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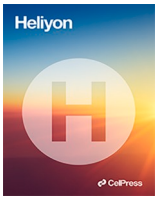

Research article

Evaluating constraints associated with farmers' adaptation strategies to climate change impact on farming in the tropical environment

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ABSTRACT

The persistent threat of climate change poses challenges to food security, despite numerous adaptation strategies, necessitating attention to achieve sustainable livelihoods. This study conducted a survey among 220 farmers in fifteen selected rural communities from five political wards in Ondo West Local Government Area, Ondo State, Nigeria, using a multistage sampling technique. Both descriptive and inferential statistical methods were used to analyse data obtained. The results indicated that 90 % of the farmers had knowledge of consequences of climate change, while 75 % have adopted various strategies to cope with the menace. The data were factorable at $p \leq 0.05$ using KMO and Bartlett's tests. Four variables were extracted out of nine analysed as significant to the explanation of constraints to CC adaptation strategies, namely: engagement in other jobs (16.499 %); farmers' experience with the varying nature of weather patterns (14.526 %); farm size variation (13.485 %); and the difficulty posed by coping with recurring erratic rainfall (11.925 %). All four variables identified and extracted explained 56.446 % of the constraints hindering farmers from coping with climate change. The study recommended further studies to identify other variables that could be accountable for the constraints in coping with the climate change scenario in the study area. The contributions of farmers' experiences to the failure of various strategies in coping with climate change form the nexus to other extracted variables and, therefore, need further investigation for sustainable agriculture globally.

1. Introduction

Climate change (CC) is undoubtedly the most significant contemporary environmental threat to combating hunger, malnutrition, disease, and poverty in Africa [1,2]. Long-term shifts in temperature, precipitation, and weather patterns constitute CC. These changes often stem from human activities like fossil fuel combustion and deforestation [3]. defines CC as a shift in climate conditions identifiable (e.g., through statistical tests) by alterations in mean and/or variability of its properties, persisting typically for decades or longer. In Nigeria, CC has manifested in various ways over the years, including rising average temperatures, erratic rainfall patterns leading to prolonged droughts and intense rainfall events, as well as more frequent and severe floods, heatwaves, and storms.

The agricultural sector in Nigeria is pivotal as it employs a significant portion of the workforce and underpins economic

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development and food security. However, while [4,5] assert that CC is a primary agricultural hazard, it has also created other challenges for the industry across different regions, imperiling food security and livelihoods. Reduced crop yields and failures due to irregular rainfall patterns significantly impact food production. Changes in temperature and humidity have facilitated increased pests and diseases, harming crops and livestock. Moreover, evolving climate conditions have affected irrigation and animal watering due to heightened evaporation and reduced water availability. Desertification, soil degradation, and erosion have all worsened [1].

To mitigate these effects and ensure the sustainability of the nation's agriculture, adaptation measures are crucial. Adaptation to climate change (CC) involves adjustments in natural or human activities in response to actual or anticipated climatic changes and their potential harmful effects or opportunities for rural farmers [6]. Nigeria has established policies and initiatives such as the National Adaptation Strategy and Plan of Action on Climate Change to address CC [7]. Initiatives include promoting climate-resilient agricultural practices, enhancing water management, and improving climate information services. However, as noted by Ref. [7], effective policies for successful adaptation in the agricultural sector require an understanding of farmers' concerns and their perceptions of CC.

In the context of changing climatic and socioeconomic conditions, including climate variability, extreme weather events such as droughts and floods, and volatile shifts in local and global markets, adaptation helps farmers achieve food security, income stability, and livelihood security [5,8]. Taking strategic actions in response to these challenges can help farmers minimize potential harm. While the list of adaptation measures against CC is extensive, examples include adopting irrigation systems, using resilient crop varieties, and employing modern agricultural mechanization. The scope, strategy, purpose, application, and timing of these measures vary.

Farmers' decisions regarding adaptation strategies are influenced by social, economic, and environmental factors [9]. However, these adaptation tactics have limitations, which vary between countries. Much of the research on CC and agriculture in Nigeria has focused on impacts and farmers' coping/adaptation methods [10–12], with limited attention given to constraints on adaptation. Therefore, through a combination of literature review and empirical analysis, this study aims to address this gap.

According to Ref. [13], farmers in India face three types of constraints: personal, institutional, and technical. Personal constraints include small-scale, fragmented land holdings, low literacy rates, lack of knowledge about coping mechanisms or resilience, and adherence to traditional beliefs. Institutional constraints encompass poor access to extension services, unreliable information sources, and limited institutional credit. Environmental constraints relate to the absence of drought-tolerant plant varieties and reliance on monsoon irrigation.

