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Climate Smart Agriculture Practices: A Synthesis of Implementation in Nigeria

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Abstract: The impact of climate is threatening sustainable food production worldwide. Climate-smart agriculture (CSA) is a strategic practice that supports farming, ameliorates food insecurity, and advances sustainable agriculture. This study assesses the implementation of CSA through the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA). From an initial in-depth search of 337 publications, 98 articles fulfilled the inclusion criteria. Results showed that awareness of CSA remains low even with a steady increase in publications from 2020-2023. The south-western region was the most studied as farmers implemented various approaches across the country with 43% of the studies highlighting the implementation of indigenous knowledge which includes adjusting the planting dates and use of natural pest control methods. Major determinants of the adoption of CSA were access to credit, contact with extension service providers, years of farming experience, and level of education. Farmers recorded an increase in production and income with improvement in soil health due to their adoption of CSA. The absence of government policies, the high cost of implementation, and low level of technical skill were hindrances to the adoption of CSA. The study concludes that farmers in Nigeria are implementing CSA practices. There is a need to increase awareness and develop the capacity of farmers through training in CSA skills. The government should legislate reforms and provide incentives to support farmers to adopt CSA.

Keywords: Climate-smart agriculture, awareness, climate-smart practices, determinants of adoption, systematic review

Introduction

Massive efforts have been made to eradicate poverty, malnutrition, and the effects of climate change worldwide, especially with the implementation of the seventeen Sustainable

Development Goals (SDGs) in 2005. Notwithstanding these efforts, about 64% of the poorest people in the world live in Africa, with 427 million of them in the sub-Saharan region and 88.4 million in Nigeria. This has necessitated the need to aggressively combat climate change (Magesa *et al.,* 2023; Izuogu *et al.,* 2021). All over the world, agricultural production activities play active roles in sustaining the livelihood of the poorest, the majority of whom live in rural areas.

Agriculture is the backbone of Africa's development as it influences the progress of other economic sectors. Alterations in climatic variables such as rainfall, relative humidity, sunshine, temperature, and soil moisture will have more negative impacts such as an increase in diseases and pests, a decrease in soil fertility and farm output, and a reduction in the availability of soil water and increase in leaching and soil erosion in developing countries due to their dependence on agriculture (Njoku *et al.,* 2024). The agricultural sector contributes more than 25 % of Africa's gross domestic product and around 70 % of its labour force. Farmers in rural areas depend on agriculture for their livelihoods; therefore, changes in climatic elements can have both immediate and delayed effects on their sustainable livelihoods (Tadesse & Ahmed, 2023).

Despite the crucial role played by this sector, the food production system in Africa, depends mainly on natural precipitation and makes little use of innovative technologies. In Africa only 5% of cultivated land has irrigation facilities, compared to 14% and 37% in Latin America and Asia respectively (Munonye *et al.,* 2023). In addition, most farmers in Africa are smallholders with inadequate production infrastructure, poor access to agricultural finance, and insufficient information (Atasie & Izuogu, 2017). Agriculture faces certain threats and uncertainties such as heat stress, drought, and decreased yields given the sector's high vulnerability (Njoku *et al*., 2024). Studies (Izuogu *et al.,* 2024; Oparaojiaku *et al.,* 2024; Osuji *et al.,* 2021) show that crop production activities in Africa will suffer more from climate change. However, Magesa *et al.* (2023) pointed out that rural livelihoods will be the most affected by the exposure of agriculture to climate change in the region.

Several nations within the tropical belt, especially countries that are most exposed to climate change have advocated different approaches to ameliorate climate change's impact on food production. Climate-smart agriculture represents a collection of agricultural production innovations targeted at mitigating the impact of climate change. Its implementation is gaining credence all over the world (Njoku *et al.,* 2024). Climate-smart agriculture practice aims at increasing food production and building farmers' resilience towards climate change. While stimulating a reduction in the emission of greenhouse gases, CSA improves farmers' production and also serves as a dependable alternative to the weaknesses of traditional agricultural practices that do not factor in climate change threats (Tabe-ojong *et al*., 2023). Climate-smart agriculture improves agronomic practices and reduces food insecurity in an uncertain production environment with adequate consideration of the context of its end-users. The introduction of CSA has broadened the horizon of current agricultural policies, and its growing importance is accompanied by the increasing awareness that climate change will worsen the development of agricultural production, thus necessitating a paradigm shift (Ojo *et al*., 2023; Onyeneke *et al*., 2020). Farmers in Nigeria are therefore very concerned given their poor adaptive capacity. In line with the increasing campaign to reduce greenhouse gas emissions, there is an urgent need for the implementation of CSA in Nigeria.

In light of this, the understanding of how efficiently farmers are practicing CSA and how policies can be implemented to reduce the effects of climate change is very important. Lack of awareness of CSA practices can lead to wrong actions by farmers. Since Nigerian farmers are diverse, farmers' knowledge of CSA is also likely to vary spatially. Even though the gains from CSA are clear, certain challenges should not be ignored. Studies (Wakweya, 2023; Ukwuaba & Ileka, 2024; Tiamiyu, 2017; Terdoo, 2020) have highlighted these critical issues that farmers need to be aware of such as the determinants, benefits, and challenges of CSA practices. To ensure the sustainability of CSA practices, it is essential to establish a holistic knowledge of farmers' decision-making when adopting these practices.

Although so much has been written concerning the critical role of CSA in farmers' adaptation to climate change there is a limited comprehensive review of published articles that synthesized the implementation of CSA as very few systematic reviews have been conducted on farmers' awareness, adoption, challenges and factors affecting the adoption of these practices. It is also important to assess how research on CSA has evolved and whether it shows the level of readiness for the expected future trends. Some of the earlier reviews, e.g. Barasa *et al*. (2021), looked at the whole of Africa, Kombat *et al.* (2021) looked at CSA practices in sub-Saharan Africa, while Agyekum *et al*. (2024) considered the benefits and challenges of CSA practices in West Africa and therefore did not focus on Nigeria. Conversely, Otitoju *et al.* (2023) conducted a review of CSA technologies in Nigeria but did not answer any of the research questions of this study, while Balogun *et al.* (2024) conducted an empirical review of CSA for the improvement of the agricultural sector in Nigeria. Notwithstanding the additions to knowledge on CSA by these reviews, not much is known about how effective the practice has been in Nigeria.

The review therefore attempts to analyse the state of research on CSA in Nigeria. It also assessed the trend, spatial variability, methods, and dynamics of CSA in Nigeria. In reviewing the Nigerian literature, the article provides a concise account of farmers' practice of CSA, identifies the major gaps in the current empirical studies especially as it concerns studies on the challenges of implementation of CSA, and bridges the gaps between researchers and farmers for sound policy design and implementation. The study was specifically conducted to identify the sources of information and awareness of farmers on CSA, describe the CSA practices, identify the factors that influence the adoption of CSA, determine the impact of CSA, and identify the challenges in the implementation of CSA by farmers in Nigeria. The research will provide a basis for further studies that will enhance research on improving the resilience of farming systems for sustainable food production.

Methodology

The study focused on Nigeria. The country has an area of about 923,768 km² with 36 states spread over six regions. Nigeria is located within latitude 10' 00' N and 8' 00' E (Izuogu *et al*., 2024) with a population estimate of 232, 679, 478 (National Bureau of Statistics, 2024). The key economic activities in the country include crude oil production, agriculture, mining, and commerce. The environmental challenges plaguing the country include flooding, desertification, deforestation, drought, erosion, and leaching. These challenges have been exacerbated mainly in the Northeast and Southeast regions by climate change.

The review used the PRISMA method to analyze the existing articles on CSA in Nigeria. This method is preferred because it describes the inclusion and exclusion criteria while defining the questions that the review aims to answer.

Criteria for eligibility

For a study to be included in the review, the article needed to evaluate the practice of CSA. Such studies must have been conducted in any part of the country. Studies that covered the sub-Saharan region or the entire continent and involved respondents from Nigeria were also considered. Studies that were not strongly related to CSA were excluded. This included studies that did not address the awareness, identification, impacts, and challenges of CSA; such studies may have essentially referred to the general concept of CSA. Publications in book chapters, conference proceedings, and editorials were also excluded. The entries in **Error! Reference source not found.** show the eligibility criteria.

Table 1. Inclusion and exclusion criteria

INCLUSION	EXCLUSION
The study must specifically address CSA	Studies that have no connection with CSA
The effects must focus on farming, sustainable livelihood, and environmental management.	False positive results
The study must be conducted in any part of Nigeria.	Studies conducted outside of Nigeria
The study must be in the English language.	Studies that were not in English
The study must be between 2014-2024.	Articles published before 2014

Data sources and search strategies

The authors conducted an advanced search of the Web of Science, Scopus, and ResearchGate for articles published on the topic between 2014 and 2024, using the three keywords: climate, smart, and agriculture. The focus was on empirical studies written in English. Different keywords were used to test the best combination that would provide a larger number of relevant articles for the study. Key search terms included 'climate' AND 'smart' AND 'agriculture', which yielded 43 articles; 'climate smart' 'AND 'agriculture' AND 'Nigeria' yielded 294 articles. At the end of this phase, we had 337 entries. The Web of Science search returned 87 entries, Scopus returned 112 articles, Research Gate, returned 138 publications.

The initial screening focused on the titles and abstracts of the articles. From the 337 entries extracted for review, 213 were selected after 124 articles were removed as duplicates. Furthermore, 74 articles were deleted as they did not address CSA, its impacts and challenges, or focused on Nigeria thus, leaving a total of 139 articles that were selected. In the second phase, a comprehensive assessment of the entire text was undertaken. The 213 articles were scrupulously reviewed to determine whether they addressed the topics relevant to the research questions within the specified year. After a thorough evaluation, 38 articles were removed, and 101 articles were selected. To ensure that only the important articles were included in the review, the search was conducted independently by the authors, who later met to give their consent to the approval of contradictory articles. At the end of the last session, 3 articles were removed, and 98 papers were selected for the final systematic review. The schema shown in figure 1 is a summary of the selection process.

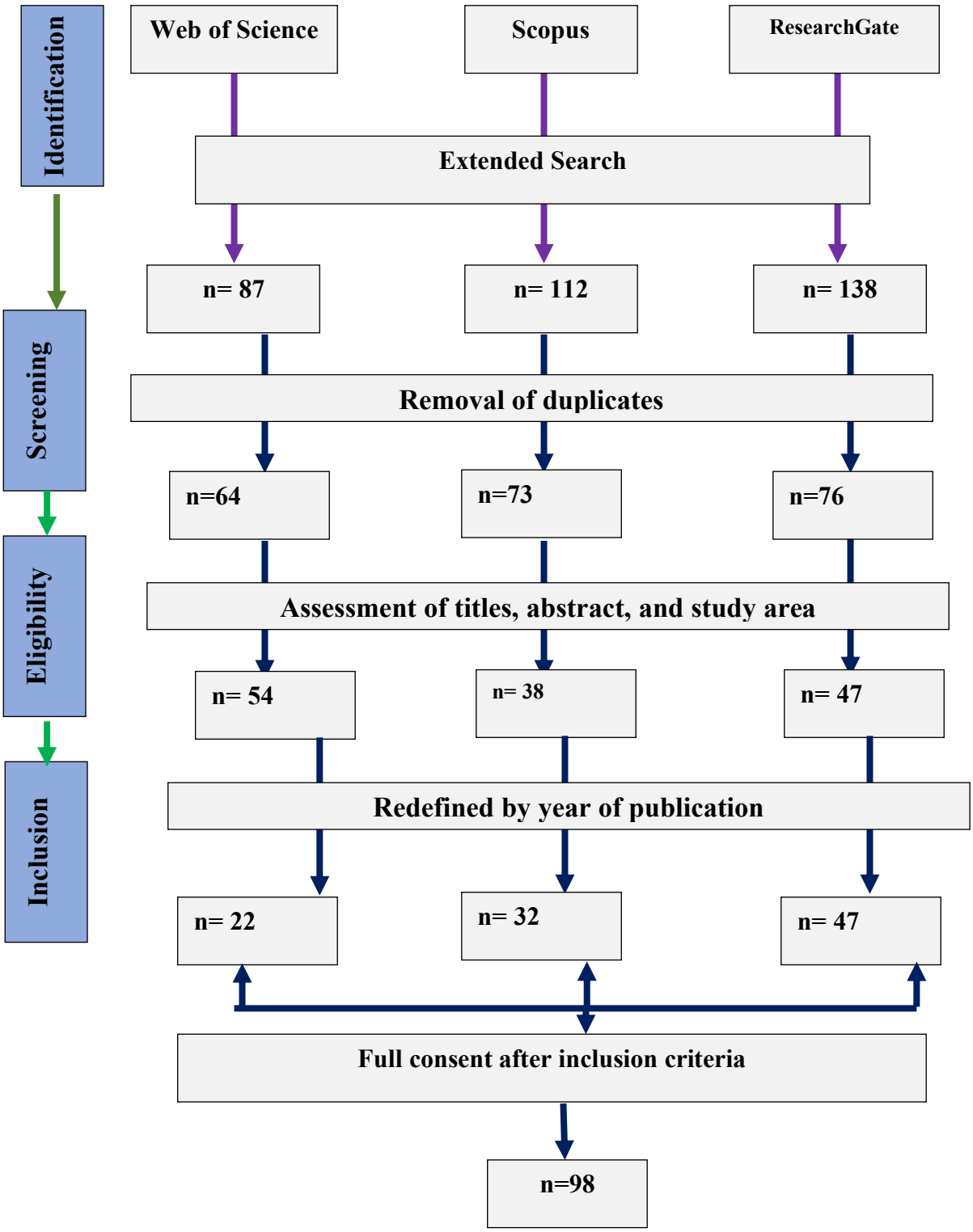

Figure 1: PRISMA selection process schema

Results and Discussion

Regions that conducted Climate Smart Agriculture studies

South-western Nigeria was the most studied region with 28% of the articles as shown in **Error! Reference source not found.**. The second most studied region was South-East Nigeria with 22%, followed by North Central (18%) and South-South (15%). The North-East and North-West regions accounted for 8% and 6% of publications respectively. Studies that included Nigeria and other nations covered in the review accounted for 2% of studies that focused on the sub-Saharan region and 1% that focused on the African continent. The result shows that all regions of Nigeria have contributed to the research results in the field of CSA. The regions were categorised based on the study areas reported in the studies rather than the region of the author.

