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Research Article

Barriers and adaptation strategies to climate change among farming households in Guinea Savanna

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Abstract
Identifying appropriate climate policy interventions that improve the resilience of Guinea Savanna farming systems to extreme weather conditions is crucial to reducing food insecurity and poverty. This study explored rural farming households' encountered adaptation barriers and strategies used toward climate change. Participatory research tools and methods were used to collect data, including household surveys, focus group discussions, key informant interviews, and field observations. A multistage sampling procedure was employed in selecting 1,500 respondents in nine livelihood zones prone to drought and floods. Problem confrontation index (PCI) and relative importance index (RII) estimations were used to rank small-scale farmers' climate adaptation barriers and strategies. Results showed that key barriers to successful climate change adaptation practices included limited access to farm inputs (PCI = 3203), poor access to agricultural machinery (PCI = 3161), and shortage of farm labour and its high cost (PCI = 3026), while the most prioritized adaptation strategies were crop diversification (RII = 0.59), planting early maturing crop varieties (RII = 0.47), and changing the timing of planting (RII = 0.42). This study provides decision-makers insights into farmers' most adaptation barriers and prioritized strategies toward climate change to design effective and context-specific policies that aim to improve farming resilience to the adverse effects of changing climate.

Keywords: Adaptation, Barriers, Climate change, Resilient farming, Strategies

INTRODUCTION

Worldwide, 2.5 billion people's livelihood sources depend on agriculture, and with a growing population, the world needs to increase food production by 60 per cent to feed over 9.5 billion people by 2050. However, over half of the world's agricultural producers are particularly at risk from climate-induced disasters that destroy seeds, crops, harvests, stored food, and livestock, especially in Africa (Food and Agriculture Organization, 2017).
Africa's vulnerability to climate change remains worrying to the extent that disaster risk reduction (DRR) strategies have been underway for years, but efforts to build resilience have failed as most of the countries lack adequate financial, institutional, and technical capacities to deal with change (Manyena, 2016). This makes climate change (CC) and its subsequent conse-

quences the most serious development challenges for several African countries, especially those of Sub-Saharan Africa (SSA) (Codjoe and Atiglo, 2020), including Guinea (United Nations Framework Convention on Climate Change, 2015).

Guinea is sensitive to the impacts of climate change, and its capacity to successfully cope or adapt to the current changing environment remains weak and uncertain as it does not have any DRR strategies in place (Van Niekerk *et al*., 2020). The agricultural sector, which employs nearly 80% of the economically active population, mainly driven by small-scale farmers, is the most affected by the adverse effects of CC (Guinean government, 2018). This has resulted in enduring extreme poverty and hunger exacerbated by poor basic services delivery from the state, limited market access, lack of infrastructure for production, rural-urban migration, and limited rural economic development initiatives (African Development Bank Group, 2018). However, the economic progress of the country depends on the performance of the agricultural sector which contributes to 20.0% of the national gross domestic (World Bank, 2018).

Guinea Savanna is known as the most climate-vulnerable area of Guinea due to the frequent occurrence of weather-related hazards, including drought and flood, causing huge obstacles to livelihoods' production and food security (United States Agency for International Development, 2018). Among the four natural regions (Lower Guinea, Middle Guinea, Guinea Savanna, and Forest Guinea) that make up Guinea, Guinean Savanna has the highest annual temperature, which can exceed 37° C during the dry season and the lowest rainfall balance unevenly distributed with 1200 mm in the northern part and 1600 mm in the southern part. Moreover, it is swept from east to south by a hot and dry wind known as Harmattan (Kante *et al*., 2019). Combined with communities' heavy reliance on forest resources, these factors have led to significant damage to soil quality and negative vegetation dynamics, leading to frequent flooding after rain and drought episodes (Guinea and United Nations Framework Convention on Climate Change, 2015). However, covering 39% of the country's surface, Guinea Savanna is home to most of the country's farmers, heavily depending on crop production, especially rice, as the country's staple food and production is still far from satisfying consumers' demand. As a result, its import from suppliers, mainly China, keeps growing at an alarming rate (Koivogui *et al*., 2018). Despite several climate-induced disasters across Guinea and especially in the agricultural sector, the practical translation of efficient adaptation and mitigation strategies is still low. It remains among the world's most vulnerable countries due to its low level of preparedness to face natural hazards (Behlert *et al*., 2020). Factors including farmers' poor access to social basic services, lack of technical assistance, limited access to agricultural inputs, institutional barriers, and financial challenges seem to impede the widespread adoption of available adaptation strategies (MacNairn, 2017). Therefore, without the required scientific information and implementation of tailored adaptation measures, CC will be highly detrimental to agricultural production in SSA (Mashizha, 2019), especially in Guinea.

