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Traditional Knowledge and Cultural Beliefs in Climate Adaptation Strategies for Food Security and Sustainable Development in Nigeria's Semi-Arid Regions: A Bibliometric Analysis (1996-2023)

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Abstract: *This paper examines the integration of traditional knowledge systems and cultural beliefs into climate adaptation strategies in Nigeria's arid regions, aiming to enhance food security and promote sustainable development. Arid regions, characterized by low precipitation and high evapotranspiration rates, are particularly vulnerable to climate variability and extremes. Effective adaptation strategies must blend indigenous wisdom with modern scientific approaches. Indigenous communities in Nigeria's arid zones have developed resilient adaptation practices rooted in Traditional Ecological Knowledge (TEK). These include agroforestry, transhumance pastoralism, and indigenous soil and water conservation techniques, crucial for sustaining livelihoods and enhancing ecosystem resilience against desertification, soil degradation, and water scarcity. The study underscores the significant role of cultural beliefs and religious practices in shaping community responses to environmental challenges. Religious teachings often emphasize stewardship of natural resources and community solidarity, influencing behaviours that support sustainable land use and environmental conservation. Integrating these cultural elements with climate-smart agriculture and sustainable land management practices highlights synergies between traditional and scientific approaches. Methodologically, the study synthesis studies that employed qualitative research methods such as in-depth interviews, Participatory Rural Appraisal (PRA), bibliometric and geospatial analysis. These approaches capture diverse perspectives from*

community leaders, agro-pastoralists, religious authorities, and local governance structures, providing insights into the spatial distribution and effectiveness of traditional adaptation practices across Nigeria's arid landscapes. The paper discusses implications for integrating traditional knowledge into climate adaptation policies, advocating for inclusive frameworks that empower local stakeholders and enhance community resilience to climate change impacts.
Keywords: climate adaptation, cultural beliefs, food security, sustainable development, traditional knowledge

INTRODUCTION

Climate change is a threat to food security and sustainable development because of its impacts on the agricultural system. It is the biggest environmental problem of our time that is threatening the existence of man and the environment (Ariko et al., 2024). It is a major threat to agricultural system and food security in many countries in sub-Saharan Africa (including Nigeria). Climate change has a direct impact on the productivity of physical production factors such as soil's moisture and soil fertility and this affects farming outputs which in turn impacts negatively on food security. The food security of a nation depends on the stability and sustainability of sufficient food from the agricultural sector (Food and Agricultural Organisation, [FAO] 2017). Traditional knowledge, religion and cultural beliefs play a significant role in climate change adaptation strategies for food security and sustainable development particularly in indigenous and local communities (Ikpe, 2021). Steps must be taken to deal with the negative effects of climate change on Nigerian agriculture especially crop production in the Semi-arid region of Nigeria.

There are two central ideas for dealing with climate change, namely, mitigation and adaptation. Mitigation is a response strategy to global climate change, and can be explained as measures that reduce the amount of emissions (abatement) or enhance the absorption capacity of greenhouse gases (sequestration) (Ikpe, 2021). Adaptation to climate change is an adjustment made to human, ecological or physical system in response to vulnerability (Adger et al. 2007). According to Oladipo (2008), adaptation to climate change entails taking the right measures to reduce the negative effects of climate change (or exploit the positive ones) by making the appropriate adjustments and changes. Adaptation, technically, is the appropriate way to deal with the unavoidable impacts of climate change. It is a mechanism to manage risks, adjust economic activity to reduce vulnerability and to improve business certainty. Adaptation has three possible objectives: to reduce exposure to the risk of damage; to develop the capacity to cope with unavoidable damages; and to take advantage of new opportunities.

Adaptation strategies refers to the practice of identifying options or methods to adapt to climate change and evaluating them in terms of criteria such as availability, benefits, costs, effectiveness,

efficiency and feasibility (Intergovernmental Panel on Climate Change [IPCC] 2021). Climate change adaptation through the modification or improvement of agricultural practices will be imperative to continue meeting the growing food demands of modern society (Rosegrant et al. 2008). Adaptation helps farmers achieve their food, income and livelihood security objectives in the face of changing climatic and socioeconomic conditions, including volatile short-term changes in local and large-scale markets (Ikpe, 2021). According to FAO (2016), climate change has a direct impact on the productivity of physical production factors.