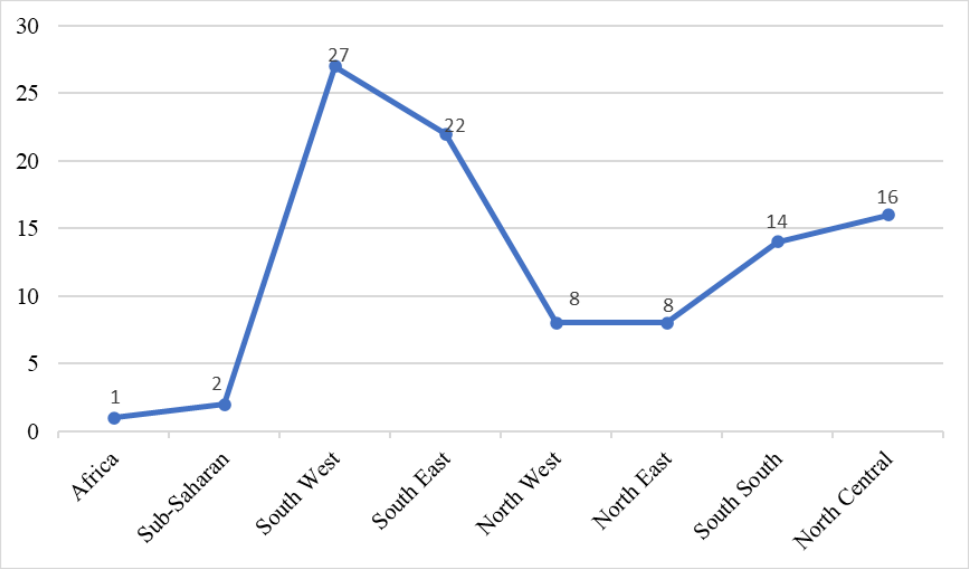

Figure 1: Regions that conducted Climate Smart Agriculture studies

Annual distribution of studies on CSA

The number of studies increased between 2021 and 2023, 2016 and 2018, as shown in **Error! Reference source not found.**. The highest number of publications, 16 each, was observed in 2018 and 2023. This is consistent with Barasa *et al.* (2021) who recorded a progression in the number of research outputs in CSA in Africa from 47 in 2018 to 56 in 2020. This can be attributed to an increasing need for research due to the detrimental effects of climate change. It also facilitates research into improved agricultural practices to ensure that more efforts are made to mitigate the future impacts of climate change on agriculture.

Table 2. Annual distribution of CSA publications

YEAR	NUMBER OF PUBLICATIONS	PERCENTAGE
2014	6	6.12
2015	3	3.06
2016	5	5.10
2017	7	7.14
2018	16	16.33
2019	8	8.16
2020	6	6.12
2021	8	8.16
2022	11	11.22
2023	16	16.33
2024	12	12.24

Methodologies by the authors

For 74% of the selected articles, the researchers (Eta *et al*, 2023; Gbadebo *et al*, 2022a; Adebayo & Ojogu, 2019; Gabriel *et al*, 2023; Adeagbo *et al*, 2023; Ukwuaba & Ileka, 2024; Mailumo *et al*, 2021; Oduntan *et al*, 2022) used interviews, most of which were designed as in-depth interviews, and the data were analysed using statistical tools as shown on **Error! Reference source not found.**. On the other hand, 9% of the studies (Mashi *et al*., 2022; Jellason *et al*., 2021; Salisu, 2022; Awoniyi *et al*., 2023) conducted focused group discussions, 4% (Aduramigba-Modupe & Amapu, 2023; Adekoya *et al,* 2023; Ogundele & Adeyemo, 2021; Olayide & Labode, 2016; Alehile, 2023) used statistical models to analyse secondary data and 3% used field observation. Other studies combined different research methods, for example, conducting a case study with field observation or a document search and field observation for their studies (Ifeanyi-Obi, *et al*., 2021; Okoronkwo, *et al*., 2024; Terdoo, 2020).

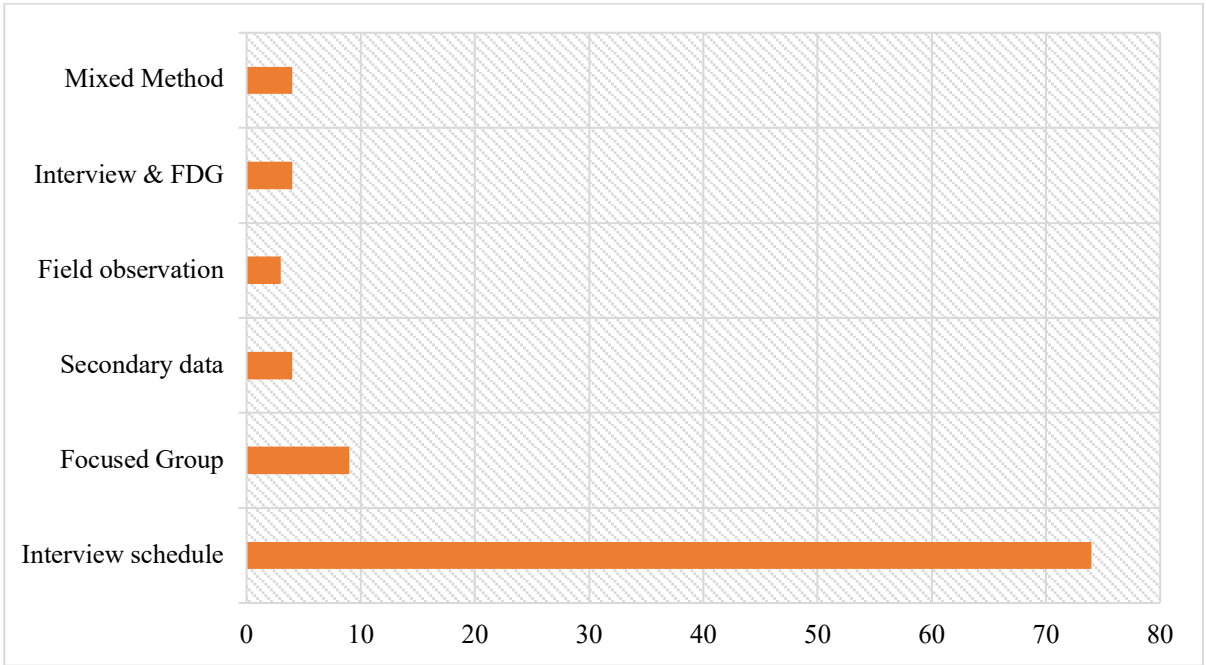

Figure 2: Research methodologies by the authors.

Awareness of climate-smart agriculture

Error! Reference source not found. shows that about 67% of publications reported that farmers are aware of CSA (Eta *et al*., 2023; Gabriel *et al*., 2023; Ifeanyi-Obi *et al*., 2021; Oduntan *et al*., 2022; Oyetunde-Usman & Shee, 2023). Tabe-Ojong *et al*. (2023) reported that although some farmers in the sub-Saharan region are not practicing CSA, the majority are aware of these practices. Farmers who are not aware of climate-smart agriculture are unable to provide correct answers to queries on CSA. The result agrees with Ekpa *et al.* (2021) and Mashi *et al*. (2022) who reported lack of awareness as a major problem in the adoption of CSA in Nigeria. Also, Ifeanyi-Obi *et al*. (2021) and Alhassan and Umoru (2024) reported a knowledge gap on CSA in Nigeria, which has delayed the integration of possible interventions by policymakers.

Farmers may not easily evaluate adaptation strategies that mitigate the negative outcomes of climate change (Agou *et al.*, 2024). This may lead to low implementation of CSA practices in Nigeria and an unsustainable agricultural system with low resilience to the challenges of climate change in addition to other associated issues that hinder sustainable food production. This also raises the question of what drives farmers to adopt CSA and what influences the various strategies they adopt to ameliorate the negative effects of climate change.

Table 3. Distribution of awareness of climate-smart agriculture according to the proportion of publications

AWARENESS	FREQUENCY	PERCENTAGE
Yes	66	67.00
No	32	33.00

Sources of information on climate-smart agriculture

The main sources of information on CSA were radio and television (46%) (Eta *et al*., 2023; Okoronkwo *et al*., 2024; Elizabeth *et al*., 2024; Oresanya & Olajide, 2023), cooperative organizations (12%) (Mbanasor *et al*., 2024; Adebayo & Ojogu, 2019; Isiwu & Ojone, 2023; Oresanya & Olajide, 2023), extension officers (18%) (Elizabeth *et al*., 2024; Isiwu & Ojone, 2023; Mbanasor *et al*., 2024; Oresanya & Olajide, 2023), internet services (8%) (Eta *et al*., 2023; Gabriel *et al*., 2023; Isiwu & Ojone, 2023), print media (11%)(Isiwu & Ojone, 2023; Mbanasor *et al*., 2024; Oresanya & Olajide, 2023; Adebayo & Ojogu, 2019) as presented in Table 4. Other sources of information mentioned in the literature are observation and experience (6%) (Gabriel *et al.*, 2023; Okoronkwo *et al*., 2024; Adebayo & Ojogu, 2019; Elizabeth *et al*., 2024; Oresanya & Olajide, 2023; Mbanasor *et al*., 2024; Isiwu & Ojone, 2023). This implies that farmers engaged multiple sources of information on CSA. The findings concur with Antwi-Agyei *et al.* (2021) who reported that radio is a variable means of disseminating information to farmers in the West African region, thereby filling gaps and improving awareness and knowledge on climate-related issues in agriculture. Furthermore, it was recognized that radio stations can reach a wider audience and provide information on climate change that is specific to the location and meets the needs of the listeners (Alidu *et al*., 2022). Providing real-time information to farmers on CSA is very important. However, Amoak *et al*. (2023) found in a study in Malawi and Ghana that the importance of climate change information sources is location-specific and that certain sources may hinder the effectiveness of the information.

One of the tasks of cooperatives is to pass on information about agricultural production to farmers. Sharing ideas within cooperatives promotes the dissemination of practicable knowledge, indigenous practices and adaptation strategies (Ahmed & Mesfin, 2017). Farmers can acquire knowledge through each other's achievements, and this makes peer collaboration an important aspect of adopting CSA.

The use of the Internet has steadily improved the dissemination of information, especially among young, educated farmers (Izuogu *et al*., 2025). However, the aging population of farmers in Nigeria stands in the way of effective use of the internet, so innovative new ideas, such as CSA practices, do not reach them.

The low percentage of farmers who learned about CSA through the print media may be due to the low literacy level of farmers in Nigeria (Mbanasor *et al*., 2024). It should be emphasised that although these communication channels were prevalent in the studies, there are differences in the level of usage and efficiency between the different regions and states in Nigeria.