Thus, given the sensitivity of African farming systems to new climatic conditions, there is a need for more empirical evidence on barriers to adaptation as well as mitigation strategies in vulnerability hotspots to provide decision-makers with substantial information allowing the application of appropriate measures to improve food production (Antwi-Agyei*et al*., 2022; Masud *et al*., 2017). Nowadays, farmers' perceptions have received much attention in CC scientific debates (Adjebeng-Danquah *et al*., 2020; Dakurah, 2021; Le Dang *et al*., 2013; Ndamani and Watanabe, 2015), but empirical evidence on farmers' adaptation barriers and strategies toward climate change remain poorly explored and constitute the fewer dimensions covered in CC adaptation discourse. Moreover, the conflicting evidence on barriers as well as their site-specific diversity requires more scientific evidence to highlight decision-making about tailored adaptation policy susceptible to mitigate the impacts of CC on vulnerable people (Eisenack *et al*., 2014; Theokritoff and Lise D'haen, 2021). Therefore, identifying barriers hindering adaptation strategies to CC could foster a significant reduction in hunger and poverty through adequate support to farmers (Ozor *et al*., 2011). This study is the first attempt that has shown interest in barriers and strategies towards climate change in Guinea Savanna. Thus, it aimed to inform policy and decision-makers on farmers' key adaptation barriers and strategies crucial to identifying suitable climate policy interventions to improve farming systems' resilience in this climate-sensitive region. Therefore, this paper sought to answer the following questions:

1. What are the key barriers to effective climate change adaptation in Guinea Savanna?
2. What are the prioritized climate change adaptation strategies in Guinea Savanna?

MATERIALS AND METHODS

Study area

Guinea Savanna (Fig. 1) is Guinea's third national geographic region after Lower and Middle Guinea, followed by Forest Guinea. Covering 39% of the country's total area, it is prone to a wide range of human and natural induced hazards, notably drought and flood (Dara, 2013). It is home to most of the country's farmers, who derive their livelihoods mainly from agriculture and livestock. Its location on the western edge of Niger's River vast basin offers small-scale farmers suitable conditions for agricultural production through floodplains. Moreover, it is made up of seventeen livelihood zones (LZs) with 70,000 square kilometres of cultivable land where farmers are practising rain-fed agriculture with productions mainly used for subsistence and the surplus sold in the local market, proceeds of which are used to purchase other needs (Institut de Recherche Agronomique de Guinée [IRAG], 2001; Holt, 2016). As a fragile area, the whole region will continue to be marginalized following the new climatic conditions combined with rapid population growth, causing greater pressure on renewable resources (Kante *et al*., 2019).