In semi-arid region, the subsistence farmers depend primarily on rainfed agriculture, comprising livestock and crop production systems for food and incomes. Rainfall in this region is generally low and erratic thus characterised by recurrent droughts, causing livestock losses and crop failures, leading to poverty and food insecurity in the region (Ariko et al. 2024). However, increasing rainfall variability has been observed in various parts of the region, displaying both spatial and temporal variability. Rainfall trends in the region have also been variable in recent decades. Climate variability is a natural characteristic of semi-arid climates, usually manifested in various ways. In semi-arid regions, rainfall variability is associated with delayed rainy season onset, early rainy season cessation, reduced length of the growing season, and frequent or prolonged intra-seasonal dry spells, often culminating in low agricultural production (Yamusa et al. 2015).

Over the past decade, bibliometric analyses have attracted increasing research attention. This analysis has become popular owing to the introduction of new software programmes, multidisciplinary methodologies, and the ability to handle large databases (Khan et al. 2022). Additionally, this analysis allows objective data analysis and identification of various trends in a specific research field and journal performance, topics, authorship, co-citations, and references (Ellili, 2023).

Bibliometric analysis is a quantitative approach to bibliographic materials that highlights the core theoretical and empirical research on a specific field. In addition, bibliometric analysis allows the classification of previous studies. It is a research methodology used to analyse and quantify the impact, productivity, and trends of research publications, authors, journals and institutions. It involves data collection, data cleaning and processing, bibliometric indicators, visualisation and mapping, statistical analysis etc. (Ellili, 2023). Bibliometric analysis is applied in different field including climate change issues, adaptation, mitigation, resilience and sustainability (Sweileh, 2020).

Most studies explored the sustainability in the agriculture industry (Daniel, 2018; Iornongo, 2021; Singh and Misra, 2021; Semba et al. 2022), food security (Ikpe, 2021; Baars et al. 2023; Singh et al. 2022), climate change (Muneja, 2024; Campbell, 2016; Wang et al. 2021; Ariko et al. 2024). A literature search using well-known databases and search engines such as Scopus database and Google Scholar revealed that there were several bibliometric studies on climate change and its

effects on various aspects on ecology or agriculture or adaptation. However, no bibliometric research papers were published on climate change, food security and sustainable development for traditional and cultural beliefs on climate change adaptation strategies in the semi-arid regions of Nigeria. Therefore, the current study will establish the first baseline data on this topic for future comparisons and for policymakers to draw plans on climate change and adaptation strategies with an emphasis on food security and sustainable development in the semi-arid region of Nigeria.

Over the years, vulnerable communities have been found to develop knowledge, ways of perceiving and responding to climate change. Inhabitants of the study area which are mostly agriculturists and depend on climate for most of their activities, are therefore, expected to develop proactive strategies to adapt to climate change induced water stress. This paper seeks to provide answers to the following disturbing questions about traditional knowledge and climate change adaptation and food security:

i. What are the traditional and cultural beliefs on adaptation strategies?
ii. How does climate change impact on food security and sustainable development in Nigeria?
iii. What are the traditional and cultural beliefs in adaptation strategies for coping with the impact of climate change on food security in Nigeria?

The paper focuses on the development of appropriate policy instrument that will effectively address traditional and cultural beliefs on adaptation strategies to climate change. Adaptation strategies is inevitable if Nigeria must attain her much desired goal of insuring food security for her teaming population of 200 million. Combating and reducing climate change is an important goal of the sustainable development goals (SDGs) which states “take urgent action to combat climate change and its impacts”.

METHODOLOGY

Bibliometric method and data collection

The data for this study were gathered and extracted from the Scopus database, specifically on July 25, 2024. This database is widely recognized for its comprehensive coverage and reliable content, housing numerous publications from reputable publishers like Elsevier, Springer, MDPI, and Taylor and Francis (Maflahi and Thelwall, 2016; Rejeb et al. 2021). The following search string was utilized in the data retrieval: "traditional knowledge", "cultural belief", "climate adaptation", "food security", "food insecurity" or "sustainability", "sustainable development", "Nigeria", "arid and semi-arid region" and Pubyear, 1995 and Pubyear, 2024.

The search encompassed titles, abstracts and keywords, resulting in an initial pool of 44 documents. Subsequently, a screening process was conducted to exclude publications lacking bibliometric data and those outside the subject area. The final selection of articles was meticulously curated to ensure alignment with the research scope, involving manual exclusion to achieve a

focused and accurate representation of the literature relevant to the search criteria. A total of 31 documents were manually selected and used for subsequent downstream analysis.