Table 4. Distribution of sources of information by proportion of publications

SOURCE OF INFORMATION	FREQUENCY	PERCENTAGE
Radio and television	45	46
Extension officers	18	18
Cooperative organizations	12	12
Print media	11	11
Internet services	45	8
Observation and experience	6	6

**Multiple responses were recorded*

Categories of CSA practices

Error! Reference source not found. shows the list of CSA practices that were discussed in the selected articles. Across all studies, 214 CSA practices were discussed in the 98 articles. These practices were grouped into six categories identified by Nwajiuba *et al*. (2015): 1) Adapted Crop Varieties (ACV), 2) Indigenous Knowledge (IK), 3) Agricultural Water Management (AWM), 4) Organic Agriculture (OA), 5) Integrated Crop Management (ICM), and 6) Conservation Agriculture (CA). Farmers' preferences, needs, and expectations were the determining factors for the choice of their specific practice (Mbanasor *et al*., 2024). The analysed articles show that farmers combine different approaches to CSA in their production activities. On the specific approaches, the studies (Eta *et al*., 2023, Ukwuaba & Ileka, 2024; Mailumo *et al*., 2021; Igberi *et al*., 2022; Gbadebo *et al*., 2022b; Jellason *et al*., 2021; Nwajiuba *et al*., 2015; Isiwu & Ojone, 2023; Muhammed *et al*., 2023; Olorunfemi *et* al., 2020; Olayide & Labode, 2016; Oyawole *et al*., 2020; Tiamiyu *et al*., 2018; Adebayo & Ojogu, 2019; Saadu *et al*., 2024; Njoku *et al.,* 2024; Tabe-ojong *et al*., 2023; Elizabeth *et al*., 2024; Mbanasor *et al*., 2024) show that farmers mainly apply indigenous knowledge (43%), which includes agronomic practices like altering planting dates and using natural pest and weed control systems.

About (32%) of the reviewed articles (Eta *et al.*, 2023; Adebayo & Ojogu, 2021; Ojoko *et al.*, 2017; Sylvester *et al.*, 2024; Jellason *et al.*, 2021; Opeyemi *et al.*, 2021; Okoronkwo *et al.*, 2024; Adekoya *et al*., 2023; Oyawole *et al*., 2020; Alhassan *et al*., 2022; Olayide & Labode, 2016; Nwajiuba *et al*., 2015; Wahab *et al*., 2020; Olorunfemi *et al*., 2020; Tiamiyu *et al*., 2018; Akinyemi *et al*., 2021; Elizabeth *et al*., 2024; Mbanasor *et al*., 2024) reported that farmers practice conservation agriculture such as covering the soil with residues which ensures that soil erosion and leaching are minimized. Other conservation farming practices adopted by farmers include crop rotation, strip cropping and minimum tillage (Isiwu and Ojone, 2023; Saadu *et al*., 2024; Akinyemi *et al*., 2021; Tabe-ojong *et al*., 2023; Onyeneke *et al*., 2021; Adebayo & Ojogu, 2019; Oyawole *et al*., 2020; Alhassan *et al*., 2022; Olorunfemi *et* al., 2020; Adekoya *et al*., 2023; Wahab *et al*., 2020). This agrees with Mbanasor *et al*. (2024) that Nigerian farmers practice conservation agriculture as an approach to mitigating the influence of climate change.

Cultivation of adapted crops (disease-resistant and high-yielding, drought and flood-resistant varieties) was the least utilized (9%) by farmers (Phiri *et al*., 2022; Adebayo & Ojogu, 2019; Njoku *et al*., 2024; Olorunfemi *et* al., 2020; Adekoya *et al*., 2023; Jellason *et al*., 2021; Ifeanyi-

Obi *et al*., 2021 ; Izuogu *et al.,* 2023 ; Oloruntoba, *et al*., 2022; Tiamiyu *et al*., 2018; Olayide & Labode, 2016; Nwajiuba *et al*., 2015; Onyeneke *et al*., 2021; Alhassan et al., 2022; Wahab et al., 2020; Tabe-ojong *et al*., 2023; Isiwu & Ojone, 2023; Oyawole *et al*., 2020) reported low utilization of certified seed varieties by farmers in Nigeria. This agrees with Sanogo *et al*. (2023) and Ankrah *et al.* (2021) who observed that crop rotation, mixed cropping, and improved varieties are the major climate-smart practices among farmers in West Africa.

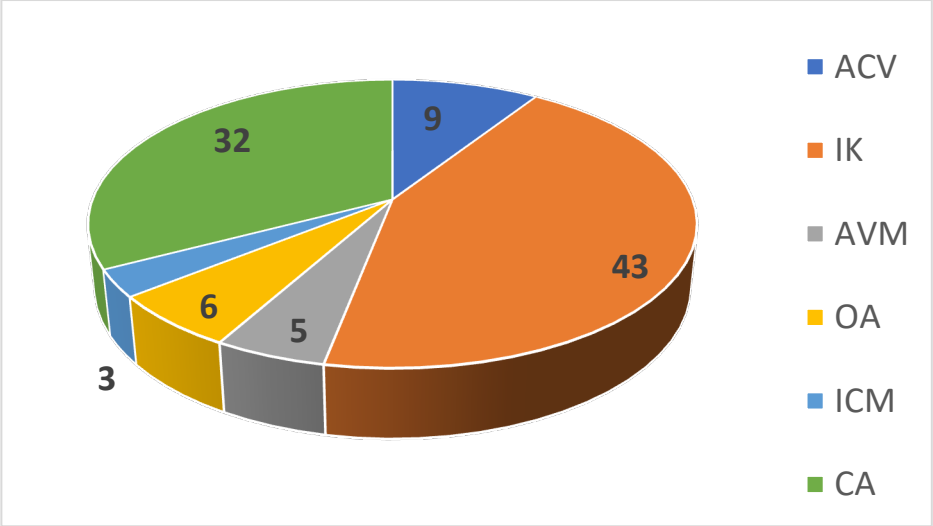

Figure 4: Climate-smart agriculture strategies identified by the studies

Determinants for the adoption of CSA practices

Climate-smart agriculture in Nigeria is influenced by several factors as shown in Figure 3. These factors were mentioned in 62 of the 98 studies. The determinants presented in these studies differ across publications. These discrepancies may be because the factors influencing the implementation of CSA across the country are site-specific.

Farmers' access to agricultural credit showed a significant and positive relationship with the practice of CSA in 43 articles (Ojo *et al*., 2023, Alhassan *et al*., 2022; Mbanasor *et al*., 2024; Gbadebo *et al*., 2022a; Okpokiri *et al*., 2021; Etim & Ndaeyo, 2020; Adebisi *et al*., 2022; Elizabeth *et al*., 2024; Gbadebo *et al*, 2022b, Emmanuel *et al*., 2025; Uduma & Nwaobiala, 2023; Adeagbo *et al*., 2023, Ojoko *et al*., 2017; Emenyonu *et al*., 2020; Omotayo & Omotoso, 2024; Goodluck *et al*., 2024; Olawuyi & Mushunje, 2020). This means that the adoption of CSA by farmers will increase if their access to credit is improved. Insufficient financial resources discourage farmers from taking risks as they have no guarantee of the financial leverage associated with implementing agricultural innovations. Low-income farmers cannot easily afford some of the identified climate-friendly agricultural practices (Oduntan *et al*., 2022). Furthermore, the availability of agricultural credit will facilitate the transition from a small-scale adopter of CSA to a large-scale adopter. If farmers have access to credit, they will be encouraged to acquire additional technologies that would have been expensive to purchase. This agrees with Tiamiyu, *et al.* (2017) who reported that agricultural credit access supports production expansion through the acquisition of improved agricultural inputs and technologies such as climate-smart agriculture.

Studies (32) reported that contact with agricultural extension officers is significantly positively related to CSA adoption (Ojo *et al*, 2023; Alhassan *et al*., 2022; Olawuyi & Mushunje, 2020; Elizabeth *et al*., 2024; Adebayo & Ojogu, 2019; Mbanasor *et al*., 2024; Obi-Egbebi & Oladapo 2020; Etim & Ndaeyo, 2020; Olorunfemi *et al*., 2020; Emmanuel *et al*., 2025; Goodluck *et al*., 2024; Adebisi *et al*., 2022; Omotayo & Omotoso, 2024; Emenyonu *et al*., 2020; Igberi *et al*., 2022; Gbadebo *et al*, 2022b; Adeagbo *et al*, 2023; Oduntan *et al*, 2022; Ekpa & Ekpa, 2021; Eta *et al*., 2023; Alhassan & Umoru, 2024). This implies that the probability of

farmers' adoption of CSA increases with an increase in extension contacts. Agricultural extension service in Nigeria is saddled with the responsibility of disseminating improved agricultural inputs and practices to farmers. Baiyegunhi *et al*. (2019) acknowledged that access to real-time production information facilitates innovation adoption among farmers. This is consistent with Mashi *et al*. (2022) who reported that the adoption of climate-smart agriculture by farmers in Nigeria increased with an increase in extension contact. Farmers who receive instantaneous information demonstrate more likelihood of adopting innovations due to their access to on-farm evaluations and this increases the possibility of adopting the technologies. This lays credence to the need for more field extension workers, especially as agricultural production experiences climate change and rapid technology development.

The relationship between the respondents' gender and adoption of CSA showed conflicting outcomes across the 12 studies that reported its influence on CSA adoption. When compared to female farmers, male farmers were more likely to adopt CSA practices (Ojo *et al*., 2023; Mashi *et al*., 2022; Adeagbo *et al*., 2023; Teklewold, 2023; Ekpa *et al*., 2017; Okpokiri *et al*., 2021; Mbanasor *et al*., 2024; Emmanuel *et al*., 2025; Omotayo & Omotoso, 2024; Obi-Egbebi, & Oladapo 2020; Njoku *et al*., 2025; Uduma & Nwaobiala, 2023; Mailumo *et al*. 2021), while Ogundele and Adeyemo (2021) observed that female farmers adopted CSA practices more than the males. Adeagbo *et al*. (2023) opined that male farmers undertake more production risks and also experiment on new agronomic practices more than female farmers. In terms of the adoption of improved seed varieties to combat climate change, Izuogu *et al*. (2023) indicated that male farmers grow more certified seeds than female farmers. The importance of understanding gender interaction with climate change for agricultural development cannot be over-emphasized. This is in line with Okello *et al*. (2018) and Ankrah *et al*. (2020) that gender influences farmers' perception of decision-making about climate change adaptation in Nigeria due to inequality in agricultural resource distribution. Women are more active in climate action because of their vast understanding of the immediate environment which is a product of their experience in the utilization of natural resources such as water, biodiversity, and soil (Waaswa *et al*., 2021).

As farmers' years of farming experience increases, the likelihood of their adoption of CSA practices increases (Ukwuaba & Ileka, 2024; Emmanuel *et al*., 2025; Okpokiri *et al*., 2021; Olorunfemi et al., 2020; Opeyemi *et al.*, 2021; Adegbite & Garube, 2024; Uduma & Nwaobiala, 2023; Oduntan *et al*., 2022; Adegbite & Garube, 2024; Mbanasor *et al*., 2024; Gbadebo *et al*., 2022a; Henri-Ukoha & Walisam, 2018; Gbadebo *et al.*, 2022b). The accumulation of years of experience in agriculture is essential because it helps farmers in critical decision-making to ameliorate climate change impact as they adopt alternative agronomic practices based on their knowledge of the trend of climatic variables. Onyeneke *et al*. (2021) opined that more experienced farmers adopted climate-smart agricultural practices in Southeastern Nigeria. In related studies by Choudhary *et al*. (2018) and Assefa *et al*. (2020), it was revealed that the likelihood of implementation of conservation agriculture is positively influenced by years of farming experience.

Fourteen of the sixty-two studies showed that the more farmers' level of education increases, the probability of their adoption of CSA increases (Gbadebo *et al*, 2022b; Emmanuel *et al*., 2025; Adegbite & Garube, 2024; Alhassan *et al*., 2022; Adebisi *et al*., 2022; Elizabeth *et al*., 2024; Mbanasor *et al*., 2024; Okpokiri *et al*., 2021; Etim & Ndaeyo, 2020; Gbadebo *et al*., 2022a; Igberi *et al*., 2022; Olorunfemi *et al*., 2020; Adeagbo *et al*, 2023; Ukwuaba & Ileka, 2024; Ojoko *et al*, 2017; Ekpa & Ekpa, 2021; Phiri *et al*, 2022; Chigozirim *et al*., 2022; Uduma & Nwaobiala, 2023). However, in a contradicting observation, Alhassan and Umoru, (2024) and Ekpa *et al*. (2017) indicated that an increase in the level of education led to a decrease in the rate of CSA implementation. Kassa and Abdi (2022) agree that education and risk orientation have a positive significant relationship with CSA adoption. Cooley *et al*. (2022) and Bamlaku and Abera (2022) confirm the positive relationship between education and the implementation

of CSA, noting that education increases technical efficiency because as farmers acquire more education, the likelihood of their adoption of soil cover, zero tillage and plant improved varieties increases (Amare *et al*., 2022; Diallo *et al*., 2020). Gbadebo *et al*. (2022b) reported that educated farmers adopted more climate-smart practices in Nigeria when compared to the non-educated farmers. Higher levels of education are expected to improve farmers' information-seeking behaviour and also ensure that the information received is effectively processed to choose the best alternatives to adapt to climate change threats (Adeagbo *et al*., 2023). This will ensure that farmers make informed decisions, improve the quality of agricultural work, and identify opportunities to maximize profits where they exist.