Data collection frame and sample size

The multistage sampling procedure was employed in selecting study areas and sample size. Initially, seventeen livelihood zones (LZs) of Guinea Savanna set up by the Guinean institute of agronomic research (Institut de Recherche Agronomique de Guinée, 2001) served as a framework for data collection. Secondly, among these seventeen LZs, nine (Bassando, Dion-Niandan Inter-River, Fié Basin, Foutanian Piémont, Kolokalan High Valley, Middle Plateau, Solima's High Plateau, Soudanese Plateau and Woulada Plateau) most experiencing drought and flood episodes were selected (Table1) based on guidance from local environmental bodies and humanitarian affairs coordinators. Third, within each selected LZs, rural communities (RCs) at higher risk were retained due to their proximity to flood-prone areas or influenced by those at low risk. Thus, twenty-two high-risk RCs (with a total population of 548,143 individuals) across the nine selected LZs were finally chosen as study areas. Following Neuman's (1991) method, 1500 respondents out of 548143 individuals were chosen to constitute the sample. To ensure a reasonable distribution of the sample and to minimize inaccuracies due to the shrinkage or growth of some communities, the probability proportional to size (PPS) sampling procedure was applied. Population sizes were used for estimating sample sizes rather than household sizes due to inconsistencies in existing households' data.

Sampled households were chosen systematically by starting from the first randomly selected household to the last one with respect to the sample size of each selected community. Household heads (either male or female) were selected to respond to the questionnaire within each household. Individuals under 40 years old and unmarried were excluded to minimise data inconsistencies, as they may not have extensive farming experience and no constraints to engage themselves in climate adaptation practices (Umunnakwe and Olajide-Adedamola, 2015). Data were collected on respond-