Inclusion and Exclusion Criteria:
Studies were included if they focused on:

i. The role of traditional knowledge and cultural beliefs in climate change adaptation strategies.
ii. Specifically, within Nigeria's semi-arid regions.
iii. Empirical research, theoretical contributions, and review articles were considered.
iv. Studies published in English between 1996 and 2023.

Exclusion criteria:

i. Studies not focusing on traditional knowledge or cultural beliefs.
ii. Studies not specific to Nigeria's semi-arid regions.
iii. Articles lacking relevance to climate change adaptation or food security.

Data Collection:
Data collection involved systematically extracting information from selected studies. Variables of interest included publication year, authors, affiliations, keywords, study methodologies, and main findings related to traditional knowledge and cultural beliefs in climate change adaptation. Full-text articles were retrieved and reviewed to ensure relevance and data accuracy.

The flow diagram of the search strategy data is presented in Figure 1.

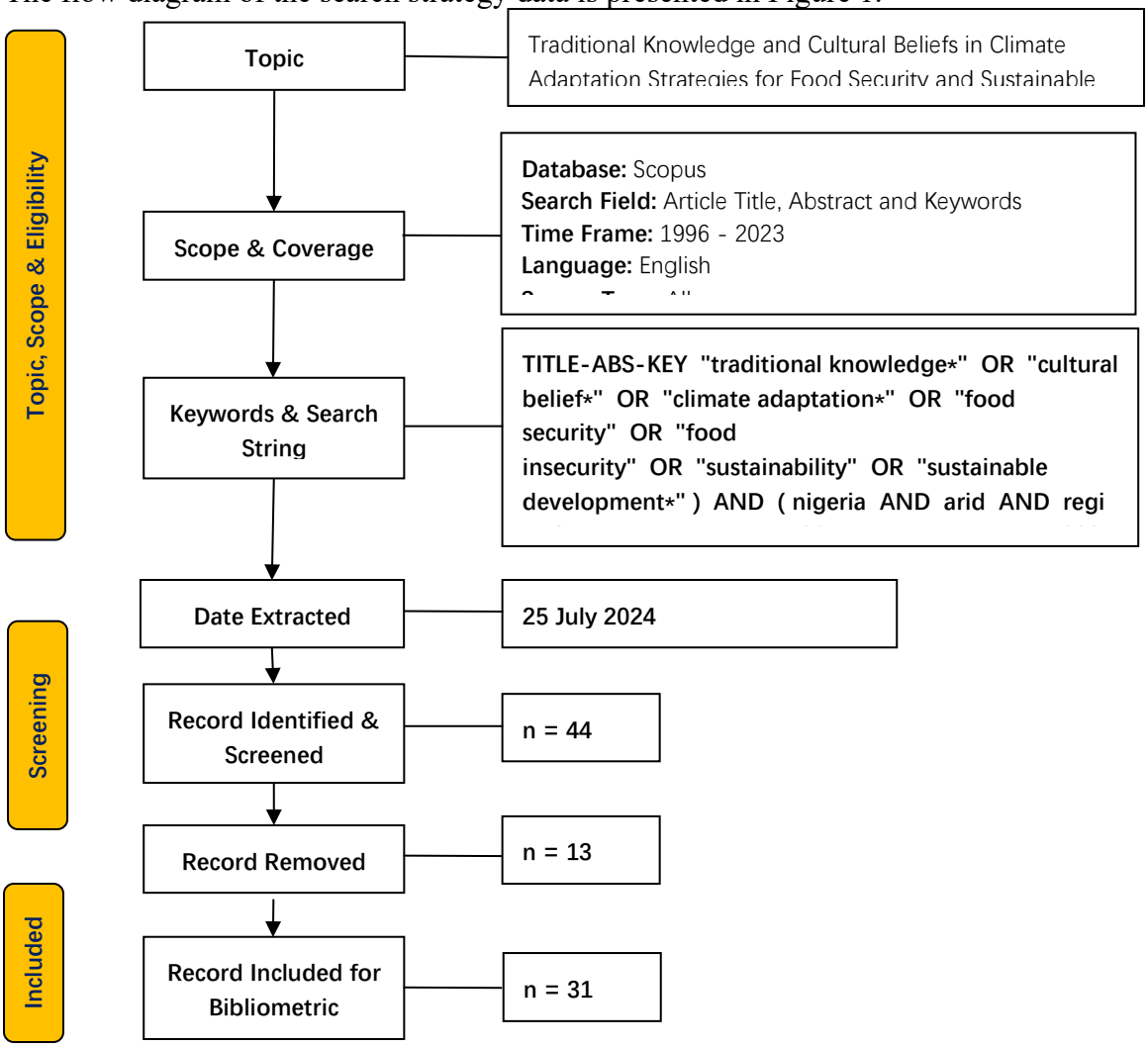

Figure 1. Flow diagram of the search strategy

Data Analysis

The 44 documents extracted from the Scopus retrieved dataset saved in CSV format were used for further analysis. To analyze the data, Microsoft EXCEL software and bibliometric software tool, specifically "Bibliometrix" R package software were utilized Keyword co-occurrence network analysis was applied to gain a comprehensive understanding of the current research landscape. Bibliometrix was employed to generate visual maps based on keywords, authors, and their interrelationships. Additionally, Bibliometrix facilitated the illustration of scientific trends and productivity within the documents, identifying the most prolific authors and significant articles published on the subject. This package encompasses powerful and comprehensive capabilities for bibliometric analysis, comprising analyses of authors, institutions, countries, and regions, as well as journal clustering and temporal trends (Fadiji et al. 2023 and Zheng, 2024).

Bibliometric Analysis: Quantitative analysis was employed to examine trends in publication outputs, authors, institutions, and citation impact. Metrics such as citation counts, h-index, and co-authorship networks were assessed to gauge the influence and dissemination of research in this field.

