallholder farmers	225	3.16	0.73	Agree
6	Limited government support with farm inputs	225	3.24	0.77	Agree
7	High cost of improved crop varieties	225	3.04	0.85	Agree
8	Unavailability of improved varieties	225	2.91	0.83	Agree
9	Limited access to weather and climate information	225	3.24	0.78	Agree
10	Inadequate access to agricultural credits	225	3.01	0.81	Agree
11	Topography of the land	225	3.30	0.68	Agree

12	High Cost of Labor for CSA	225	3.10	0.74	Agree
13	Policy and regulation inconsistency	225	3.04	0.92	Agree
14	Infertile soil	225	2.81	1.34	Agree
15	Increased incidences of pests and diseases	225	3.06	1.23	Agree
16	Cultural and social resistance	225	3.16	1.07	Agree
17	Non-availability of inputs in local markets	225	3.19	1.01	Agree
18	Inadequate institutional support	225	3.07	0.88	Agree
	Grand Mean	**225**	**3.09**		**Agree**

Table 2 presents the mean and standard deviation analysis of respondents' views on the constraints affecting the utilization of Climate-Smart Agricultural (CSA) practices among smallholder farmers. The highest-rated constraints include capital intensiveness of CSA practices (Mean = 3.31, SD = 0.75), inadequate knowledge and understanding of CSA and its practices (Mean = 3.31, SD = 0.72), and topography of the land (Mean = 3.30, SD = 0.68). Other prominent constraints identified include unavailability of improved crop varieties (Mean = 3.27), limited government support with farm inputs (Mean = 3.24), limited access to weather and climate information (Mean = 3.24), and high illiteracy among smallholder farmers (Mean = 3.16). Additionally, respondents agreed that cultural and social resistance (Mean = 3.16), non-availability of inputs in local markets (Mean = 3.19), inadequate institutional support (Mean = 3.07), policy inconsistency (Mean = 3.04), high cost of improved crop varieties (Mean = 3.04), high cost of labor (Mean = 3.10), and increased incidences of pests and diseases (Mean = 3.06) also constrain the effective adoption of CSA practices. Only one constraint, lack of awareness (Mean = 2.36, SD = 1.16), was rated as disagree, suggesting that awareness of CSA exists to some extent. The grand mean of 3.09 indicates that farmers generally perceive the challenges outlined on table 2 as significant impediments to effective CSA adoption. This finding aligns with Kabato, Getnet, Sinore, Nemeth, Molnár, (2025) who posited that climatically smart agriculture practices may call for expensive agricultural technology or infrastructure, which are out of reach for many farmers, especially smallholders, inadequate infrastructure, insufficient technical expertise, and unsuitable farming models for small landholdings.

5. Conclusion and Recommendation

This study concludes that the smallholder farmers in Uzo-Uwani Local Government Area, Enugu State have high awareness of the CSA practices with varying degree and they are already utilizing some of these practices but to a low extent. The level of Climate-smart practice utilization inUzo-Uwani seems inadequate to meet the challenges of climate change. This low utilization of CSA Practices among smallholder farmers in Uzo-Uwani has been accounted for by many challenges such as capital intensiveness of CSA practices, inadequate knowledge and understanding of CSA and its practices, unavailability of improved crop varieties, limited government support with farm inputs among others. Based on the conclusion, the study recommends that strategies that will encourage smallholder farmers to fully utilize the CSA practices be put in place in order to achieve the set objectives of CSA. Such strategies include strengthening of agricultural extension services in order to provide smallholder farmers with practical training and support on CSA techniques tailored to local conditions, availability of timely and localized climate data through different platforms to help farmers make informed decisions on crop selection, planting times, and resource use, development and promotion of microcredit and insurance products designed for smallholders to invest in CSA practices without risking their livelihoods and encouragement of farmer-to-farmer knowledge sharing and collective action. These strategies can empower smallholder farmers to become active agents of environmental sustainability while enhancing their resilience and productivity in the face of climate change.

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