Membership in a cooperative society was reported to have a positively influenced CSA implementation by 38 studies (Ojoko *et al*., 2017, Saadu *et al*., 2024, Emmanuel *et al*., 2025; Phiri *et al*., 2022; Okpokiri *et al*., 2021; Mbanasor *et al*., 2024). Membership in a cooperative offers several benefits to farmers such as the opportunity to learn innovative practices through cross-fertilization of knowledge, access to agricultural credit as well as receiving relevant training (Akinbode & Bamire, 2015). This finding agrees with Oparaojiaku *et al.* (2024) that farmers in Nigeria are more likely to adopt climate-smart agriculture practices when they join agricultural associations. As a farmer social group, cooperatives play a key role in educating farmers. Therefore, farmers who identify with cooperatives tend to be better informed and more receptive to improved agricultural practices that enhance agricultural productivity than non-members (Ojoko *et al*., 2017). Apart from networking for efficient agricultural labour services, cooperatives also serve as a conduit for many climate change interventions as they have the advantage of reaching a larger audience at once. Diallo *et al*. (2020) reported that membership in cooperative membership propels the chances of farmers in Nigeria using improved seeds in their adaptation to climate change.

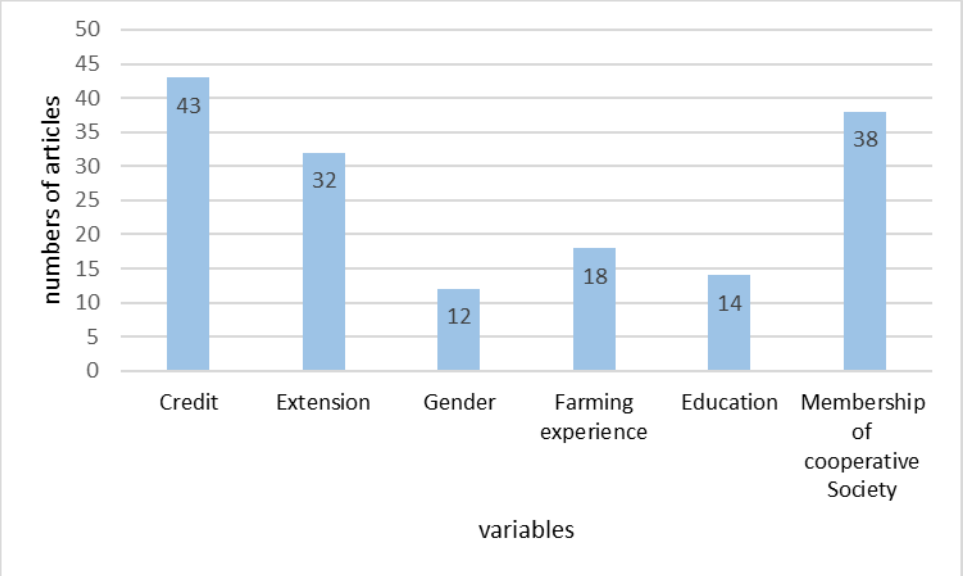

Figure 3: Reportage on the determinants of adoption of climate-smart agriculture in articles. Note: multiple counting was recorded

Benefits of implementing CSA practices

Many benefits of adopting CSA were reported in the articles reviewed. Farmers have implemented CSA practices to secure such benefits as increasing agricultural yields (Gabriel *et al.,*2023; Kolapo & Kolapo, 2023; Olawuyi & Mushunje, 2020; Saadu *et al.,* 2024; Njoku *et al.,* 2024; Fanen & Olalekan, 2014; Goodluck *et al*., 2024), improving soil health (Gabriel *et al.,*2023; Olawuyi & Mushunje, 2020; Fanen & Olalekan, 2014), increase in farm net income, (Kolapo & Kolapo, 2023; Ekpa *et al.,* 2017; Yekinni & Ladigbolu, 2023; Saadu *et al*., 2024;

Olawuyi & Mushunje, 2020; Goodluck *et al*., 2024; Solaja *et al*., 2024), reduction in post-harvest losses(Gabriel *et al.,* 2023), reduction in the exposure of farm-families to agrochemicals (Yekinni & Ladigbolu, 2023; Adegbite & Garube, 2024), reduction in environmental challenges (Fanen & Olalekan, 2014) and reduction in the level of food insecurity (Ekpa *et al.,* 2017; Gbadebo *et al*., 2022b; Saadu *et al.,* 2024; Adegbite & Garube, 2024). This implies that when farmers implemented CSA, they were able to increase agricultural production, as an increase in crop production usually leads to increased income and a reduction in farmers' poverty, this will bring about improvement in their level of food security. Kolapo and Kolapo (2023) think that farmers' net incomes increase when yields increase as a result of adopting CSA practices. As reported by Saadu *et al* (2024), crop yields of farmers practicing CSA increased by $17.62 while food expenditure increased by $20.00. Also, compared to existing farm practices, CSA avails farmers of increased food and feed production and a reduction in the emission of greenhouse gases. It was reported that farmers who adopted the conservation agriculture package of CSA earned higher net income compared to non-adopters. This is consistent with Omotoso *et al*. (2024) who established a direct positive relationship between CSA implementation and improvement in household nutrition suggesting that CSA practices enabled adopters to diversify their diets and increase their per capita food consumption among farming households. It also implies that the implementation of CSA is useful for farmers who adopt the practice. Njoku *et al*. (2024) observed that farmers in Nigeria benefitted from the practice of CSA through improved agricultural production, reduced vulnerability, and higher market value of farm produce.

These findings also agree with Adetomiwa and Adeyera (2023) who reported increased crop productivity in kg/ha when farmers implemented CSA packages. According to their results, farmers would have had a lower crop yield if they had ignored CSA practices. When farmers practiced zero tillage with cover crops and crop rotation, they reported a yield of 1245 kg/ha. This means that the practice led to a noticeable increase in their yields. Saadu *et al*. (2024) used linear regression with an endogenous treatment effects model to find that the adoption of CSA positively affected farmers' crop yields by 21.9 % by increasing the values of technical efficiency. In South Africa, Omotosho *et al*. (2024) revealed that agricultural yield increased with farmers' adoption of CSA. One of the strategies of CSA is the practice of agricultural water management such as soil and water conservation and this is reported to have increased farmers' income through the improvement of soil fertility and quantity of water available for arable crop production.

When farmers adopt climate-smart practices in agriculture, they have a comparative advantage over non-adopters in terms of higher production, increased income, and improved crop protection (Gbadebo *et al.,* 2022b).

The findings are consistent with reports from other countries where farmers have realized the aforementioned benefits through the adoption of CSA. CSA implementation reduced poverty rate with the attendant increase in standard of living among farmers. Several studies have reported that the adoption of CSA has had a positive influence on farmers' resilience capacity. (Ali *et al*., 2022; Habtewold *et al*., 2021; Abegunde *et al.,* 2022; Mujeyi *et al*., 2021; Nkumulwa & Pauline, 2021; Adego *et al*., 2019; Diallo *et al*., 2020; Bedeke *et al*., 2019).

Challenges of CSA practices

The implementation of CSA in Nigeria is faced with several challenges. This review showed (**Error! Reference source not found.**) that the absence of government policies and incentives (8), high costs of implementing some of the practices (49), inadequate funding for agricultural production (51), lack of information (27), and lack of access to extension services (21) were they key challenges highlighted in the articles considered to hinder climate-smart

implementation across Nigeria. It is worthy of note that several articles considered implicated inadequate funding for agricultural production (Adebayo & Ojogu, 2021; James, 2019; Chigozirim *et al*., 2022; Ifeanyi-Obi, *et al.,* 2021; Okpokiri *et al*., 2021; Goodluck *et al*., 2024 ; Elizabeth *et al*., 2024; Shehu , 2024; Terdoo, 2020; Opeyemi *et al*., 2021; Salisu, 2022; Ekpa *et al*., 2017; Ekpa *et al*., 2021; Onyeneke *et al*., 2018; Okoronkwo *et al*., 2024; Olugbenga *et al*.,2023; Apeh *et al*., 2024; Sylvester *et al*., 2024; Njoku *et al*., 2024; Adebayo *et al*., 2019; Emmanuel *et al*., 2025) as a challenge to implementation of CSA, this followed by high costs of implementing some of the practices (Opeyemi *et al*., 2021; Chigozirim *et al*., 2022; Unaeze *et al*., 2023; Shehu , 2024; Ifabiyi *et al*., 2024; Ekpa *et al*., 2021; Terdoo, 2020; Okoronkwo *et al*., 2024; Njoku *et al*., 2024; Emmanuel *et al*., 2025 Ifeanyi-Obi *et al*., 2021; Sylvester *et al*., 2024; Akinyemi *et al*., 2021), lack of information (Opeyemi *et al*., 2021; Terdoo, 2020; Gbadebo *et al*., 2022; Goodluck *et al*., 2024; Chigozirim *et al*., 2022), non-availability of extension workers (Shehu , 2024; Igberi *et al*., 2022; Ekpa *et al*., 2017; Elizabeth *et al*., 2024; Goodluck *et al*., 2024 ; Gbadebo *et al*., 2022b; Onyeneke *et al*., 2018; Salisu, 2022; Apeh *et al*., 2024; Ifeanyi-Obi *et al*., 2021; Olugbenga *et al*., 2023; Sylvester *et al*., 2024; Akinyemi *et al*., 2021; Emmanuel *et al*., 2025), non-active involvement of government agencies (Goodluck *et al*., 2024 ; Elizabeth *et al*., 2024; Shehu , 2024; Terdoo & Adekola, 2014; Ekpa *et al*., 2021; Igberi *et al*., 2022; Olugbenga *et al*.,2023; Adebayo *et al*., 2019;), poor access to agricultural inputs (Ekpa *et al*., 2017; Igberi *et al*., 2022; Okpokiri *et al*., 2021; Onyeneke *et al*., 2018; Elizabeth *et al*., 2024; Goodluck *et al*., 2024 ; James , 2019 Ifeanyi-Obi *et al*., 2021; Apeh *et al*., 2024; Adebayo *et al*., 2019; Chigozirim *et al*., 2022). . It can be implied from this review that funding is a critical part of CSA practices that if not available may create a major setback in its implementation. In a previous study of farmers in Nigeria, Igberi *et al.* (2022) highlighted the the challenges of the implementation of climate-smart agriculture including the absence of information, high cost of implementation, and inconsistent government policies.

The findings here are consistent with the position of the Food and Agriculture Organisation of the United Nations (FAO) and International Crop Research for the Semi-Arid Tropics (ICRISAT) (2019), which reported that funding for CSA in Nigeria is limited. The authors pointed out that access to global climate finance from international partners such as the Green Climate Fund and the Global Environment Facility is possible through effective preparation and capacity development activities. The absence of funds to support CSA practice has emerged as a pressing barrier. This is because the implementation of CSA demands upfront financing. Shittu *et al*. (2021) reported that the absence of this can lead to the delay in realizing the expected benefits.

According to Wakweya (2023), existing government regulations relating to climate change adaptation and mitigation are not adequately enforced due to a lack of legal guidance for citizens. Jayne *et al*. (2018) and Davis *et al*. (2022) observed that the inadequacy of extension officers and support services in African countries has hindered the transfer of CSA messages to farmers. This has resulted in low awareness and a lack of knowledge of CSA practices. On other occasions, they observed that the transferred CSA practices do not specifically address the needs of the smallholder farmers. The findings are in line with Oduntan *et al.* (2022) who observed that irrespective of the attendant gains of CSA, barriers such as inadequate financial resources, low level of technical skills, absence of risk advisory services, and incorrect information on innovations may hinder the implementation of the practice by farmers in Nigeria.

These challenges are similar to those identified by Kongsager (2017), Jones *et al.* (2023), Long *et al*. (2016), and Wassie and Pauline (2018) in other countries in the sub-region. These challenges negatively influence farmers' reception of CSA as well as the crucial target of reducing food insecurity and supporting national development.

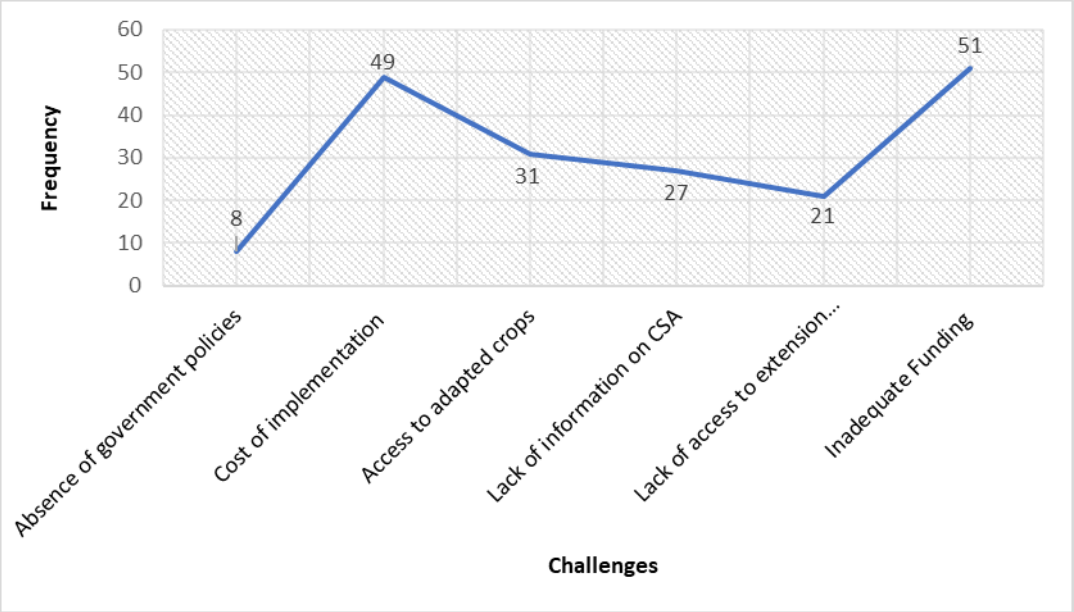

Figure 4: Reportage on Challenges to the Adoption of Climate Smart Agriculture according to the proportion of publications. Note: Multiple counting was recorded.