Content Analysis: Qualitative synthesis methods were used to analyse the content of selected studies. Themes related to traditional ecological knowledge (TEK), cultural practices, adaptation strategies, and their implications for climate resilience and sustainable development in semi-arid regions were identified and synthesized.

Methodologies Synthesized:

The study synthesized various research methodologies employed in the literature, including:

In-Depth Interviews: Many studies utilized in-depth interviews with community leaders, agro-pastoralists, religious authorities, and local governance structures to capture local perspectives on traditional adaptation practices.

Participatory Rural Appraisal (PRA): PRA techniques were utilized to engage communities in assessing their vulnerabilities, resources, and adaptation strategies, ensuring participatory approaches to research.

Geospatial Analysis: Geographic information systems (GIS) and geospatial tools were employed to map the spatial distribution of traditional adaptation practices and assess their effectiveness across Nigeria's semi-arid landscapes.

Implications for Policy and Practice:

The analysis discussed implications for integrating traditional knowledge into climate adaptation policies and practices. Recommendations were made for policymakers, practitioners, and researchers to recognize and leverage traditional knowledge systems and cultural beliefs in developing context-specific climate adaptation strategies. This approach aimed to empower local communities and enhance their resilience to climate change impacts.

Figure 2: Description of the main information in the analysed data

The description of the main information in the analysed data is presented in Figure 2. The data show that after the search between 1996-2023, 28 sources were clustered using the keywords. Thirty-one documents were filtered; 104 authors, 166 author's keywords; 1483 references with an 11.2 average age and 13.39 average citations per documents. Among the documents filtered, 5 were of
single authored document, while 29.03% were of international co-authorship.

The proportion of document distribution by type is presented in Figure 3. The data show that articles were used more in the collection of literatures, followed by reviews, book chapters and conference papers (26), reviews (2), book chapters (2) and conference paper (1).

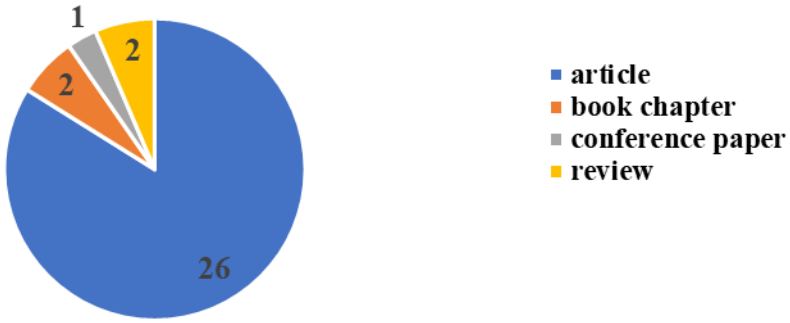

Figure 3: The proportion of document distribution by type

The data on the top 9 countries by number of publications and citations are presented on Figure 4. The data show that materials of 2021 and 2022 were used more with in the year reviewed.