In Southwestern Nigeria, food crop farmers encounter four groups of constraints hindering the adoption of adaptation techniques [14,15]. These include public, institutional, and labor constraints; land-related challenges, community norms, and religious beliefs; high input costs, technological limitations, and inadequate information on early warning systems; and geographical distance from farms, limited access to CC adaptation information, off-farm employment, and credit constraints. identifies factors impeding sorghum farmers in Kwara State, Nigeria, from implementing adaptation strategies. These include irregular extension services, absence of subsidies for planting materials, lack of government policies on CC adaptation, reliance on stubbles for erosion control, limited knowledge of adaptation measures, weak institutional capacity, information accessibility issues, absence of water management techniques, low awareness levels, and cultural influences. In Taraba State, Nigeria [16], discusses constraints to CC adaptation strategies among rice farmers, categorizing them into socioeconomic factors such as insufficient capital, poor information access, low education levels, lack of credit facilities, low awareness, inadequate extension services, and high input costs; agronomic factors like land tenure issues and absence of improved agricultural technology; and politico-infrastructural factors such as poor infrastructure and lack of government policies on CC.

Similarly, in Northern Ghana [17], identifies unpredictable weather as the primary barrier to adopting adaptation techniques among farmers. Other constraints include inadequate government support, limited access to weather data, land tenure challenges, high input costs, ineffective extension services, low education levels, and soil fertility issues. In a study across four Local Government Areas (LGAs) in Ondo State, Southwest Nigeria [5], key obstacles to farmers' use of adaptation strategies include financial constraints, labour scarcity, inadequate agricultural extension services, limited access to climate information and resistant crop varieties, deficient agricultural programs, unreliable agro-meteorological information, high labor costs and low wages, poor working conditions, crop management complexities, inadequate farm inputs, and nutrient competition among crops.

This study addresses a critical research gap by focusing on the rural suburbs of Ondo West Local Government Area (LGA), Nigeria, where limited site-specific studies exist regarding the constraints faced by farmers in adopting climate change (CC) adaptation strategies. Given that farmers are among the most vulnerable groups to the impacts of CC, gaining insights into the specific challenges faced at the community level within Ondo West LGA becomes imperative, as location-specific obstacles often require site-dependent knowledge for effective interventions. Without such focused studies, it remains challenging to tailor interventions to alleviate the difficulties experienced by local farmers adequately. Unfortunately, there remains a dearth of research with a similar focus on the rural suburbs within this LGA up to the time of this study. It is within this context that this study seeks to examine the socio-economic characteristics of farmers and identify the constraints associated with their choices of climate change adaptation strategies in the study area. The findings of this research not only contribute to filling the existing research gap but also hold significant utility for policymakers, agricultural extension services, and local communities by providing insights necessary for designing targeted and effective strategies to enhance farmers' resilience to CC impacts in this region.

2. Methodology

2.1. Study area

Ondo West Local Government Area (LGA) in Ondo State, Southwest Nigeria, served as the study area (Fig. 1a). Geographically, it is

situated between longitudes 4° 50′ and 4° 85′ east of the Greenwich Meridian and latitudes 4° 75′ and 7° 02′ north of the equator. The LGA shares borders to the north and west with Ile-Oluji/Oke-Igbo LGA and a small part of Ogun State; to the south and east with Odigbo LGA; and to the east with Ondo East LGA. The study area falls within the tropical rainforest region, conducive for both cash and food crop farming [18]. The research region comprises twelve political wards, with seven wards classified as urban due to their location in the city portion of the LGA, while the remaining five wards are categorized as rural suburbs (Fig. 1b).

According to the 2006 National Census in Nigeria, the population of Ondo West LGA is 283,672 people, with a population density of 481.4/km^2. A significant portion of the population in the study area relies primarily on agriculture for their livelihood, which also provides employment opportunities. The main cash crop cultivated is cocoa, alongside other crops such as yam, cassava, oil palm, kolanut, coffee, cashew, rubber, wood, maize, plantain, cocoyam, rice, and banana.

As reported by Ref. [19], the Ondo region features a lowland tropical rainforest climate, characterized by an annual rainfall average of about 1,800 mm, mean monthly temperatures hovering around 28 °C, and mean relative humidity of approximately 79 %. The rainy season typically spans from April to October, while the dry season usually lasts from November to March in Ondo [20].

