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RESEARCH ARTICLE

DYNAMICS OF CLIMATE SMART AGRICULTURE IN NIGERIA

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ABSTRACT

The impact of climate is threatening sustainable food production the world over. CSA is a strategic practice that supports farming, ameliorates food insecurity and advance 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 of the analysis showed that awareness of CSA remains low even with a steady increase in the number of publications from 2020-2023. The south-western region was the most studied as farmers implemented various approaches across the country with 52% 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 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 as a result of their adoption of CSA. Absence of government policies, high cost of implementation and low level of technical skill are hinderances to adoption. The study concludes that farmers in Nigeria are implementing CSA practices. There is need to increase awareness and develop the capacity of farmers through training in the essential CSA skills. Government should legislate reforms and provide incentives to support farmers to adopt CSA.

KEYWORDS

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

1. INTRODUCTION

Massive efforts have been made to eradicate poverty, malnutrition and the effects of climate change (CC)worldwide, especially with the implementation of the 17 Sustainable Development Goals (SDGs) in 2005. Notwithstanding these efforts, about 64% of the poorest people in the world lives 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 CC (Magesa et al., 2023; Izuogu et al., 2021).

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, etc. will have more negative impacts in developing countries due to their dependence on agriculture. 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 and 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 the African region, only 5% of cultivable area has irrigation facilities, compared to 14% and 37% in Latin America and Asia respectively. In addition, most farmers in Africa are smallholders with inadequate production infrastructure, poor access to agricultural finance and insufficient information. Agriculture faces certain threats and uncertainties given the sector's high vulnerability. Studies show that crop production activities in Africa will suffer more from CC, even though researchers point out that rural livelihoods will be the most affected by the exposure of agriculture to CC in the region (Magesa et al., 2023). Improvement in agricultural production in Nigeria demands a holistic strategy that addresses the interlinked threats arising from adverse weather effects.

Several nations within the tropical belt, especially countries that are most exposed to CC have advocated different approaches to ameliorate CC impact on food production. CSA represents a collection of agricultural production innovations targeted at mitigating the impact of CC. Its implementation is gaining credence as all over the world. CSA practice aims at increasing food production and building farmers' resilience towards CC. 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 the traditional agricultural practices that do not factor in CC threats (Tabe-ojo et al., 2023). CSA improves agronomic practices in agriculture 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 CC will worsen the development of agricultural production, thus necessitating a paradigm shift (Ojo et al., 2023). Farmers in Nigeria are therefore very concerned given their poor adaptive capacity.

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Despite the increasing campaign to reduce greenhouse gas emissions, there is an urgent need for 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 CC 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, there are certain challenges that should not be ignored. Studies have highlighted these critical issues that farmers need to be aware of. 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 CC, there is no comprehensive review of published articles to show the dynamics of 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, most researchers looked at the whole of Africa, CSA practices in sub-Saharan Africa, and at the benefits and challenges of CSA practices in West Africa and therefore did not focus on Nigeria (Barasa et al., 2021; Kombat et al., 2021; Agyekum et al., 2024). Conversely, a study in Otitoju et al., 2023 has conducted a review of CSA technologies in Nigeria but did not answer any of the research questions of this study. While other researchers conducted an empirical review of CSA for the improvement of the agricultural sector in Nigeria (Balogun et al., 2024). 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 analyze 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 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.

2. METHODOLOGY

The study focused on Nigeria. The country has an area of about 923,768 km^2 with 36 states spread over six regions. The environmental challenges plaguing the country include flooding, desertification, deforestation, drought, etc. These challenges have been exacerbated by CC.

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.

2.1 Criteria for eligibility

In order for a study to be included in the review, it was important that the article evaluated 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 Table 1 show the eligibility criteria.

Table 1: Inclusion and exclusion criteria

Inclusion	Exclusion
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
Study must be conducted in any part of Nigeria	Studies conducted outside Nigeria
Study must be in English language	Studies that were not in English
Study must be within the 2014-2024	Articles published before 2014

2.2 Search

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, 139 were selected after 124 articles were removed as duplicates, while 74 articles were deleted as they did not address CSA, its impacts and challenges, or focused on Nigeria. In the second phase, a comprehensive assessment of the entire text was undertaken. The 139 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.