Conclusion and Recommendation

The study concludes that even most of the farmers in Nigeria are aware of climate-smart agricultural practices in Nigeria though radio and television served as the main sources of information. The main category of climate-smart agriculture practiced by farmers in Nigeria is conservation agriculture. Key factors influencing CSA adoption include access to credit, agricultural extension services, education, and farming experience. Farmers who implemented CSA have seen improvements in crop yields, soil health, and food security. However, several barriers to adoption persist, such as inadequate government support, insufficient extension services, and a lack of technical skills. Furthermore, limited studies exist on farmers' perceptions and the benefits of CSA in Nigeria, highlighting a gap in research and understanding.

To promote the adoption of CSA which will support farmers' resilience, improve agricultural production, and sustainable environmental management, the study recommends that governmental and non-governmental should increase the creation of awareness through the mass media. Extension organizations should be revitalized with the private sector playing more active roles in the dissemination of agricultural information. Farmers should be encouraged to adopt other categories of climate-smart agriculture such as the cultivation of adapted crop varieties and organic agriculture. Funds should be made available to farmers in Nigeria to facilitate their implementation of climate-smart agriculture and ensure that they access the benefits of these practices. The government should enact policies that will support the development of farmers' technical skill capacity for the implementation of climate-smart agriculture. Also, more studies should be conducted to assess farmers' perceptions of CSA to ensure that policies are data-driven with farmers' needs.

Conflict of interest

All the authors declare that there is absence of conflict of interest as it concerns the publication of this article.

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Ethical clearance

The study does not require ethical clearance as the systematic reviews did not involve human subjects, animals, or any sensitive data.

Data availability statement

The set of data analysed during the study are available through the corresponding author if the request is reasonable enough.

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ARTICLE DETAILS	KEY FINDING
GENERAL INFORMATION ON CLIMATE-SMART AGRICULTURE	
Adeagbo, O. A., Bamire, A. S., Akinola, A. A., Adeagbo, A. D., Oluwole, T. S., Ojedokun, O. A., Ojo, T. O., Kassem, H. S., and Emenike, C. U. (2023). The level of adoption of multiple CC adaptation strategies: Evidence from smallholder maize farmers in Southwest Nigeria. *Scientific African*, 22, e01971. https://doi.org/10.1016/j.sciaf.2023.e01971	Planting of improved maize variety, changing planting date, minimum tillage, crop rotation, intercropping, fertilizer quantity adjustment, and non-agronomic activities were among the CSA practices identified Sex, age, years of education. access to credit influenced adoption of CSA
Adeagbo, O. A., Ojo, T. O., & Adetoro, A. A. (2021). Understanding the determinants of climate change adaptation strategies among smallholder maize farmers in South-west, Nigeria. *Heliyon*. https://doi.org/10.1016/j.heliyon.2021.e06231	CSA practices included Agroforestry, crop rotation, drought tolerance, early planting, intercropping, mulching, soil water conservation. Household size, frequency of extension visits, non-farm income influenced adoption of CSA
Agoh E.C, Chukwuemeka O.S, Ekeledo P.I., Udemezue, J.C. (2024) Gender Roles on Climate Smart Agriculture on Small Holders Farmers of some Selected Root and Tuber Crops in Imo State, Nigeria, *Global Journal of Research in Agriculture and Life Sciences* ISSN: 2583-4576 04 (05)	Climate-smart agricultural practices identified include mixed farming, integrated pest management, mulching and adjusting planting dates. Age influenced CSA adoption
Alhassan, U., & Umoru, H. E. (2024). Rural farmers' perceptions of and adaptations to CC in Sub-Saharan Africa: Does CSA matter in Nigeria and Ethiopia? *Environmental Economics and Policy Studies, 26*, 613–652. https://doi.org/10.1007/s10018-023-00388-8	Key CSA practices were highlighted to include cover cropping, adoption of minimum tillage, practice of crop rotation with legumes, etc Determinants of adoption of climate smart agriculture were age, education, farm size, access to extension services
Alhassan, Y. J., Sanchi, I. D., Ikpe, E., & Norbert, S. (2022). Assessment of CSA practices adopted by crop farmers in adapting to CC and environmental issues in Zamfara State, Nigeria. *Discoveries in Agriculture and Food Sciences, 10*(5), 58–70	Prevalent CSAP adopted by the farmers were: cover cropping, application of organic manures, adoption of minimum tillage, practice of crop rotation with legumes, usage of mulching, application of inorganic fertilizers and planting of improved seed varieties Determinants of CSA adoption included age, education, access to extension services, and access to credit facilities.
Apeh, C. C., Agbugba, I. K., Apeh, A. C., Okere, R. A., & Mzuyanda, C. (2024). Women's participation in climate-smart agriculture (CSA) in Southeast Nigeria. *Rwanda Journal of Agricultural Sciences, 3*, 1	Farmers are aware of CSA practices. Sources of information include community leaders, women groups and relatives. High-yielding crop varieties, crop diversification, change in planting calendar, fertilizers and manure application, minimum/zero tillage, cover cropping, mulching, fallowing, mixed cropping and crop rotation as CSA practices used by farmers
Isiwu, E. C., & Ojone, A. S. (2023). Strategies for promoting climate-smart agricultural practices among smallholder farmers for sustainable development in Enugu State, Nigeria. *Journal of Sustainable Development in Africa, 25*(3).	Identified channels of awareness to include agricultural bulletins, broadcast through radio or television channels

	CSA practices included rainwater harvesting, planting drought resistant crops, mulching, intensified use of organic matter), irrigation, minimum tillage, zero bush burning, bush fallowing, crop rotation
Mashi, S. A., Inkani, A. I., & Obaro, D. O. (2022). Determinants of awareness levels of CSA technologies and practices of urban farmers in Kuje, Abuja, Nigeria. *Technology in Society, 8*(2), 43–56. https://doi.org/10.1016/j.techsoc.2022.102030	Farmers are aware of CSA. Marital status, gender, and religion have no effect on CSA awareness. Income levels, ownership of economic assets, availability of extension services, membership of an association influenced adoption of CSA practices.
Nyong, E. E., & Bassey, D. E. (2019). Analysis of adaptation of climate-smart agricultural practices of yam farmers in Akwa Ibom State, Nigeria. *Journal of Agricultural and Environmental Research & Management, 4*(1), 164–177.	Education significantly encouraged implementation of CSA Practices adopted include multiple cropping, crop diversification, mulching, making of ridges, cover cropping, organic manure application, and making of mounds in farms
Obianefo, A. C., Isibor, A. C., Umebali, E. E., & Ahaneku, C. E. (n.d.). A stochastic frontier analysis of maize production efficiency and its climate-smart agricultural practice determinants in Southeast Nigeria. *International Journal of Multidisciplinary Comprehensive Research, 3*(1).	Extension service and cooperative membership influence implementation of CSA Water management, minimum tillage, residue management, use of irrigation pump for dry season planting, mulching, crop rotation, early planting, obtaining credit were practiced by farmers
Oduntan, O., Obisesan, A. A., & Ayo-Bello, T. A. (2022). Factors influencing adoption of CSA practices among maize farmers in Ondo State, Nigeria. *Journal of Economics and Allied Research, 7*(4).	Factors influencing adoption of CSA to include marital status, access to extension services, farming experience, membership of farmers' association, and access to credit List of CSA practices included integrated pest management, conservation agriculture, agro-forestry, mulching, crop rotation, crop diversification, planting of cover crops, irrigation
Ogundele, O. O., & Adeyemo, T. A. (n.d.). Temporal dynamics in climate-smart agricultural practices among smallholder farmers in Nigeria. *IOSR Journal of Environmental Science, Toxicology and Food Technology, 15*(10), 23–29.	Farmers are aware of CSA. CSA practices include planting of improved seeds, conservation agricultural practices (agroforestry, and relay cropping), crop diversification (intercropping), use of improved seeds, and the practice of soil conservation
Okoye, N. N., Weli, V. E., & Nwagbara, M. O. (2024). Climate dynamics and sweet potato yield across the agroclimatic belts of Nigeria. *International Journal of Weather, Climate Change and Conservation Research, 10*(2), 1-19.	Climate-smart innovations include technologies and farming practices, farm production processes, and postharvest management
Omotayo, A. O., & Omotoso, A. B. (2025). Climate-smart agricultural technology and gender-differentiated food and water security: Evidence from smallholder sunflower (*Helianthus annuus L.*) farmers. *Agricultural Water Management, 308*, 109276. https://doi.org/10.1016/j.agwat.2024.109276	The study concludes that CSA adoption enhances water availability, and crop yield.

Omotoso, A. B., & Omotayo, A. O. (2023). Enhancing dietary diversity and food security through the adoption of climate-smart agricultural practices in Nigeria: A micro-level evidence. *Environment, Development and Sustainability.* https://doi.org/10.1007/s10668-024-04681-8	Crop diversification, crop rotation, mulching, agroforestry, uses of organic manure, planting of improved varieties were practiced as CSA Determinants of adoption of CSA were gender of the household head, contact with an extension agent, household size, years of educational attainment of household head, farm size
Onyeneke, R. U., Amadi, M. U., Njoku, C. L., & Osuji, E. E. (2021). Climate change perception and uptake of climate-smart agriculture in rice production in Ebonyi State, Nigeria. *Atmosphere, 12*, 1503. https://doi.org/10.3390/atmos12111503	Some of the practices identified were planting improved rice varieties, insurance. planting different crops, adjusting planting and harvesting dates Challenges include lack of inputs access as their constraint, inadequate land was reported, capital, pests and diseases were also reported inadequate climate information and poor extension service
Osuafor, O. O., & Ude, K. D. (2021). Valuation of rice farmers' preferences and willingness to pay for climate-smart agricultural technologies in Southeast Nigeria. *Asian Journal of Economic Modelling, 9*, 48–57. https://doi.org/10.18488/journal.8..91.48.57	Rainwater harvesting, cover crops method, directed seeded rice, systems of rice intensification, use of solar pumps were adopted by rice farmers Primary occupation, access to credit, and distance to market, Influenced the implementation of CSA
Oyetunde-Usman, Z., & Shee, A. (2023). Adoption of drought-tolerant maize varieties and interrelated climate-smart agricultural practices in Nigeria. *Agriculture & Food Security, 12*(1). https://doi.org/10.1186/s40066-023-00429-1	Farmers are aware of CSA practices Highlighted the determinants of CSA practices
Phiri, A. T., Charimbu, M., Edewor, S. E., & Gaveta, E. (2022). Sustainable scaling of CSA technologies and practices in Sub-Saharan Africa: The case of Kenya, Malawi, and Nigeria. *Sustainability, 14*, 14709. https://doi.org/10.3390/su142214709	Gender had no significant influence on the adoption of selected CSAs. Farmers are aware of CSA Farmers practiced early planting, mulching/maximum soil cover, use of composite manure, late planting, home garden, crop diversity
Salisu, K. (2022). Barriers to the adoption of CSA practices in the dryland of northern Nigeria. *Journal of Agriculture and Agricultural Technology FUDMA, 8*(1), 232–243. https://doi.org/10.33003/jaat.2022.0801.gg087	Farmers are aware of CSA practices. Poor access to fertilizer, unavailability of extension workers, inadequate capital, unavailability of equipment among others all militating against the ability of the rural dwellers to effectively take up various CSA practices .
Tabe-Ojong, M. P. J., Aihounton, G. B. D., & Lokossou, J. C. (2023). CSA and food security: Cross-country evidence from West Africa. *Global Environmental Change, 81*, 102697. https://doi.org/10.1016/j.gloenvcha.2023.102697	CSA practices include intercropping, organic fertilisers, and planting of improved seeds, Farmers are aware of CSA practices