2.2. Data collection

In order to gather information from a selected number of arable farmers in the study area, we designed a structured questionnaire. The questionnaire included various items and questions regarding the participants' socioeconomic characteristics, their constraints related to adaptation strategies, and the type of assistance they would require. We utilized a multi-stage sampling technique to select the total number of respondents for the study. During the first stage, we selected all five rural political wards in the LGA, namely Ward 2 (Gbaghengha/Gbongbo/Ajagba Alaafia), Ward 4 (Ilunla/Bagbe/Odowo I), Ward 5 (Ilunla/Bagbe/Odowo II), Ward 6 (Litaye/Obunkekere/Igbindo), and Ward 12 (Orisumbare/Araromi). In the second stage, we employed simple random sampling to choose three villages in each of the five rural political wards, resulting in a total of fifteen (15) settlements selected for the survey (refer to Table 1). The final stage involved using simple random sampling to select fifteen (15) farmers from each of the selected villages. Consequently, the study's sample consisted of two hundred and twenty (220) arable farmers in total. Notably, the survey achieved a 100 % success rate as all copies of the questionnaire were completed and returned for analysis.

Fig. 1. a: Map of Ondo state showing Ondo West LGA. (Inset: Map of Nigeria showing Ondo state) *(source: Google image)* b: Map of Ondo West LGA showing the Political Wards (*Source: Independent National Electoral Commission, Akure*).

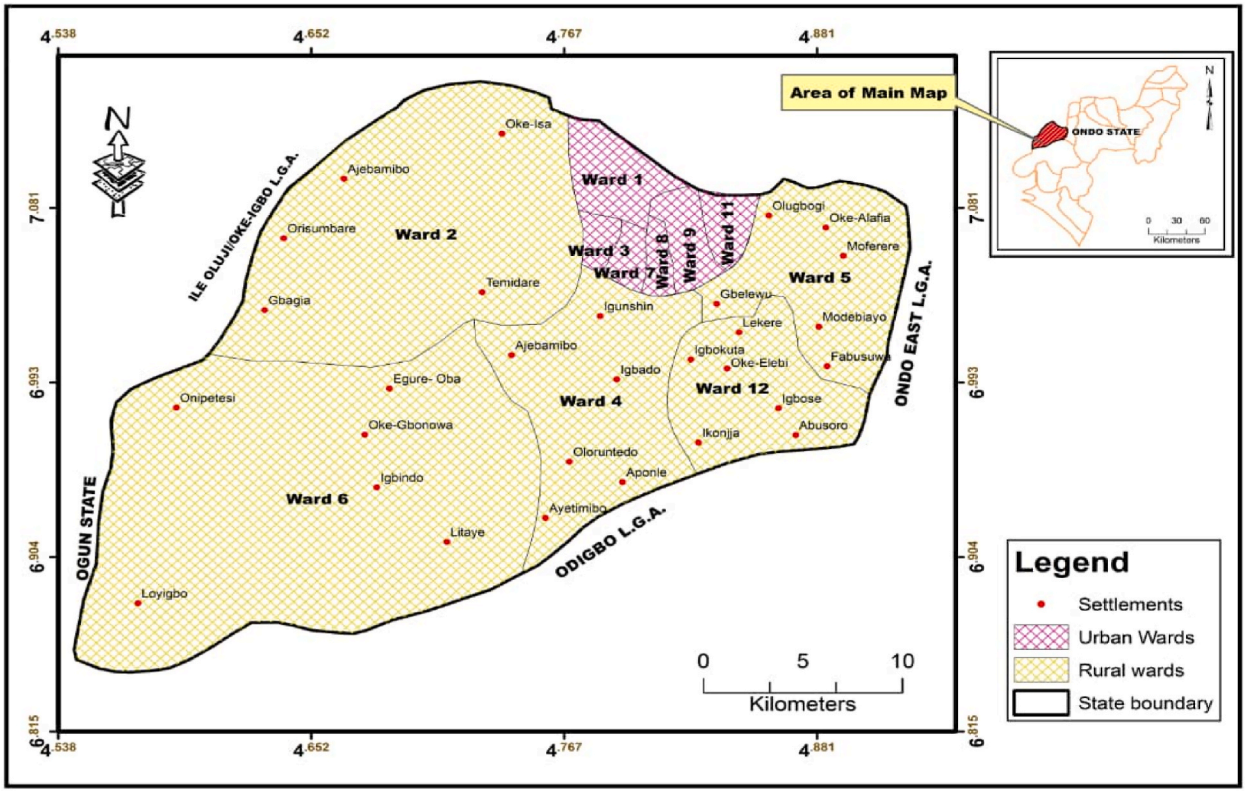

Fig. 1. (*continued*).