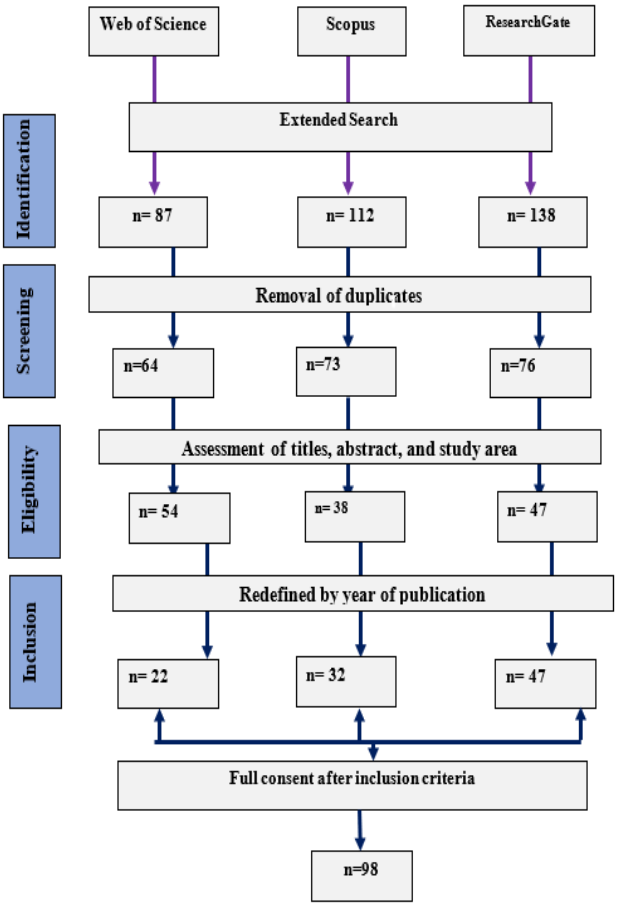

Figure 1: PRISMA selection process schema

3. RESULTS AND DISCUSSION

3.1 General information on the reviewed paper

Southwestern Nigeria was the most studied region with 27.5% of the articles as shown in Figure 2. 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 6.5% 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.

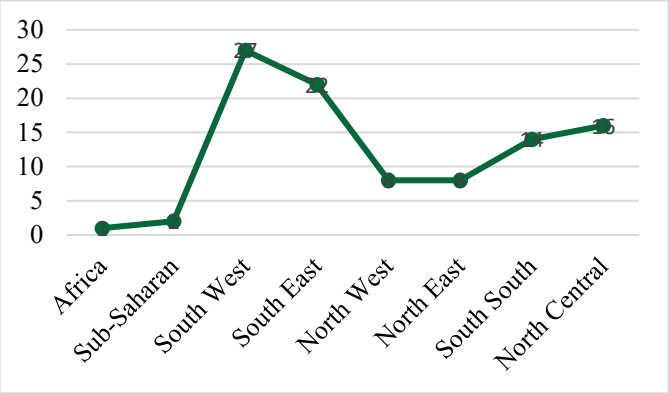

Figure 1: Regional distribution of articles

The number of studies increased between 2021 and 2023, 2016 and 2018, as shown in Table 2. The highest number of publications, 18 each, was observed in 2021 and 2018. This is consistent with Barasa et al., who recorded progression in the number of research outputs in CSA in Africa (Barasa et al., 2021). This can be attributed to an increasing need for research due to the detrimental effects of CC. It also facilitates research into improved agricultural practises to ensure that more efforts are made to mitigate the future impacts of CC on agriculture. More than 10302 respondents were surveyed from the approved publications, with the sample size ranging from 80 to 320 respondents.

Table 2: Annual distribution of 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

3.2 Methodologies by the authors

For 82% of the selected articles, the researchers used interviews, most of which were designed as in-depth interviews, and the data were analysed using statistical tools (Eta et al., 2023; Gbadebo et al., 2022a; Adebayo and Ojogu, 2021; Gabriel et al., 2023; Adeagbo et al., 2023; Ukwuaba and Ileka., 2024; Mailumo et al., 2021; Oduntan et al., 2022). On the other hand, 9% of the studies conducted focused group discussions (Mashi et al., 2022; Jellason et al., 2021; Salisu, 2022; Awoniyi et al., 2023) 5% used statistical models to analyse secondary data and 3% used field observation (Aduramigba-Modupe and Amapu, 2023; Adekoya et al, 2023; Ogundele and Adeyemo, 2021; Olayide and Labode, 2016; Alehile, 2023). 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).