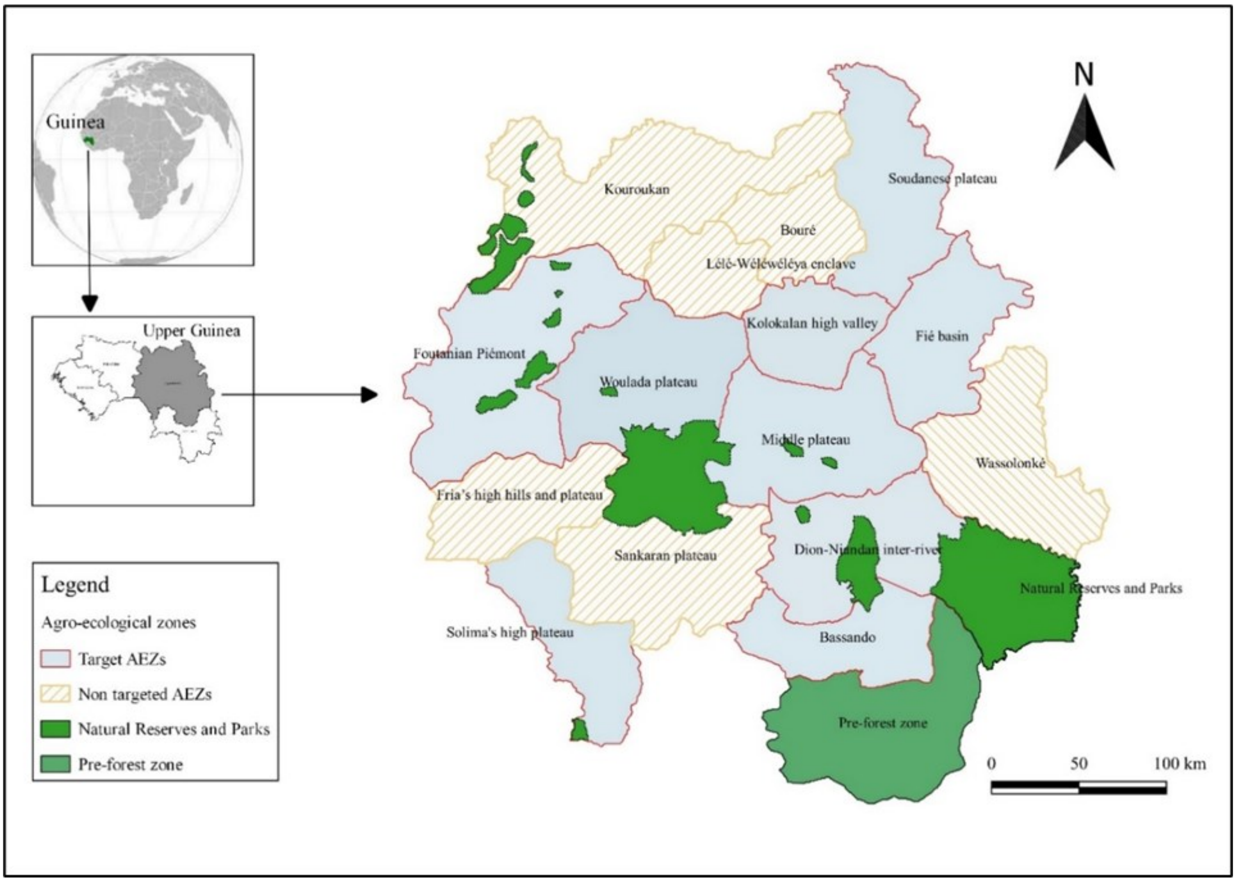

Fig. 1. *Map of the Guinea Savanna*

Table 1. Sampled households' distribution by livelihood zones

Livelihood zones	Number of respondents
Bassando	41
Dion-Niandan inter-river	108
Fié basin	153
Foutanian Piémont	188
Kolokalan High Valley	306
Middle plateau	374
Solima's high plateau	50
Soudanese plateau	215
Woulada plateau	65
Total	1,500

ents' socio-economic characteristics, key climate adaptation barriers and strategies. Respondents were asked to score their perceived barriers and adaptation strategies on a Liker scale ranging from 1 to 4: (1) no problem, (2) low level, (3) moderate level, and (4) high level, respectively for barriers; and also (1) do not use, (2) rarely used, (3) often used, and (4) yearly used, respectively for adaptation strategies.

Focus group discussions (FGDs) and key informant interviews (KIIs) were used to complement and triangulate information. They helped collect substantial information that could not be obtained from household surveys. The corresponding members were purposely selected based on their in-depth agricultural experience and knowledge of its challenges. FGDs members included between 8-12 participants per community and were made up of different community members, including farmers, community kings, farm-based organisations, and school teachers. Two targeted farmers, based on their significant and relevant contributions to the issues raised during FGDs were used for KIIs in each community. The Content Analysis (CA) (Bengtsson, 2016) which aims to turn a lot of raw data into usable evidence through data reduction methods (Hawkins, 2013) was used to analyse FGDs and KIIs data. The overall collected information from field observations and those obtained from FGDs and KIIs were integrated into the discussion and were also used to comment on the study results. Field observations followed these FGDs and KIIs to obtain supplementary information on farmers' land-use types and changes, farm-based activities, and existing resources.

Due to ethnic diversity, the local language Maninka was used to collect data from respondents from the centre to the northern part of the study area, while the Djallonka language was used to collect data from respondents in the southern part of the study area. No translator was recruited as these languages were familiar to the author and field assistants.

Data analysis

Respondents' socio-demographic data obtained during surveys were subject to descriptive statistics using a statistical programme for social studies (SPSS version 21.0) and Microsoft Excel (version 2019). Data on adaptation strategies and climate barriers were subjected to relative importance index (RII) and problem confrontation index (PCI) estimations. The RII method was used to determine the most used climate-adaptation practices in this study. The RII is often used to assess the degree of usage of climate adaptation practices and arrange them in order of merits and is widely used by scholars (Antwi-Agyei, Abalo, *et al*., 2021; Kassem *et al*., 2020; Popoola *et al*., 2020; Tesfahun and Chawla, 2020). The RII was computed using the following formula:

$$RII = \sum \frac{W}{A * N} \quad \text{Eq.1}$$

Where:

W = the weight accorded to an individual respondent's statement ranging from 1 to 4;

A = the highest response integer which is 4; and

N= the total number of respondents (N=1,500).