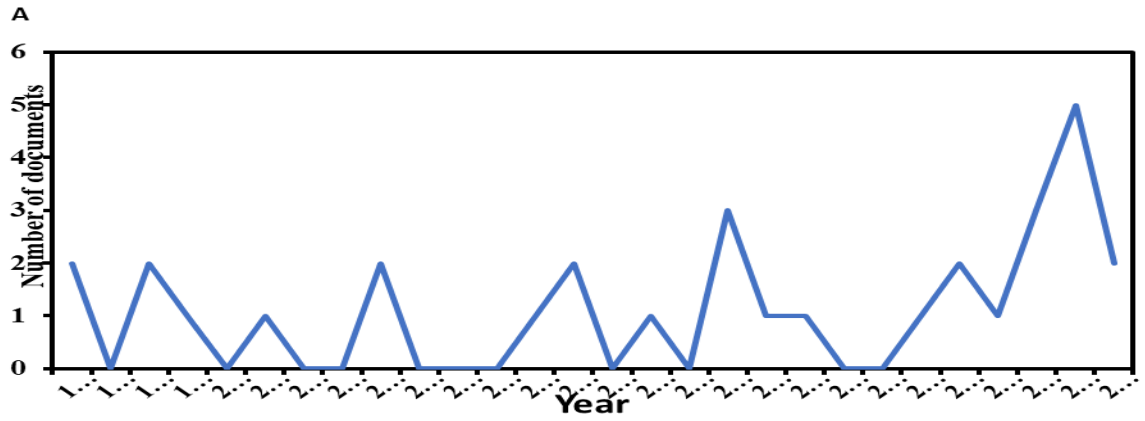

Figure 4: Number of documents reviewed by years (1996 – 2023)

The 31 documents filtered from the search were analysed on the year-by-year review analysis. The data (Fig. 4) show that documents published between 2021 – 2023 were the most reviewed. The result further show that 2019 – 2013 experienced the highest scientific publication under the years reviewed.

The scientific publications by yearly average citations is presented in Fig. 5.

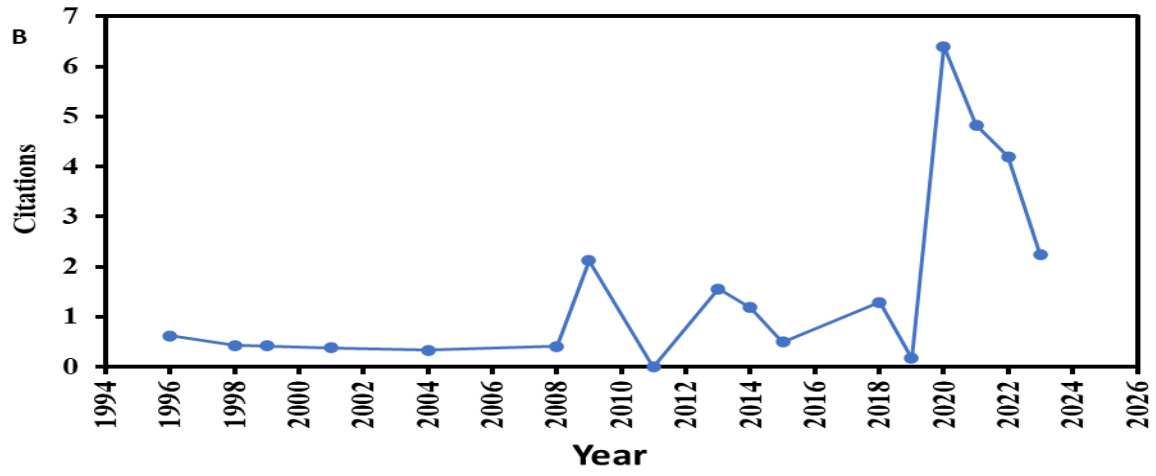

Figure 5: Scientific publications by yearly distribution; Yearly average citations

Figure 6 presents the scientific publications by yearly average citations. The result show that China has the highest yearly average citation, followed by Nigeria, Benin, France and Mali were the least cited.