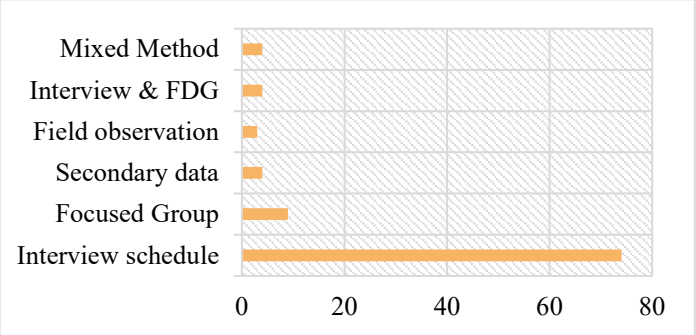

Figure 2: Research methodologies by the authors

3.3 Level of awareness and sources of information

Table 3 shows that about 66% of publications reported that farmers know nothing about CSA (Eta et al., 2023; Mashi et al., 2022; Gabriel et al., 2023; Ifeanyi-Obi, et al., 2021; Oduntan et al., 2022). A study reported that although some farmers in the sub-Saharan region are practicing CSA, the majority are not aware of these practices (Kombat et al., 2021). As a result, farmers are unable to provide correct answers to queries on CSA. Researchers have identified lack of awareness as a major problem in the adoption of CSA in Nigeria (Ekpa and Ekpa, 2021). Farmers may not easily evaluate adaptation strategies that mitigate the negative outcomes of CC. This may lead to low implementation of CSA practices in Nigeria and an unsustainable agricultural system with low resilience to the challenges of CC 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 CC. A knowledge gap on CSA in Nigeria, which has delayed the integration of possible interventions by policy makers (Ifeanyi-Obi et al., 2021; Alhassan and Umoru, 2024).

The main sources of information on CSA were radio and television (45.92%), cooperative organizations (12.24%), Extension officers (18.37%), internet services (8.16%), print media (11.22%) (Eta et al., 2023; Okoronkwo, et al., 2024; Mbanasor et al., 2024; Isiwu and Adejoh, 2023; Gabriel et al., 2023). Other sources of information mentioned in the literature are observation and experience (6.12%) (Gabriel et al., 2023, Okoronkwo, et al., 2024). The findings concur with researchers 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 (Antwi-Agyei et al., 2021). Furthermore, it was recognized that radio stations are able to reach a wider audience and provide information on CC 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, a study found in Malawi and Ghana that the importance of CC information sources is location-specific and that certain sources may hinder the effectiveness of the information, (Amoak et al., 2023).

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 and 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. 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 3: Awareness and sources of information

Awareness	Frequency	Percentage
Yes	**66**	67.35
No	**32**	32.65
Source of information		
Radio and television	**45**	45.92
Extension officers	**18**	18.37
Cooperative organizations	**12**	12.24
Print media	**11**	11.22
Internet services	**45**	8.16
Observation and experience	**6**	6.12

3.4 Identification of CSA practices

Figure 4 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., in 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 of CSA in their production activities. On the specific approaches, the studies show that farmers mainly apply indigenous knowledge (52%), which includes agronomic practices like altering planting dates and using natural pest and weed control systems (Eta et al., 2023, Ukwuaba and Ileka, 2024; Mailumo et al., 2021; Igberi et al., 2022), Gbadebo et al., 2022b; Jellason et al., 2021).

About (32%) of the reviewed articles reported that farmers practice conservation agriculture such as covering the soil with residues which ensures that soil erosion and leaching are minimized (Eta et al, 2023, Adebayo and 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). Other conservation farming practices adopted by farmers include crop rotation, strip cropping and minimum tillage (Isiwu and Adejoh, 2023).

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; Jellason et al., 2021, Solaja et al. Ifeanyi-Obi et al., 2021). A study reported low utilization of certified seed varieties by farmers in Nigeria (Izuogu et al., 2023; Oloruntoba, et al., 2022). This agrees with Sanogo et al., who observed that crop rotation, mixed cropping and improved varieties are the major practices farmers (Sanogo et al., 2023).