The PCI was used to identify the most critical adaptation barriers that hinder farming households from using available local adaptation practices. The choice for PCI was due to the fact that it helps to identify and analyse the most critical problem confrontation and it has been used by many scholars (Antwi-Agyei *et al*., 2021; Kabir *et al*., 2019; Masud *et al*., 2017; Ndamani and Watanabe, 2015; Pickson and He, 2021; Popoola *et al*., 2020; Tesfahun and Chawla, 2020). The PCI value was estimated using the following formula:

$$PCI = (P_n * 0) + (P_l * 1) + (P_m * 2) + (P_h * 3) \quad \text{Eq.2}$$

Where:

PCI = problem confrontation index;

P_n = the number of respondents who ranked the barrier as no problem;

P_l = the number of respondents who ranked the barrier as low level;

P_m = the number of respondents who ranked the barrier as moderate level, and

P_h = the number of respondents who ranked the barrier as high level.

RESULTS AND DISCUSSION

Farming households' climate adaptation strategies in Guinea Savanna

Results indicated that farming households adopted varied adaptation practices (Table 2) to reduce the adverse impacts of climate change on their farming activities and livelihood sources. Small-scale farmers ranked crop diversification (CD) (RII = 0.59) as the most used climate adaptation strategy. This could be motivated by farmers' decisions to boost food security under hostile climatic conditions. Depending on the season and weather conditions, many crop varieties with the same or different species are grown to increase crop portfolio and avoid dependence on a single crop far from meeting household food needs, especially in times of climate uncertainties. It usually includes a mixture of grasses, legumes and vegetable crops like cassava or potato.

Contrary to the present results, Antwi-Agyei *et al*. (2021) found timely harvesting of produce and storage (RII = 0.77) as the most important climate adaptation strategies practised by farmers in the Savanna agroecological zone of Ghana. This demonstrates that climate change poses many adaptation challenges depending on the socio-economic conditions of the communities' respective regions. Utilization of early maturing crop varieties (ECVs) (RII = 0.47) was ranked as the second most important climate adaptation strategy by respondents. The relevance of this practice could be due to the fact that it helps farmers counter food shortages often caused by erratic rainfall or floods that lead to significant crop losses. Similar results were found by Masud *et al*. (2017) and Ogada *et al*. (2020), respectively, in the Lawra District of Ghana and north-eastern Tanzania, where the usage of ECVs by farmers was gradually increasing. Changing the timing of planting (CTP) (RII = 0.42) was identified as the third most important climate adaptation practice. This could be explained by emerging new climatic conditions which affect the traditional farming calendar and leads to late or early farming practices in Guinea Savanna. Hence, farmers either rush one or other agricultural activities or delay one or another activity. However, CTP appears to be a risky climate adaptation strategy for small-scale farmers in the Guinea savanna because access to weather information and extension services remains a major concern in Guinean farming systems (MacNairn, 2017).

Livelihood diversification (LD) (RII =0.40) and agroforestry-intercropping (AFI) (RII = 0.32) activities were other climate adaptation practices available to farmers in the Guinea Savanna. Both LD and AFI with low uptake were farmers' income-generating activities in addition to hand hoe farming. Studies showed that farmers' access to a portfolio of livelihood activities, including on-farm and off-farm activities, is likely to enable them to adjust to change and addressed household's urgent needs compared to those strongly addicted to sectors that bear only climate-sensitive livelihood (Olsson *et al*., 2015; Onyeneke *et al*., 2018). The cultivation of improved crop varieties (CICVs) (RII = 0.28) was ranked the last important climate adaptation strategy by respondents. The study suggests that adopting improved crop varieties as climate adaptation practice in Guinea Savanna could be related to farmers' income sources, satisfaction and education level. Farmers ascertained that improved varieties of seeds were purchased mainly from the informal sector and few from official agro-dealer. Therefore, limited access to improved crop varieties constrained farmers to enlarge the cultivated areas and largely used fertilizers rather than purchasing certified seeds that were more affordable to people with improved sources of income than poor ones. Moreover, improved varieties did not seem to fully meet farmers' expectations and consumers as many complained about the taste while others about conservation issues after being prepared, which led to its dis-adoptions. However, through their experiences gained over many years, varieties such as Ninkin, Nerika, Sika, Kologbè, Chinese, Dissibakhoulén, were rice varieties mentioned by farmers because of their ability to survive some drought or flood conditions. While 60.6% of farmers had access to improved crop varieties in Colombia (Martínez and Pachón, 2021), about 5.1% of respondents had access to improved crop varieties in Guinea Savanna, and 10% in Nigeria, where only 5 - 10% of cultivated land was planted with improved seeds (Uduji and Okolo-Obasi, 2018).