Terdoo, F., & Adekola, O. (2014). Assessing the role of climate-smart agriculture in combating climate change, desertification, and improving rural livelihood in Northern Nigeria. *African Journal of Agricultural Research, 9*(15), 1180–1191. https://orcid.org/0000-0001-9747-0583	Respondents in the study area are aware of CSA practices. Major challenge identified as the inactive involvement of non-governmental agencies.
Ukwuaba, I. C., & Ileka, C. M. (2024). Determinants of the extent of use of CSA practices by farm households in Southeast Nigeria. *European Modern Studies Journal.* https://doi.org/10.59573/emsj.8(2).2024.5	Identified organic manure, crop diversification, crop rotation, and mixed farming system as CSA practices Determinant of adoption were age, education, farming experience, farm size, extension access, and livestock ownership
Victory, G. O., Lizzie, O. A. & Olaitan, A. A. (2022). Climate-Smart Agricultural Practices at Oyo State-Nigeria.	Farmers are aware of CSA. Some of the CSA practices identified include altering planting dates, use of improved cassava varieties, use of mulching techniques, and agroforestry practices CSA adoption was influenced by education, farming experience, and size of farmland,
AWARENESS OF CLIMATE-SMART AGRICULTURE	
Gabriel, I., Olajuwon, F., Klauser, D., Blessing, M., & Renn, M. (2023). State of CSA practices in the North Central and Northwest zones of Nigeria. *CABI Agriculture and Bioscience, 4*, 33. https://doi.org/10.1186/s43170-023-00156-4	Farmers are aware of CSA practices. Extension services was the main source of CSA information for farmers. Major benefits of CSA included increase of productivity and reduction of crop loss
Gbadebo Olubukola Victory, Oyewolea. L., Anifowoset. O., & Iselobhorf. (2022). Adoption and utilization of climate smart agricultural practices by cassava farming households in Ido local government area, Oyo state, Nigeria. *Fudma Journal Of Sciences*, *6*(4), 107 - 111. https://doi.org/10.33003/fjs-2022-0604-1016	Farmers have adequate knowledge of climate smart agricultural practiceAdoption of CSA is constrained by low literacy level. Variables such as education, significantly influenced CSA adoption
Mailumo, S. S., Onuwa, G. C., & Oyewole, S. (2021). Adoption of CSA among food crop farmers in Birnin-Kudu Local Government Area, Jigawa State, Nigeria. *RJOAS, 2*(110). https://doi.org/10.18551/rjoas.2021-02.20	From the results, the level of awareness of climate smart agriculture was high and several adaptation strategies were consciously or unconsciously adopted and practiced by the famers CSA identified were early planting, mixed cropping, cover cropping, multiple planting dates, dry season farming, planting improved variety and late planting. Factors that influence the adoption of the CSA practices are age, headship of households, education, farm size, experience in farming, household size, and income from farming
Olorunfemi, O.D., Olorunfemi, T.O., Oladele, O.I., Malomo, J.O (2021) Knowledge of Extension Agents on Climate Smart Agricultural Initiatives in South West Nigeria. Journal of Agricultural Extension, 25 (4):	Respondents are aware of CSA. Significant factors influencing extension agents' involvement in the dissemination of CSAI are educational qualification, years of experience, and participation in CSA training.

Olorunfemi, T.O, Olorunfemi, O.D, and Oladele, O.I (2019) Determinants of the involvement of extension agents in disseminating climate smart agricultural initiatives: implication for scaling up. *J Saudi Soc Agric Sci.* https://doi.org/10.1016/j.jssas.2019.03.0031-8	There is high level of awareness of CSA practices. Extension services was a major source of CSA information. Determinants include educational qualification, participation in CSA training, and years of experience.
Unaeze, H. C., & Paul-Orekie, K. C. (2023). Assessment of cassava-based farmers' willingness to accept climate-smart agriculture in Etche Local Government Area, Rivers State. *International Journal of Agriculture and Earth Science, 9*(7).	Reported high level of CSA awareness. Respondents attested that cost of adoption were their major constraint.

SOURCES OF INFORMATION ON CLIMATE-SMART AGRICULTURE	
Adebayo, A. E., & Ojogu, E. O. (2019). Assessment of the use of CSA practices among smallholder farmers in Ogun State. *Acta Scientific Agriculture, 3*(6), 47-56. https://doi.org/10.31080/ASAG.2019.03.0473	Information on climate-smart agricultural practices was mostly obtained from fellow farmers, family and relatives Minimum tillage, crop rotation, use of mulching, and use of organic manure were practiced by farmers as CSA Major challenges associated with the use of CSA practices were lack of government support, lack of finance, and inadequate training. There was a significant relationship between respondents' source of information and use of CSA practices
Chigozirim, O. N., Ikechukwu, O. C., Nneka, A.-A. F., & Ukeh, O. O. (2022). Institutional interventions and climate-smart practices of farmers in Nigeria. *Sarhad Journal of Agriculture, 38*(4), 1314-1321.	Source: Extension, Media and Friends The findings revealed that the socio-economic status of rural farmers, especially income and education are significant factors influencing their access to institutional support and adoption of CSA Constraints include superstitious beliefs to farming, costs of climate smart agriculture, lack of adequate climate information, lack of adequate plan and action by stakeholder
Elizabeth, O. I., Ebenezer, K. A., Olayinka, O. A., Samuel, O. K., Durojaiye, A. M., Abosede, A. V., & Racheal, O. K. (2024). Use of climate-smart agricultural practices among smallholder farmers in Ogun State, Nigeria. *Agricultural Extension Society of Nigeria.* https://dx.doi.org/10.4314/jae.v29i1.24S	Radio, Television, Mobile phone, Extension agent, Neighbours & friends were identified as sources of CSA related information Practices adopted by farmers included minimum tillage, crop rotation, and mulching, use compost or farm yard manure, planting cover crops, mixed cropping. Challenges to CSA adoption were lack of supportive government policies, insufficient access to credits, lack of information, lack of finance to adopt the technology, limited access to extension service, lack of technical know-how, land tenure system issues Factors that influence CSA adoption were education, annual income, contact with extension agent

Eta, H. C., Idiku, F. O., Elemi, G. F., & Eremi, E. O. (2023). Crop farmers' access to e-information for CSA production in Cross River State, Nigeria. *Journal of Agricultural Extension, 27*(3), 26-34. https://dx.doi.org/10.4314/jae.v27i3.3	Farmers got information on climate-smart agriculture from the radio, internet websites, and social media Agroforestry, water harvesting practice, construction and use of irrigation facilities, and land reclamation practices were practiced by farmers There was a weak, positive relationship between farmers' use of climate-smart agriculture practices and access to e-information
Mbanasor, J. A., Kalu, C. A., Okpokiri, C. I., Onwusiribe, C. N., Nto, P. O. O., Agwu, N. M., & Ndukwu, M. C. (2024). Climate-smart agriculture practices by crop farmers: Evidence from South-East Nigeria	Cooperative societies were the largest source of awareness, followed by the internet print media, friends, and radio/ television The determinants of CSA adoption identified in the study include gender, household size, farming experience, education level, labour force size, income, extension exposure, credit access, risk orientation, and cooperative membership Farmers are aware of CSA practices Climate-smart agricultural practices include conservation agriculture,residue soil cover, minimal soil disturbance, zero tillage, crop rotation, integrated crop management, mulching, application of manure, planting of adapted crop varieties disease/resistant varieties.
Oresanya, A. J., & Olajide, B. R. (2023). Farmers' propensity to use reality television shows for information on climate-smart agriculture strategies in southwestern Nigeria. *Agricultura Tropica et Subtropica, 56*(6), 47–56. https://doi.org/10.2478/ats-2023-0008	Sources of information include radio, fellow farmers, family and friends, family meetings, television, extension agents, mobile phones and newspaper.
CATEGORIES OF CLIMATE-SMART AGRICULTURE ADOPTED	
Adebisi, L. O., Adebisi, O. A., Jonathan, A., Oludare, O. T., & Egbodo-Boheje, E. (2022). Effect of climate-smart agricultural practices on food security among farming households in Kwara State, North-Central Nigeria. *Pesquisa Agropecuária Tropical, 52*, e70538.	Result revealed that crop rotation was used by farmers as CSA. Analysis showed education, access to extension visits, farm size, off-farm income as determinants
Adekoya, E. A., Adenikinju, F. A., Ogunbayo, E. I., Oyelami, O. B., Olutegbe, S. N., Osadebamwen, G. U., Oyeranti, A. O., Olajubutu, F. O., Enya, I. E., & Aburime, P. (2023). CSA practices for sustainable food systems in Nigeria: An agroecology-specific analysis. *FARA Research Report, 7*(68), 858–883. https://doi.org/10.59101/frr072368	CSA practices include mono-cropping, improved variety, use of inorganic, change of time of planting

Alalade, O. A., Adisa, R. S., Iyilade, O. A., Popoola, O. P., & Owoyale, Y. A. (2022). Status of climate smart agriculture among Village Alive Development Initiative farmers in North-Central Nigeria. *Journal of Agriculture and Food Sciences, 20*(2), 104–118	Highlighted relevant practices such as mobility and social networks, altering farming systems, agricultural insurance scheme, diversification on and beyond the farm, farm financial management, and knowledge management and regulations
Godfrey C. Onuwa, Oludare Adediire, Cletus Ajoma and Ganiyu Binuyo (2024) Adoption Of Climate-Smart Agricultural Practices: Empirical Evidence Among Vegetable Farmers In Bassa, Nigeria, Big Data in Agriculture (BDA) 6(1) (2024) 14-20 10.26480/bda.01.2024.14.20	Identified the following CSA practices viz irrigation farming, use of improved seed varieties, planting date adjustment, farm diversification, agrochemicals application, improved agronomic practices Agro-forestry
Iyiola-Tunji, A. O. (2021). Climate-smart livestock production: Options for Nigerian farmers. *Nigerian Journal of Animal Production, 48*(4), 136–148.	CSA practices includes use of crop-livestock integration system with adequate waste management and utilization. Utilization of methane reducing feed additives.
Muhammed, I., Abdulazeez, A., & Adamu, G. K. (2023). Climate-smart agriculture on sustainable cowpea beans production in Katsina State, Nigeria. *Sahel Journal of Geography, Environment and Development, 4*(2), 43–52.	Farmers adopted water harvesting for their farms.
Nwafor, E. J., Musediku, S. A., Akinlabi, T. S., Bernadette, U. U., & Adebayo, S. M. (2018). Adoption of climate-smart agricultural practices and farmers' willingness to accept incentives in Nigeria. *International Journal of Agriculture and Environmental Research (IJAER, 4)*(4), 198–205. https://www.researchgate.net/publication/331358005	Climate smart agricultural practices include the use of irrigation system, cultivation of upland rice and use of improved crop varieties to reduce the impact of floods on crop production
Nwajiuba, C., Emmanuel, T. N., Bangali, F. A. R., & Solomon, S. (2015). *State of knowledge on CSA in Africa: Case studies from Nigeria, Cameroon, and the Democratic Republic of Congo*. Forum for Agricultural Research in Africa, 978–9988. Retrieved from https://library.faraafrica.org/2021/01/19/state-of-knowledge-on-csa-in-africa-case-studies-from-nigeria-cameroon-and-democratic-republic-of-congo/	CSA practices include adjusting of planting dates, use of improved varieties, rain water harvesting and inter-cropping were identified as CSA practices.

Ojo, I. E., Akangbe, J. A., & Owolabi, A. O. (2023). Needs of extension agents on techniques for climate-smart rice production in North-Central Nigeria. *Journal of Agricultural Extension, 28*(1), 86-92.	CSA included weather insurance, operating alternate wet and dry technique, multiple inlet irrigation, site-specific nutrients managements, cropping calendar, use of climate information services.
Okpokiri, C. I., Agwu, N. M., Onwusiribe, N. C., & Igwe, K. C. (2021). Analysis of usage and determinants of climate-smart agriculture among farmers in Ebonyi State, Nigeria. *Journal of Community and Communication Research, 6*(2), 220-228.	Climate Smart Agricultural practices like use of resistant varieties, mulching, nitrogen management among others were practiced in the study area. Gender, household size, level of education, income, cooperative membership, credit use were the determinants of the level of Climate Smart Agriculture
Olayide, O. E., & Labode, O. (2016). Differential impacts of rainfall and irrigation on agricultural production in Nigeria: Any lessons for CSA? *Agricultural Water Management, 178*, 30–36. https://doi.org/10.1016/j.agwat.2016.08.034	Inadequate finance and poor knowledge on the proper application of climate smart agricultural practices were the major challenges in the study area. Key CSA practices include conservation agriculture, intercropping, use of improved seed and integrated soil facility management.
Oloruntoba, A. L., Ayobami, A. O., Asuquo, J., Olufunke, O., & Egbodo-Boheje, O. E. (2022). Effect of CSA practices on food security among farming households in Kwara State, North-Central Nigeria. *Pesquisa Agropecuária Tropical, 52*, e70538. https://doi.org/10.1590/1678-4499.20220053	Reported agroforestry, conservation agriculture, crop rotation, crop diversification mulching, use of organic manure,, planting crops with early maturity, planting drought-tolerant crop varieties, planting of cover crops, intercropping, irrigation
Ovuoba, M. N., Onyeneke, R. U., & Osuji, E. E. (n.d.). Gender and climate-smart agriculture in rice farming in Ikwo Local Government Area, Ebonyi State, Nigeria. *Faculty of Agriculture, Nnamdi Azikiwe University, Awka, Nigeria.*	Practices include nursery, intercropping, minimum tillage, crop diversification, shifting cultivation, knowledge of integrated pest management, adjusting harvesting dates, adjusting planting dates
Oyawole, F. P., Dipeolu, A. O., Shittu, A. M., Obayelu, A. E., & Fabunmi, T. O. (2020). Adoption of agricultural practices with CSA potentials and food security among farm households in northern Nigeria. *Open Agriculture, 5*, 751–760. https://doi.org/10.1515/opag-2020-0076	CSA practices adopted by maize farmers includes green manure, agroforestry, organic manure, refuse retention and crop rotation.
Oyawole, F. P., Dipeolu, A. O., Shittu, A. M., Obayelu, A. E., & Fabunmi, T. O. (2019). What drives the adoption of climate-smart agricultural practices?	Green manure, agroforestry, organic manure, refuse retention, crop rotation, zero/minimum tillage were among the CSA practices in the study area