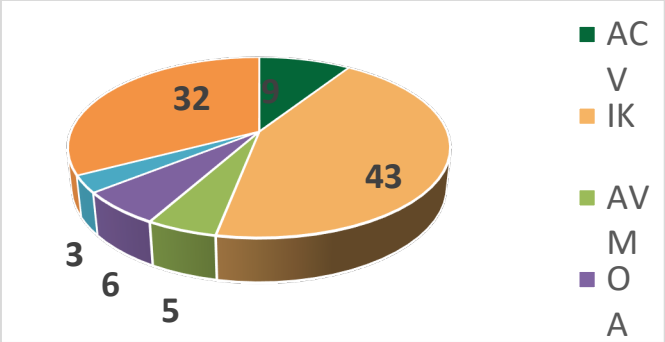

Figure 3: CSA Strategies identified by the studies

3.5 Determinants for the adoption of CSA practices

CSA in Nigeria is influenced by several factors. These factors were mentioned in 62 of the 98 studies. The determinants presented in these studies differ across publications. These discrepancies may be due to the fact that 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 (Ojo et al., 2023, Gbadebo et al, 2022b, Adeagbo et al., 2023, Ojoko et al., 2017). 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. Research reported that agricultural credit access supports production expansion through the acquisition of improved agricultural inputs (Tiamiyu et al., 2017)

The majority of studies reported that contact with agricultural extension officers is significantly positively related to CSA adoption (Ojo et al, 2023; Gbadebo et al, 2022b; Adeagbo et al, 2023; Oduntan et al, 2022; Ekpa and Ekpa, 2021; and Alhassan and Haruna, 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. Research acknowledged that access to real-time production information facilitates innovation adoption among farmers (Baiyegunhi et al., 2019). 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 experience CC and rapid technology development.

The relationship between the respondents' gender and adoption of CSA showed conflicting outcomes across the studies. When compared to female farmers, male farmers were more likely to adopt CSA practices in line with the findings of most researchers (Ojo et al., 2023; Mashi et al., 2022; Adeagbo et al., 2023; Mailumo et al., 2021). While other researchers observed that female farmers adopted CSA practices more than the males (Ogundele and Adeyemo, 2021). The findings of Ojo et al., is however supported by Adeagbo et al., who opined that male farmers undertake more production risks, and also experiment on new agronomic practices more than female farmers (Ojo et al., 2023; Adeagbo et al., 2023). In terms of adoption of improved seed varieties to combat CC, Izuogu et al., indicated that male farmers grow more certified seeds than female farmers (Izuogu et al., 2023). The importance of understanding gender interaction with CC for agricultural development cannot be over-emphasized. A study found that gender influences farmers' perception of decision making with regards to CC adaptation due to inequality in agricultural resource distribution (Okello et al., 2018). Women are more active in climate action because of their vast understanding of the immediate environment which is a product of their experience in 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 as suggested (Ukwuaba and Ileka, 2024, Opeyemi et al, 2021, Oduntan et al, 2022; Gbadebo et al, 2022b). The accumulation of years of experience in agriculture is essential because it helps farmers in critical decision making to ameliorate CC impact as they adopt alternative agronomic practices based on their knowledge of the trend of climatic variables. In related studies, it was revealed that the likelihood of implementation of conservation agriculture is positively influenced by years of farming experience (Choudhary et al., 2018; Assefa et al., 2020).

The more farmers' level of education increases, the probability of their adoption of CSA increases (Gbadebo et al., 2022b; Gaworek-Michalczenia et al., 2022; Adeagbo et al., 2023; Ukwuaba and Ileka, 2024; Ojoko et al., 2017; Ekpa and Ekpa, 2021; Gadebo et al., 2022b; Phiri et al, 2022). However, in a contradicting observation, it was indicated that an increase in level of education led to a decrease in the rate of CSA implementation (Alhassan and Haruna; 2024; Ekpa et al., 2017). Researchers agree that education and risk orientation have a positive significant relationship with CSA adoption (Kassa and Abdi, 2022). The positive relationship between education and the implementation of CSA, noting that education increases technical efficiency because as farmers acquire more education (Cooley et al., 2022; Bamlaku and Abera, 2022). The likelihood of their adoption of soil cover, zero tillage and plant improved varieties increases (Amare et al., 2022; Diallo et al., 2020). Higher levels of education are expected to improve farmers' information-seeking behaviour and also ensure that information received is effectively processed to choose the best alternatives to adapt to CC threats ensuring that farmers make informed decisions, improve the quality of agricultural work and identify opportunities to maximize profits where they exist (Adeagbo et al., 2023).