Barriers affecting the successful adoption of climate adaptation practices

Results indicate that farming households faced several barriers that impede the climate adaptation practices (Table 3). Limited access to farm inputs (PCI = 3203) was the highest-ranked barrier affecting climate adaptation practices in Guinea Savanna. This finding shows that low usage of agricultural inputs is detrimental to traditional farming systems and constitutes an important constraint to the progress of agriculture in Guinea Savanna. This could be a reason why rice production in Guinea is yet to meet the increasing demands of consumers. The study also suggests that factors including low support to farmers, enduring poverty, and poor access to credit could be barriers to purchasing agricultural inputs such as fertilizers, chemicals, seeds, crop health products, and other needful tools. Although this region has great potential for rice growing, poor provision of farm inputs is a serious problem that local authorities must urgently address to reduce rice imports from foreign suppliers. Contrary to our findings Pickson and He (2021) found unpredictable weather (PCI = 802) as the highest-ranked barrier affecting climate change adaptation in Chengdu, China, showing the diversity of barriers between geographical entities. Poor access to farm machinery (PCI = 3161) was ranked the third most important barrier to successfully implementing climate adaptation practices in Guinea Savanna. This could be explained by the scarcity of agricultural

Table 2. Climate change adaptation practices adopted by farming households in the study area.

Adaptation strategy	Number of small-scale farmers adopting these strategies				RII	Rank
	Not used (W=1)	Rarely used (W=2)	Often used (W=3)	Yearly used (W=4)		
Crop diversification	715	72	165	548	0.59	1
Planting early maturing crop varieties	896	154	175	275	0.47	2
Changing the timing of planting	793	496	128	83	0.42	3
Livelihood diversification	1104	38	215	143	0.40	4
Agroforestry intercropping	1304	32	83	81	0.32	5
Cultivation of improved crop varieties	1424	18	37	21	0.28	6

W is the weight given to the respondents' statement. RII = relative importance index obtained using formula (Eq. 1).

machinery as well as the inability of the majority of farmers to afford a single day's work of available technologies, especially tractors. Animal power was the largest mean available to farmers. This situation could be part of the worsening poverty level and food insecurity in Guinea Savanna, where farmers only practice subsistence farming.

The shortage of agricultural labour and its high cost (PCI = 3026) was ranked as the third most important barrier to climate change adaptation in Guinea Savanna. FGDs and KIIs revealed that access to and job satisfaction for waged workers were parts of major emerging concerns in the rural agricultural system in Guinea Savanna. Respondents ascertained that wage labourers mainly composed of unschooled young men were rare and difficult to handle as many prefer to settle in cities, mining areas or join the Western world known as paradise rather than being in villages known as uncomfortable places, not to mention the increasing price of a day's work per person. A farmer noted on the young people:

Nowadays young people do not like work at all, they are roam in town when their parents are working on farms. If you pay them to do your work, they will give a long period before coming and on this particular day, they come to the farm around noon and leave at 4 p.m. What work could they do from noon to 4 p.m.? So, you have to be rich to pay them much more time as bigger your farm size.

Weak government support for small-scale farmers' agricultural inputs (PCI = 2973) is the fourth and closest barrier to labour shortages. This demonstrates a flaw in Guinea's agricultural system which is detrimental to the country's food self-sufficiency. According to respondents, the Guinean government is not yet able to provide a sufficient quantity of agricultural inputs, particularly fertilizers, likely to cover the needs of farmers in this region. The little that the government sends is diverted to traders who then resell to the farmers at a high price and instructions for use were not followed regarding the quantity to be used, and where and when to use them.