Evidence from maize farmers in Northern Nigeria. *Nigerian Journal of Agricultural Economics, 9*, 14–28.	
Oyawole, F. P., Shittu, A., Kehinde, M., Ogunnaike, G., & Akinjobi, L. T. (2020). Women empowerment and adoption of climate-smart agricultural practices in Nigeria. *African Journal of Economic and Management Studies, 12*(1), 105–119. https://doi.org/10.1108/AJEMS-04-2020-0137	Identified CSA practices and determinants of their adoption to include ownership of plots, social capital, gender, and distance to farm
Salihu, A. T., Uduma, B. U., Jude, N. E., & Shittu, M. A. (2018). Adoption of climate-smart agricultural practices and farmers' willingness to accept incentives in Nigeria. *International Journal of Agricultural Environmental Research (IJAER), 4*(4), 198-205	Farmers adopted agro forestry, CSA with manure and CSA without manure.
Shehu, H. (2024). Assessment of smallholder farmers' adoption of climate-smart agriculture practices in Borno State, Nigeria. *Journal of Agricultural Economics, Environment and Social Science, 10*(2), 101-111. https://doi.org/10.56160/JAEESS/2024/10/2/010	Climate smart agricultural practice were reduced tillage, crop residue management, crop rotation/intercropping, water retention and erosion control technique; home garden and compost making/green manuring. Severe constraint to CSA adaptation included lack of awareness and limited information, limited access to credit, high cost of labour, and policy inconsistencies.
Idowu O. Ologeh, Joshua B. Akarakiri, and Francis A. Adesina Promoting Climate Smart Agriculture Through Space Technology in Nigeria	Swamp farming, irrigation, mixed cropping, crop substitution, land fallowing, use of pesticides, were CSA practices adopted
Tiamiyu, S. A., Ugalahi, U. B., Eze, J. N., & Shittu, M. A. (2018). Adoption of climate-smart agricultural practices and farmers' willingness to accept incentives in Nigeria. *International Journal of Agriculture and Environmental Research, 4*(4), 198–205 Tiamiyu, S. A., Ugalahi, U. B., Fabunmi, T., Sanusi, R. O., Fapojuwo, E. O., & Shittu, A. M. (2017). Analysis of farmers' adoption of CSA practices in Northern Nigeria. *International Conference on Agriculture and Food.*	Deliberate cultivation and ploughing in of certain leguminous plants into the soil as green manure Preparation and use of Farm Yard Manure and/or Compost Minimizing tillage operation to conserve soil moisture and health Practices such as integrated Pest/Weed Management, agro-forestry, efficient soil fertilization and water management were not highly adopted.
Wahab, A. A., Abubakar, J. A., Angara, U. A., Qasim, O. A., & Yakubu, A. A. (2020). Adoption of climate-smart agricultural practices among smallholder	Adopted CSAPs in the study areas were planting of improved seed varieties, crop rotation, incorporation of crop residues on farm, intercropping crops and trees, mulching to conserve soil water, water harvesting and others

farmers in the northwest agro-ecological zone of Nigeria. *Nigerian Journal of Agricultural Extension, 21*(4), 39–45.	
DETERMINANTS OF ADOPTION OF CLIMATE-SMART AGRICULTURE	
Ekpa, D., Akinyemi, M., & Ibrahim, H. I. (2017). Investigating climate smart agricultural practices in livestock production in Sokoto State, Nigeria: An application of principal component analysis. *FUDMA Journal of Sciences, 1*(1), 103-108	Age, gender, marital status and household size significantly influenced CSA adoption
Emenyonu, C. A., Eze, C. C., & Ejike, O. U. (2020). Influencing cassava farmers' climate-smart agriculture perception in Anambra State, Nigeria. *American Journal of Climate Change, 9*, 217-227.	The factors that influenced the farmers' level of CSA adoption included age, level of education, access to extension agents and access to climate change information
Faleye, O. S., & Afolami, C. A. (2020). Determinants of choice of climate-smart agriculture practices adoption among yam-based farming households in Ogun State, Nigeria. *Journal of Agricultural Science and Practice, 5*(3), 131-141.	Age and gender negatively influenced adoption of CSA while household size and agricultural information positively influenced adoption CSA practices include zero tillage, mulching, mixed farming, mixed cropping and crop rotation. Gender and plot ownership influenced adoption of CSA
Fapojuwo, O. E., Ogunnaike, M. G., Shittu, A. M., Kehinde, M. O., & Oyawole, F. P. (2018). Gender gaps and adoption of climate smart practices among cereal farm households in Nigeria. *Nigerian Journal of Agricultural Economics, 8*(1), 38–49.	
Henri-Ukoha A. & Walisam A. Adoption of climate smart agricultural practices by smallholder vegetable farmers in Obio-Akpor Local Government Area, AJATE, 2018;7(2):126-137	Coefficients of farming experience and household size were statistically significant and influenced the usage of climate smart practices
Igberi, C., Osuji, E., & Odo, N. (2022a). Adaptability of climate-smart agricultural practices in yellow cassava and implications in Nigeria	Earthling up of cassava plot, change in spacing between plant stands, and change in farming date were practiced by farmers Alternative to agriculture, empowerment programs, and crop variety diversifications, were climate smart adaptive measures utilized. Age, education, household size, and extension contacts influenced climate smart adaptive measures of yellow cassava.

Obi-Egbedi, O., & Oladapo, O. T. (2024). Do climate-smart agricultural practices drive food security of maize farming households in Ogun State, Nigeria? *Ghana Journal of Science, Technology and Development, 7*(2).

Ojo, T. O., Kassem, H. S., Ismail, H., & Adebayo, D. S. (2023). Level of adoption of CSA among smallholder rice farmers in Osun State: Does financing matter? *Scientific African, 21*, e01859. https://doi.org/10.1016/j.sciaf.2023.e01859

Olawuyi, S. O. (2019). Effect of adoption of alternative conservation agricultural practices on smallholder farmers' production output in South-West Nigeria. *Cogent Social Sciences, 5*, 1588447. https://doi.org/10.1080/23311886.2019.1588447

Olawuyi, S. O., & Mushunje, A. (2020). Heterogeneous treatment effect estimation of participation in collective actions and adoption of climate-smart farming technologies in South-West Nigeria. *GeoJournal, 85*, 1309–1323.

Olorunfemi, T. O., Olorunfemi, O. D., & Oladele, O. I. (2020). Determinants of the involvement of extension agents in disseminating climate-smart agricultural initiatives: Implication for scaling up. *Journal of the Saudi Society of Agricultural Sciences, 19*, 285–292

Shittu, A., Kehinde, M., Adeyonu, A., & Ojo, O. (2021). Willingness to accept incentives for a shift to CSA among smallholder farmers in Nigeria. *Journal of Agricultural and Applied Economics, 53*(4), 1–21. https://doi.org/10.1017/aae.2021.19

Solaja, S., Kolawole, A., Awe, T., Oriade, O., Ayojimi, W., Ojo,I., Nayan, G., Adedayo,R., Etta-Oyong, S., Olasehinde,F., Asemokhai, O., & Nsikak, I (2024) Assessment of smallholder rice farmers' adaptation strategies to climate change in Kebbi State, Nigeria. *Heliyon, https:/doi.org/10.1016/j.heliyon.2024.e35384*

Age and access to extension agents influenced the adoption of CSA among farmers

Gender of household head, marital status, access to climate information, access to off-farm income, access to cooperative and access to credit were the determinants of level of adoption of CSA technology

CSA farm size cultivated, total farm size, access to extension services and social capital components are significant predictors of adoption

Participation in collective actions had adoption-increasing effect
Also, information acquisition, access to extension service and frequency of visit by extension workers are significant features that predict adoption.

CSA practices disseminated and adopted were cover crops planting, minimum tillage practices, use of soil amendments, conversion of waste to compost, agro-forestry, resource conservation and use of agro-weather related initiatives Determinants include extension agents, educational qualification, years of experience

Identified factors influencing farmers willingness to adopt CSA practices

Size of the farm influenced CSA implementation

Teklewold, H. (2023). Understanding gender differences on the choices of a portfolio of climate-smart agricultural practices in sub-Saharan Africa. *World Development Perspectives, 29*, 100486. https://doi.org/10.1016/j.wdp.2023.100486	Farm income, gender, marital status, education, and farming experience were determinants of farmers' climate smart agricultural practices.
Uduma, F. C., & Nwaobiala, C. U. (2023). Determinants of cassava farmers' knowledge and attitude towards climate-smart agricultural practices in Imo State Southeast, Nigeria. *International Journal of Agriculture and Rural Development, 27*(1), 6900-6908.	Farmers had high knowledge of climate smart agricultural practices.
BENEFITS OF ADOPTION OF CLIMATE-SMART AGRICULTURE	
Adegbite, B. A., & Garuba, A.-A. S. (2024). Assessing socio-economic benefits and challenges of climate-smart agriculture on perishable food crop production system in Southwest Nigeria. *British Journal of Earth Sciences Research, 13*(1), 17-21	The adoption of CSA in the Southwestern region has strengthened vegetable crop production system that brings increased yield. Climate resilient agriculture is known to have transformed the tomatoes/pepper production system in the North Nigeria, and the southern farmers could perform magic toward sustainable. It also supported production and growth with efficient climate resilient practices. Farmers adopted intercropping, crop rotation and irrigation system respectively. Age, educational level, farm distance and years of experience were determinant factors to adoption.
Ekpa, D., Oyekale, A. S., & Yuni, D. N. (n.d.). Poverty decomposition for high and low users of climate-smart agricultural techniques in Northwest Nigeria. *International Journal of Environment and Pollution Research, 5*(2), 26–41.	Poverty rate was higher for low-users of climate smart agricultural practices than for high-users for all dimensions under consideration and for all the decomposition techniques used
Etim, N. A., & Ndaeyo, N. U. (2020). Adoption of climate-smart agricultural practices by rice farmers in Akwa Ibom State, Nigeria. *Journal La Lifesci, 1*(4), 20-30. https://doi.org/10.37899/journallalifesci.v1i4.203	Education level of farmers, family size, farm income and access to information on climate change influenced adoption of climate smart agricultural practices Farmers in the study location received information on climate change from village meetings, friends, relatives and other farmers.
Fanen, T., & Olalekan, A. (2014). Assessing the role of climate-smart agriculture in combating climate change, desertification, and improving rural livelihood in Northern Nigeria. *African Journal of Agricultural Research, 9*(15), 1180-1191.	Benefits include reduction in challenges of soil erosion, deforestation, and has increase soil fertility with increasing yield and reducing environmental challenges. CSA practices have reduced the challenges of soil erosion, deforestation, and increase soil fertility we constantly experienced on our farms Age was a major determinant of CSA adoption.