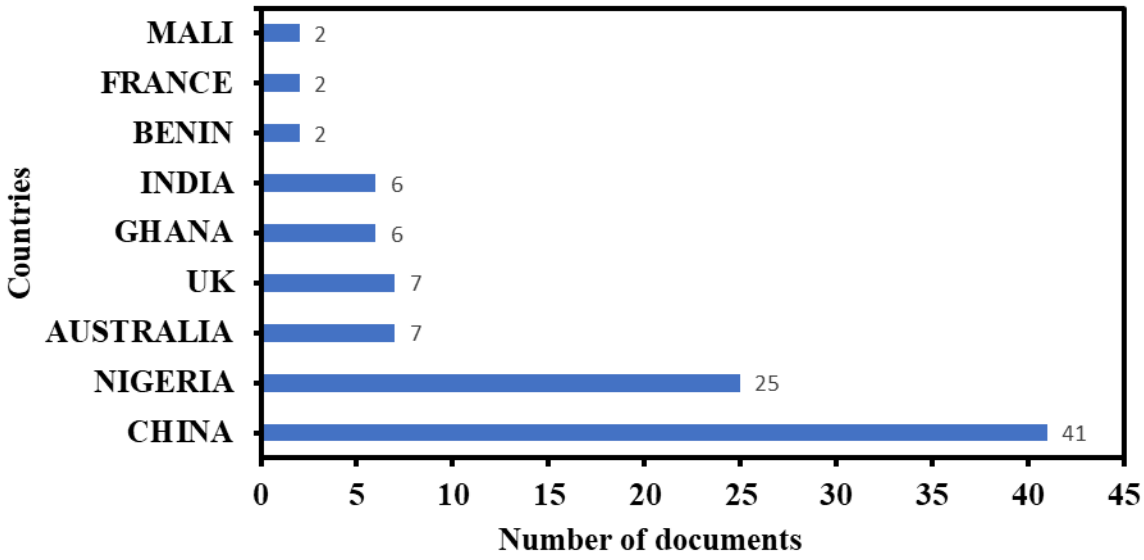

Figure 6: Scientific publications by yearly average citations

The data of the most relevant affiliations are presented in Figure 6. The result show that Zhejiang University is the most affiliated reviewed (14) followed by Gansu agricultural university and Northwest Institute (10). The International Crops research had six, Ahmadu Bello University, Zaria had four; Flinders university, Northwest Normal University, University for Development and University of Lagos all had three, while Ekiti State University had only 2 affiliations.