Other most important barriers constraining farmers from successful climate adaptation practices included limited access to credit (PCI = 2823), high illiteracy lev-

Table 3. Barriers affecting successful climate adaptation practices.

Barriers	No problem	Low level	Moderate level	High level	PCI	Rank
Limited access to farm inputs	79	240	580	601	3203	1
Poor access to farm machinery	93	265	530	612	3161	2
Shortage of labour and its high cost	151	235	551	563	3026	3
Poor government support with farm inputs	95	366	510	529	2973	4
Limited access to credit	150	360	507	483	2823	5
High illiteracy level among farmers	137	435	399	529	2820	6
Limited access to improved crop varieties	208	315	476	501	2770	7
Lack of inter-generational transmission of indigenous knowledge	209	305	501	485	2762	8
Poor agricultural extension service delivery	301	267	475	457	2588	9
Limited knowledge-based climate adaptation strategies	456	566	249	229	1751	10
Lack of access to timely weather information	508	549	375	68	1503	11

PCI = Problem confrontation index obtained using formula (Eq. 2).

el among farmers (PCI = 2820), and limited access to improved crop varieties (PCI = 2770). Such barriers could be explained by farmers' limited access to cash income-generating activities to meet their needs fully. Surveys reveal that, except for selling cash crops, other sources of income for farmers were mainly household livestock, mining, and fishing. Many farmers were unaware of microcredit opportunities, while others considered it a high-interest business not affordable. Some were upset to take out agricultural-based microcredit due to fear of climate-induced disasters, which often destroy on-farm livelihoods. Weak education levels and poverty may also prevent farmers from purchasing certified seeds, remaining focused on traditional crop varieties with low yields , and being vulnerable to extreme drought and flood events.

Last but not least, barriers to climate adaptation in Guinea Savanna were lack of inter-generational transmission of indigenous knowledge (PCI = 2762), poor agricultural extension service delivery (PCI = 2588), limited knowledge-based climate adaptation strategies (PCI = 1751), and lack of access to timely weather information (PCI = 1503). The study suggests that these barriers have educational implications in the study area. Among 1,500 household heads, only 1.2% had a tertiary education qualification, either retired civil servants or school teachers, while over 68.06% had not spent a single day in school. Education level as a determinant of climate adaptation is documented by numerous scholars (Antwi-Agyei *et al*., 2021; Hirpha *et al*., 2020; O'Neill *et al*., 2020; Randell and Gray, 2019).

Conclusion

For the first time, this study has explored key climate adaptation strategies and corresponding implementation barriers encountered by farming households across nine livelihood zones in Guinea Savanna. Results highlight that about four-fifths of farming households employed climate adaptation practices to respond to extreme weather events. Practices including crop diversification, planting of early maturing varieties, and changing the timing of planting, were the most climate adaptation strategies used by farmers to maintain household on-farm livelihoods amidst extreme weather conditions. Other strategies included livelihood diversification, agroforestry-intercropping, and the cultivation of improved crop varieties. Moreover, findings also highlight that farming households were confronted with numerous barriers which were impeding them from successfully adopting the aforementioned adaptation practices. With complex issues, major and pressing key barriers were limited access to farm inputs, poor access to farm machinery, and shortage of farm labour and its high cost. Other reported barriers by farmers were poor governmental support to farmers with farm inputs, limited access to microcredit, high illiteracy level among farmers, limited access to improved crop varieties, lack of inter-generational transmission of indigenous knowledge, poor agricultural extension service delivery, limited knowledge-based climate adaptation strategies, and lack of access to timely weather information. These barriers were making the Guinea Savanna farming system a horrible ordeal. Addressing these concerns with tailored policies will enable small-scale farmers to tackle food shortages, build resilience, and avoid wasting and misdirecting potential DRR funds in Guinea Savanna. With policy implications, this study contributes to the scientific bodies of literature on adaptation barriers and strategies toward climate change.

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Conflict of interest

The authors declare that they have no conflict of interest.

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