Table 1
Names of the selected villages for the survey.

S/No	Ward number	Name of the Ward	Names of the selected villages
1.	Ward 2	Gbaghengha/Gbongbo/Ajagba Alaafia	Orisumbare, Laje and Temidire
2	Ward 4	Ilunla/Bagbe/Odowo I	Igbado, Igunshin and Odowo
3.	Ward 5	Ilunla/Bagbe/Odowo II	Fabusuwa, Modebiayo and Moferere
4.	Ward 6	Litaye/Obunkekere/Igbindo	Egure Oba, Oke Onipetesi and Litaye
5.	Ward 12	Orisumbare/Araromi	Lekere, Abusoro and Igbokuta

2.3. Data analysis

This study employed both descriptive and inferential analyses. Descriptive analysis included techniques such as percentage calculations, tabulation, and more. Additionally, Factor Analysis (FA) was utilized to identify constraints hindering the successful adaptation of various strategies to climate change (CC) among farmers in the study area. A minimum Eigenvalue of 1.000 was set, indicating that variables falling below this threshold were not considered strong enough to explain the significant and valuable options for farmers. The data's factorability, confirmed by the KMO and Bartlett's tests (as shown in Table 1), was established at $p < 0.05$. This aligns with previous studies [21–24], where FA was deemed suitable for extracting relevant and significant variables from datasets. The analysis was conducted using Statistical Product for Service Solutions (SPSS).

3. Results and discussion

3.1. Basic characteristics of the respondents

Table 2 reveals that males accounted for 90 % (197) of the total respondents in the survey, while females represented 10 % (23). The survey maintained gender neutrality. Observations indicate that both males and females engage in farming in Ondo State, consistent with the findings of Ademola (1994) and Fakoya (2007).

The study also found that farmers have varying years of experience in farming, as presented in the table. Among all respondents, 42 % (93) had experience of not more than 10 years, 30 % (65) had between 11 and 20 years of experience, and 16 % (36) had 21–30 years

Table 2
Some basic attributes of the respondents.

S/No	Categorization	Total (%)	Cumulative total (%)
A	Sex		
	Male	197 (90 %)	197 (90 %)
	Female	23 (10 %)	220 (100 %)
B	**Years of experience in farming**		
	1–10 years	93 (42 %)	93 (42 %)
	11–20 years	65 (30 %)	158 (72 %)
	21–30 years	36 (16 %)	194 (88 %)
	31–40 years	12 (6 %)	206 (94 %)
	41–50 years	9 (4 %)	215 (98 %)
	>50 years	5 (2 %)	220 (100 %)
C	**Respondents' farmland sizes (%)**		
	<5 acres	64 (29 %)	64 (29 %)
	6–10 acres	85 (39 %)	149 (68 %)
	11–15 acres	33 (15 %)	182 (83 %)
	16–20 acres	31 (14 %)	213 (97 %)
	>20 acres	7 (3 %)	220 (100 %)
D	**Respondents' claim on change in their farmland sizes**		
	Increase	44 (20 %)	44 (20 %)
	Decrease	135 (61 %)	179 (81 %)
	No change	41 (19 %)	220 (100 %)

of experience. Additionally, 12 % (26) of the total respondents had at least 40 years of experience, mainly comprising older farmers. This distribution can be attributed to the recent high cost of food items in urban centers, leading many Nigerians to turn to farming as a means of livelihood.

The results in Table 2 further show that respondents own varying sizes of farmland. The largest proportion of farmers, 39 % (85), had between 6 and 10 acres of farmland, while 29 % (64) and 15 % (33) cultivated between 11 and 15 acres, respectively. Farmers with at least 16 acres accounted for 17 % (38) of the respondents. This distribution reflects the diverse age groups involved in farming in the study area, indicating that farming has attracted younger individuals [25]. [24] lamented the predominance of older farmers in their study area who may no longer possess the physical strength to cope with the demands of farming.

Furthermore, the survey revealed varied responses to questions about changes in the sizes of farmlands over the past 20 years (from 2003 to 2022), as shown in Table 2. Three different responses were identified: 61 % (135) reported a decrease in their farmland sizes, 20 % (44) reported an increase, and 19 % (41) reported no change in their farmland sizes during this period [26].