Membership in a cooperative society has been reported to have a positively influenced CSA implementation (Ojoko et al., 2017, Saadu et al., 2024, Phiri et al., 2022). 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 and Bamire, 2015). 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 labor services, cooperatives also serve as a conduit for many CC interventions as they have the advantage of reaching a larger audience at once. A study reported that membership in cooperative membership propels the chances of farmers in Nigeria using improved seeds in their adaptation to CC (Diallo et al., 2020)

3.6 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 production, increasing agricultural yields, improving soil health, and reducing food insecurity (Gbadebo et al., 2022b).

A study reported increased crop productivity in kg/ha when farmers implemented CSA packages (Adetomiwa and Adeyera, 2023). 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. Researchers used a 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 (Saadu et al., 2024).

When farmers implemented CSA, they were able to increase agricultural production through commercialization, as an increase in crop production usually leads to increased income and reduction in farmers' poverty. It was reported that farmers who adopted the conservation agriculture package of CSA earned higher net income compared to non-adopters. The opinion that farmers' net incomes increase when yields increase as a result of adopting CSA practices (Kolapo and Kolapo, 2023). As reported, crop yields of farmers practicing CSA increased by N19389 ($17.62) while food expenditure increased by N 21938 ($20.00) (Saadu et al., 2024). Also, compared to existing farm practices, CSA avails farmers of increased food and feed production and reduction in emission greenhouse gases. Research 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 capital food consumption (Omotoso et al., 2024).

These findings agree with Mailumo et al., in 2021 that farmers who adopted CSA practices had higher yields in Jigawa State, Nigeria. In South Africa, Omotosho et al., revealed that agricultural yield increased with farmers' adoption of CSA (Omotosho et al., 2024). 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 comparative advantage over non-adopters in terms of higher production, increased income, and improved crop protection (Gbadebo et al., 2022b). This implies that the implementation of CSA is useful for farmers who adopt the practice.

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

4. Challenges

The implementation of CSA in Nigeria is facing several challenges. It was reported that the absence of government policies and incentives, and high costs of implementing some of the practices are some of the issues delaying the implantation of CSA (Adebayo and Ojogu, 2021; Ifeanyi-Obi et al., 2021; Salisu, 2022). Inadequate funding for agricultural production, poor access to adapted crops/seeds, lack of information, and lack of access to extension services has also reduced the desire of farmers to adopt climate-smart practices by farmers in Nigeria. (Adebayo and Ojogu, 2021; Izuogu et al., 2023; Sylvester et al., 2024; Igberi et al., 2022; Okoronkwo, et al., 2024; Opeyemi et al., 2021 Ekpa et al., 2021., Opeyemi et al., 2021; Ekpa and Ekpa (2021)

This is consistent with the FAO and ICRISAT, 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. A study reported that the absence of this can lead to delay in the realizing the expected benefits (Shittu et al., 2021).

Existing government regulations relating to CC adaptation and mitigation are not adequately enforced due to lack of legal guidance for citizens (Wakweya, 2023). Researchers observed that the inadequacy of extension officers and support services in African countries has hindered the transfer of CSA messages to farmers (Jayne et al., 2018; Davis et al., 2022). This has resulted to low awareness and lack of knowledge of CSA practices. At other occasions, they observed that the transferred CSA practices that do not specifically address the needs of the smallholder farmers. Researcher had argued 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 (Oduntan et al., 2022).

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

5. Conclusion and Recommendation

CSA awareness among farmers in Nigeria is low. Among farmers who are currently practicing CSA, the use of indigenous knowledge serves as the dominant strategy.

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, 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. Government should introduce policies that will support the development of farmers' technical skill capacity Also, more studies should be conducted to access farmers' perceptions of CSA to ensure that policies are data-driven with farmers' needs.

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Ethical clearance

The study does not require ethical clearance as the systematic reviews did not involvehuman 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.

Authors' Contributions

ICU: (40%) Conceptualization, study design and analysis

OJO: (10%) Data collection, review & editing

OMO: (10%) Data collection & review

ISC: (10%) Revision of manuscript

IJO: (10%) Revision of manuscript

EO: (10%) Plagiarism check and review

AJB: (10%) Review and editing

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