	Perceived the challenges of climate change to be too numerous and complex to be easily addressed by CSA approach
Ifeanyi-Obi, C. C., Akwiwu, U. N., Uche, C. C., Abuta, A., & Onwusika, A. I. (2023). Effects of capacity building on rural women involvement in climate-smart agriculture initiatives in Rivers State, Nigeria. *Annals of Science and Technology - A, 8*(1), xx-xx	Benefits on rural women involvement in CSA initiative are better knowledge of CSA for increased use of CSA practices, capacity to add value to their farm products, and capacity to train others on CSA practices The major CSA management practices they know include mixed farming, crop management practices, application of indigenous knowledge and practices, and soil management practices.
Kolapo, A, and Kolapo, O. J (2023) Implementation of conservation agricultural practices as an effective response to mitigate climate change impact and boost crop productivity in Nigeria. *Journal of Agriculture and Food Research* 12 100557	Crop productivity showed that farmers obtained significant yield in kg/ha from implementation of alternative package of conservation agricultural practices. Also, adopters of alternative package of conservation agricultural practices received more income than non-adopters Age, gender, farming experience, farm size, formal education, access to extension services and membership in association influenced CSA adoption among the farmers
Njoku, C. L., Mgbeokwere, M. C., Izuogu, C. U., Olaolu, M. O., Azuamairo, G. C., Ibrahim-Olesin, S., & Agou, G. D. (2024). Effects of climate-smart agricultural practices on cassava farmers' output in Ebonyi State, Nigeria. *Agricultural Extension Society of Nigeria, 21*(24), 239-246. https://dx.doi.org/10.4314/jae.v29i1.27S	Findings revealed that as farmers adopt more CSA practices, there is a corresponding increase in agricultural output, indicating a positive relationship CSA practices include early planting, mixed cropping, ridging/furrows, timely weeding, use of cover crops, use of improved planting materials, use of organic manure, mulching, contour terracing, agroforestry, irrigation, use of disease-resistant varieties, and minimum tillage Lack of credit, Land fragmentation, High cost of labour, High cost of transportation, Lack of formal education
Obi-Egbebi, O. and Oladapo, O.T. (2020). Do climate-smart agricultural practices drive food security of maize farming households in Ogun State, Nigeria. Ghana *Journal of Science, Technology and Development*. 7(2) 135-150	Study concluded that Climate-Smart Agricultural Practices improve food security among maize farmers and should thus be encouraged.
Ojoko, E. A., Akinwunmi, J. A., Yusuf, S. A., & Oni, O. A. (2017). Factors influencing the level of use of CSA practices in Sokoto State, Nigeria. *Journal of Agricultural Sciences, 62*(3), 315–327. https://doi.org/10.2298/JAS1703315O	The adoption of climate-smart agriculture significantly improved crop yield, income and food security status of smallholder farmers. The major CSA practices adopted include crop rotation, application of organic and inorganic fertilisers, and multiple cropping Majority of the farmers are aware Major determinants of CSA practices adoption are age, membership of an association

Olawuyi (2021) Towards Food Security: Adoption Benefits Of Climate-Smart Conservation Agriculture In Southwest Nigeria, The Journal of Development Area 55 (1)	Benefits include absence of environmental hazard, erosion control, increase water infiltration, conserve moisture and aid soil aeration. Enhance crop productivity Allow for the production of different crops, increased soil biological activities, suppressed weeds and reduced effect of heat. Less labor intensive and reduction in production cost and increased income
Terdoo, F. (2020). Exploring farmers' perceptions of CSA: Empirical evidence from Northern Nigeria. *FUDMA Journal of Sciences, 4*(3), 121–131. https://doi.org/10.33003/fjs-2020-0403-353	CSA lies in its ability to integrate agricultural productivity with environmental targets and address the livelihood needs and cultural biases of local farmers
Yekinni O.T. and Ladigbolu T. A. (2023) Assessment of stakeholders' satisfaction for sustainable ecological agricultural practices that promote climate smart agriculture in Northeastern Nigeria. FARA Research Report Vol 7(77):999-1006. https://doi.org/10.59101/frr072377	Greater net return, reduced exposure to pesticides and harmful chemicals, Enhanced farm biodiversity, safe and healthy environment, cleaner groundwater and surface water, reduced greenhouse gas emission, improved soil quality
CONSTRAINTS TO THE ADOPTION OF CLIMATE-SMART AGRICULTURE	
Akinyemi, M., Adeola, S. S., Hassan, C. O., Balogun, S. O., Ekpa, D., Adaraniwon, B. S., & Hassan, M. T. (2021). Analysis of climate-smart agricultural practices among maize farmers in Funtua Agricultural Development Zone of Katsina State, Nigeria. *International Journal of Agricultural Economics, 6*(2), 71-77.	Poor extension visits, low low level of awareness constrained CSA adoption Farmers practiced minimum tillage, mixed farming, and cover cropping. Hosehold size, farm size and education influenced CSA adoption
Alabi, O. O., & Anekwe, C. E. (2023). Economics of climate-smart agricultural practices used by smallholder sorghum producers in Nigeria. *Australian Journal of Science and Technology, 7*(1).	The constraints facing smallholder sorghum producers in the use of CSAPs were inadequate extension services, lack of access to information, and poor government policy Conservation agriculture, crop diversification, planting of heat, and drought resistant varieties of crop Determinants were age, educational level, and extension services.
Apeh, C. C., Chukwuone, N. A., Onyekuru, N. A., & Apeh, A. C. (2024). Gendered analysis of the economic impact of adoption of multiple climate-smart agriculture practices in Nigeria. *Journal of Agricultural Extension, 28*(4), 131. https://dx.doi.org/10.4314/jae.v28i4.13	Gender gap was reported as a constrain in CSA adoption Widespread adoption of diverse CSA packages, with mixed cropping and improved seed use being the most common. Reported a positive association between CSA adoption and net farm income.
Ekpa, D., Akinyemi, M., & Ibrahim, H. I. (2017). Investigating climate smart agricultural practices in livestock production in Sokoto State, Nigeria: An application of principal component analysis. *FUDMA Journal of Sciences, 1*(1), 103-108..	Constraints to adoption of CSA were reported to include lack of access to credit, lack of access to high quality breeds, lack of awareness of climate smart agricultural practices, high cost of labour. Access to formal education, access to means of communication and extension contact influenced the implementation of CSA

Ekpa, D., Tiri, G. D. and Ekpa, M. O. (2021) Analysis of the Challenges of Climate Smart Agricultural Practices among Crop Farmers in North-west, Nigeria." *Journal of Agriculture and Environment*, 17.2: 7-24	Challenges of CSA adoption in North-west Nigeria included lack of access to credit, lack of access to high quality breeds, lack of awareness of climate smart agricultural practices, high cost of labour, high cost of inputs, lack of demonstration/training on climate smart agricultural techniques, and lack of processing technology. Access to formal education, access to means of communication and extension contact were significantly associated with higher use of climate smart agricultural practices
Emmanuel, O. E., Nnenna, O. M., Nkiruka, B.-C. G., Anulika, U. O., Thankgod, E. K., Angela, O. N., Nwuguru, N. R., Ekunyi, U. N., Ighokpozi, O. E., Ajah, O. E., Chinenyenwa, T.-A. A., Olivia, O. C., Marylilian, O. O., Agu, O. P., Rhoda, I. T., Ojochenemi, I., & Chukwuka, C. C. (2025). Assessment of climate-smart agricultural practices of plantain farmers in Anambra State, Nigeria. *Asian Journal of Agriculture, 9*, 140-149	Problems of capital, soil fertility, lack of technical know-how, poor extension access, lack of timely information on weather conditions, instability in the planting calendar, high cost of inputs, and limited lands constrained plantain production and adoption of CSA practices. Farmers were aware of climate change. Climate-smart agricultural (CSA) practices adopted include mixed farming, movement to different sites, planting of early maturing variety, crop rotation, and application of farm yard manure (71.1%). Age, gender, level of education, household size, farm size, farming experience, extension contacts, credit use, and victim of climate events statistically influenced the adoption of CSA practices.
Goodluck, A. U., Enoh, E. F., Precious, A. O., Tega, E. O., Okogu, G. O., & Endurance, O. N. (2024). Adoption of climate-smart agricultural practices by cassava farmers in Delta State, Nigeria. *International Journal of Advanced Research in Innovative Ideas in Education, 10*(3).	Constraints included limited information access, financial barriers, inadequate infrastructure, and pest pressures. Access to credit, research gaps, and limited social capital were moderate concerns Weather forecasting, drought-resistant varieties, soil conservation, and crop diversification. Education, agricultural credit, frequent extension contacts supported adoption
Ifabiyi, J. O., Banjoko, I. K., Shuaib, O. M., Oladejo, A. O., & Komolafe, S. E. (2024). Status of climate-smart poultry production practices in Kwara State, Nigeria. *SVU-International Journal of Agricultural Sciences, 6*(3), 14-23. https://doi.org/10.21608/svuijas.2024.291239.1371	The result showed that feeding management processing, preservation of poultry products, and conversion of poultry droppings into compost manure were practiced by farmers. High cost of feed, high temperature, and lack of start-up capital were the main constraints affecting poultry production.
Ifeanyi-Obi, C. C., Olayiwola, I. F., Aderinoye-Abdulwahab, S., Ayinde, A. F., Umeh, O. J., andTologbonse, E. B. (2021). Promoting uptake and integration of CSA technologies, innovations and management practices into policy and practice in Nigeria. *International Journal of CC Strategies and Management*, 14(4), 354–374. https://doi.org/10.1108/IJCCSM-09-2021-0101	Challenges include poor farmers' attitude and resistance to change, insecurity, lack of infrastructure and utilities such as electricity supply, shortage of extension workers/specialists and their mobility Farmers are aware of CSA practices. Respondents are not aware of any CSA related matter captured in Nigeria policy.

	CSA practices identified to include use of improve crop varieties, Soil management practices, crop management practices, and controlled grazing.
Igberi, C. O., Osuji, E. E., Odo, N. E., Ibekwe, C. C., Onyemauwa, C. S., Obi, H. O., Obike, K. C., Obasi, I. O., Ifejimalu, A. C., Ebe, F. E., Ibeagwa, O. B., Chinaka, I. C., Emeka, C. P. O., & Orji, J. E. (2023). Assessment of prioritized CSA practices and technologies of household farmers in Southeast, Nigeria. *Universal Journal of Agricultural Research, 10*(1), 53–63. https://doi.org/10.13189/ujar.2022.100105	Lack of access to up to-date information, inadequate access to micro-finance and insurance, poor access to agricultural input and output markets constrained the adoption of CSA practices CSA implemented were planting of single crop, using a mixture of appropriately chosen genotypes of a given species, use of quality seeds and planting materials of well-adapted crops and varieties, crop rotation and diversity, integrated pest management, improved water use and management. Age, education, occupation, and years in farming experience influenced the adoption of CSA practices and technologies
Igberi, C.O., Osuji, E.E., Anuli, R.O., Paul, C.O. and Ngozi O.E. (2022). Climate smart adaptive measures of yellow cassava linkages and implications in Southeast Nigeria. *Agrociencia*, 56(4), 1–32. DOI: 10.47163/1646.Ag	Constraints to CSA adoption included absence of up to-date information, inadequate to agricultural input and output markets, lack of national level planning and implementation Integrated Pest Management, use of quality seeds, adjusting time of planting, planting trees on beams and mulch of different materials were the major CSA practices identified. Perception of climate change was the determining factor for CSA adoption. Sources of information included radio and public places Age, education, household size, and extension contacts influenced climate smart adaptive measures of yellow cassava Alternative to agriculture, empowerment programs, engagement strategies, and crop variety diversifications were climate smart adaptive measures utilized in the area.
James, S. O. (2019). Yam-based farmers' response to challenges of climate-smart agriculture in Kogi State, Nigeria. *Journal of Agriculture, Environmental Resource and Management, 4*(2413-425).	Challenges included unavailable information, lack of credit, poor technical know-how, unavailable cultivar and poor extension services Farmers are aware of CSA and strategies Mixed cropping, migration from yam to other crops, crop diversification, alteration of heaps/mound size, movement to different sites, use of pesticides, soil/water conservation crop rotation, change time/pattern of land preparation, mulching/change of mulching materials, early harvest of yam, application of farmyard manure /fertilizer, agro-forestry, were implemented as CSA practices
Ojo, I., Akangbe, J., Kolawole, A., Owolabi, A., Obaniyi, K., Ayeni, M., & Adeniyi, V. (2024). Constraints limiting the effectiveness of extension agents in disseminating climate-smart agricultural practices among rice farmers in North-Central Nigeria. *Frontiers in Climate, 6*, 1297225	Insufficient number of extension workers, lack of incentives for staff motivation, inadequate means of transportation.

Onyeneke, R. U., Igberi, C. O., Uwadoka, C. O., & Aligbe, J. O. (2018). Status of climate-smart agriculture in southeast Nigeria. *GeoJournal, 83*(2), 333–346. https://doi.org/10.1007/s10708-017-9773-z	Constraints include lack of access to input, insufficient capital, high cost of labour and inadequate extension services. Insurance, planting of different crops, planting on nursery and livelihood diversification were the CSA practices reported. Farmers are aware of CSA practices
Opeyemi, G., Opaluwa, H. I., Adeleke, A. O., & Ugbaje, B. (2021). Effect of climate-smart agricultural practices on farming households′ food security status in Ika North East Local Government Area, Delta State, Nigeria. *Journal of Agriculture and Food Sciences, 19*(2), 30–42.	High cost of input, lack of access to agricultural credit, high cost of production, inadequate financial resources were the major challenges of adoption of CSA
Sylvester, C. L., Umar, H. S., & Galadima, O. E. (2024). Effects of CSA practices on food security situation of farmers in Nasarawa State, Nigeria. *UNIZIK Journal of Agricultural Economics and Extension, 1*(11), 10.	The absence of information and capital were the main challenges to the use of the technology Practices adopted included comprehensive field management, on-farm risk reduction, crop/livestock management, agroforestry, and soil conservation practices Determinants include participation in non-agricultural activities, household size, valuable farm assets, comprehensive field management, on-farm risk reduction and crop/livestock management were significant