In addition, the reduction in farmland sizes among respondents was attributed to various interconnected factors, as highlighted in Fig. 2. A significant portion (47 %) of respondents cited erratic and unreliable rainfall patterns as a primary reason for changes in their farmland sizes. This reflects the ongoing challenges posed by climate change, as unpredictable weather conditions can directly impact agricultural productivity and land usability. Additionally, 33 % of respondents pointed to the high cost of farm inputs as a driving force behind decreased farmland sizes. This indicates the economic pressures faced by farmers, where rising input costs can limit the scale of agricultural operations.

Moreover, 10 % of respondents mentioned poor yields as a factor influencing their decision to reduce farmland sizes. This links back to the effects of climate change and other related issues such as soil degradation or pest infestations, which can lower productivity and render larger land areas unviable for cultivation. Lastly, 8 % of respondents highlighted poor access to credit facilities as contributing

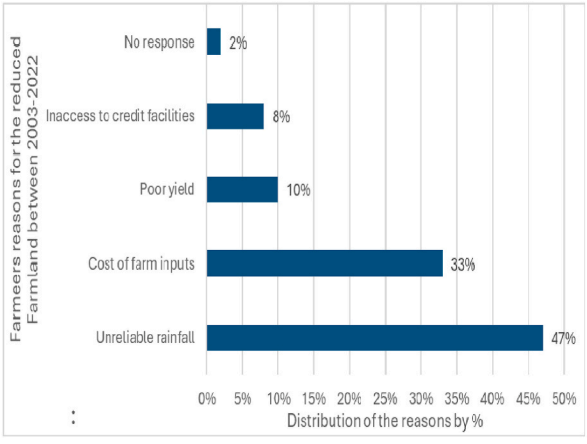

Fig. 2. Farmers' reasons for the Reduction in their farmland sizes.

to reduced farmland sizes, showcasing the broader challenges within the agricultural sector related to financial constraints and access to necessary resources for farm expansion or maintenance. These findings collectively underscore the complex interplay between climatic, economic, and systemic factors impacting agricultural practices and land use decisions, highlighting the need for holistic and targeted interventions to support sustainable farming practices amidst evolving environmental and economic landscapes.

However, the results as presented in Fig. 3 showed that 65 % are aware of the CC while 17 % claimed unawareness of the scenario. The remaining 18 % (40) either claimed no knowledge or provided no data. This finding corroborated the observations of [24,19].

3.2. Constraints to farmers' strategies of adaptation to climate change

Nine (9) constraints were analysed based on responses from the participants. These are as follows: (i) Education level; (ii) Use of drought-resistant varieties; (iii) Variation in farm size; (iv) Adjusting to erratic rainfall; (v) Institutional challenges in implementing strategies; (vi) Suitability of certain crops to rainfall patterns; (vii) Divided attention between farming and other jobs; (viii) Experience with extreme weather events; (ix) Crop failure.

The results of FA shown in Table 3 indicates that four variables were significant in evaluating constraints related to the implementation of adaptation strategies for addressing the challenges posed by climate change in the study area.

Farmers' engagement in other jobs emerged as the top constraint and was identified as the most significant factor affecting the effectiveness of adaptation strategies. It showed a rotated component matrix (RCM) of 78.6 with a weight of 1.485 and accounted for 16.499 % of the variance in the study. One of the coping mechanisms adopted by farmers to tackle climate change challenges is engaging in other jobs to sustain their livelihoods in their community. [27,28], and [29] also observed similar results and concluded that farmers require assistance from relevant stakeholders to enable them to focus entirely on their primary job of farming, thus ensuring sustainable food security.

Farmers' experience also significantly contributes to the constraints faced in effectively implementing various strategies to adapt to climate change (CC). It ranks second with an eigenvalue of 1.307 and 71.4 in the second order of the RCM. It accounts for 14.526 % variance in the issues related to constraints associated with the implementation of CC adaptation strategies. Experience can hinder farmers from adopting suggested strategies due to previous outcomes from similar strategies. Farmers may lack adequate attention to adopting any strategy, possibly influenced by previous experiences [30,31]. have suggested intensive and consistent education and enlightenment programs, along with practical achievements in adopting such measures in known locations, which could reignite farmers' hope and belief in adopting such strategies.

Another salient and significant variable extracted by FA is the **farm size reduction**. This variable was ranked third and found most important in the third order of the RCM. It as eigen value of 1.214 and 13.485 % variance in explaining constraints to the success of various strategies towards adapting to climate change associated challenges. Also associated with the second extracted variable, the experience on the devastating effects of CC could have led to the reduction in the sizes of the farmers' respective farmlands. Such reduction in the size may consider the full maximization of the benefits associated with the implementation of a particular strategy in coping with CC [31,32]. noted that farmers in their study area have considered reduction in the sizes of their farmland to sustain the grievous impact of the change in climate in their respective localities.

The challenge associated with **coping with erratic rainfall** which happens to be one of the signs of CC in the study was also identified and extracted. It is ranked fourth and with highest value in the fourth order of the RCM among other arrays of variables. It has a weight of 1.074 and variance of 11.935 % of the total value of 56.446 % of all extracted variables. Unreliable rainfall in the areas that depends majorly on rain-fed agriculture will pose serious threats to agriculture, the experience which may discourage farmer from investing substantially in agriculture. The findings of [33–35] corroborated this finding when they lamented on the loss of large expanse of land to flood disaster which has hindered and discouraged many affected farmers from active farming in their respective areas.

3.3. Conclusion and recommendation

Identifying coping strategies for the consequences of climate change (CC) in farming is a necessary step, but translating these strategies into tangible improvements for farmers is crucial. This study revealed several barriers hindering the effective implementation of CC adaptation strategies, despite high awareness (90 %) and adoption rates (75 %) among respondents. Factors such as engaging in other jobs, past climate farming experiences, changes in farm sizes, and challenges in adjusting to erratic rainfall patterns were identified as significant constraints, collectively explaining 56.446 % of the impediments. The remaining 43.54 % represents a substantial portion that requires further exploration to uncover additional variables impacting adaptation strategies. Moreover, the pivotal role of farmers' experiences in navigating these challenges underscores the need to integrate this knowledge into adaptation planning processes for successful outcomes in coping with CC effects.

3.4. Policy implications and future work

The findings of this study hold crucial policy implications for agricultural and environmental policymakers. Understanding the specific constraints faced by farmers in implementing climate change (CC) adaptation strategies is essential for designing targeted interventions and policies that effectively address these challenges. Policymakers can leverage this knowledge to develop support mechanisms, such as financial assistance programs or tailored training initiatives, to enhance farmers' resilience to CC impacts.

Future research endeavours should delve deeper into harnessing farmers' experiences and perspectives to inform sustainable CC

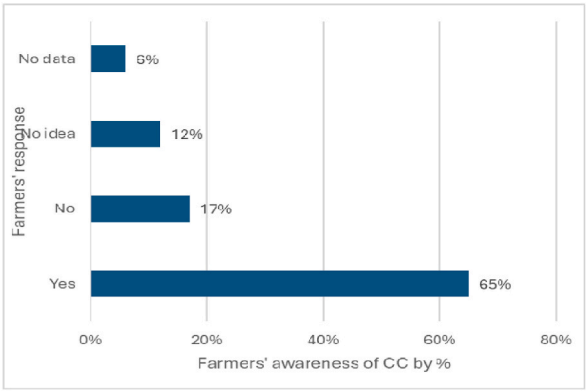

Fig. 3. Farmers' claim on the awareness of the impact of CC on farming.

Table 3
Extracted variables and their respective RCM, weight (Eigen value) and the percentage explained.

S/N	Variable Name	RCM	Eigen Value	% variance	Cum. %
1	Engagements in other jobs	98.6	1.485	16.499	16.499
2	Past Experience	71.4	1.307	14.526	31.026
3	Change in farm size	70.7	1.214	13.485	44.57
4	Adapting to erratic rainfall	72.5	1.074	11.925	56.446

adaptation strategies in farming practices. This includes exploring innovative technologies, knowledge-sharing platforms, and collaborative efforts among stakeholders to foster resilience and sustainability in agriculture amidst changing climate conditions. By integrating these insights into policy frameworks and research agendas, stakeholders can work together to create more resilient and adaptive agricultural systems for the future.

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Data availability statement

The datasets during and/or analysed during the current study available from the corresponding author on reasonable request.

CRediT authorship contribution statement

Timothy A. Akinkuolie: Writing – review & editing, Visualization, Supervision, Resources, Data curation, Conceptualization. **Timothy O. Ogunbode:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Methodology, Formal analysis, Data curation, Conceptualization. **Victor, O. Oyebamiji:** Writing – review & editing, Methodology, Investigation, Formal analysis, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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