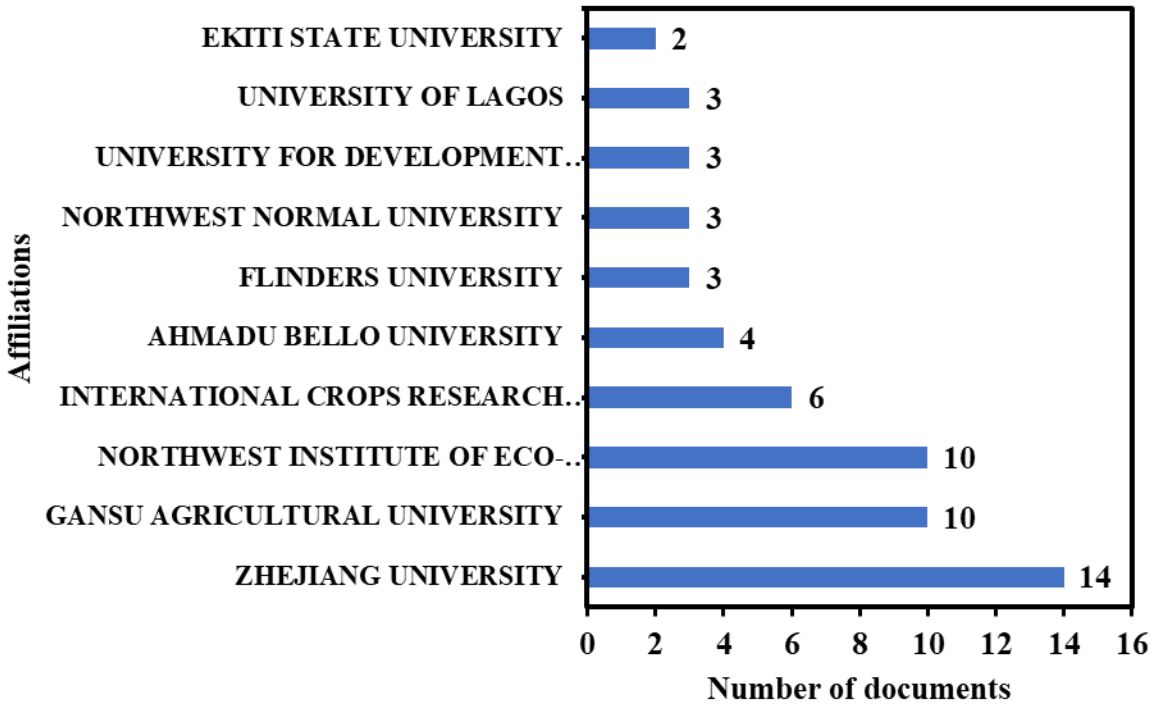

Figure 7: The most relevant affiliations

Table 1: Sources and document contribution

S/N	Sources	Articles
1.	Environmental Earth Sciences	2
2.	Geo-Journal	2
3.	Journal of Arid Environments	2
4.	Ecological Indicators	1
5.	Environmental Monitoring and Assessment	1
6.	Food Policy	1
7.	Food Security	1
8.	Forest Ecology and Management	1
9.	Global Food Security: Emerging Issues and Economic Implications	1
10.	Handbook of Climate Change Resilience	1
11.	Hydrogeology Journal	1
12.	International Journal of Climatology	1
13.	International Journal of Environmental Sustainability	1
14.	Journal of Geo-visualization And Spatial Analysis	1
15.	Journal of Hydrology	1
16.	Journal of Sustainable Agriculture	1
17.	Management of Environmental Quality: An International Journal	1
18.	Paddy and Water Environment	1
19.	Proceedings of the lasted International Conference on Environmental Management and Engineering	1
20.	Quarterly Journal of Engineering Geology	1
21.	Remote Sensing	1
22.	Science of The Total Environment	1
23.	Sustainability	1
24.	Sustainable Energy Technologies and Assessments	1
25.	Sustainable Water Resources Management	1
26.	Water	1
27.	Water and Environment Journal	1
28.	Water Resources Research	1

The data show that climate change and adaptation strategies are trending issues. To cope with the vagaries of climate change, farmers adopt various coping strategies in order to boost food production and support food security. The farmers use several adaptation strategies. The sources and documents contributions used in this research are presented in Table 1. The data show that twenty-eight (28) sources were used with relevant articles selected from them. Analysis of the most relevant authors was done. The data show that out of the numerous authors considered, ten (10) were most relevant with two documents reviewed from their works.

Table 2: Top 10 most cited publications

S/N	Author	Title	Journal	Citations
1	Ikpe et al. (2017)	Evidence od climate change and adaptation strategies in Sokoto State, Nigeria	IOSR Journal	92
2	Tougiani et al. (2009)	Community mobilisation for improved livelihoods through tree crop management in Niger	GeoJournal	54
3	Yila and Resurreccion (2020)	Determinants of smallholder farmers' adaptation strategies to climate change in the semi-arid Nguru Local Government Area, North-eastern Nigeria	Management of Environmental Quality: An International Journal	39
4	Abubakar et al. (2020)	Mapping Maize Fields by Using Multi-Temporal Sentinel-1A and Sentinel-2A Images in Makarfi, Northern Nigeria, Africa	Sustainability	32
5	Carter and Alkali (1996)	Shallow groundwater in the northeast arid zone of Nigeria	Quarterly Journal of Engineering Geology	30
6	Hamisu et al. (2021)	Performance and economic viability of the PV system in different climatic zones of Nigeria	Sustainable Energy Technologies and Assessments	26
7	Schilling et al. (2011)	Controls on Interactions Between Surface Water, Groundwater, and Riverine Vegetation Along Intermittent Rivers and Ephemeral Streams in Arid Regions	Water Resources Research	19
8	Cannell et al. 1998	Complementarity of light and water use in tropical agroforests II. Modelled theoretical tree production and potential crop yield in arid to humid climates	Forest Ecology and Management	19
9	Dittoh et al. (2013)	Micro irrigation-based vegetable farming for income, employment and food security in West Africa	Global Food Security: Emerging Issues and Economic Implications	17

10	Raji et al. (2022)	Spatially Explicit Scenario Analysis of Habitat Quality in a Tropical Semi-arid Zone: Case Study of the Sokoto–Rima Basin	Journal of Geovisualization and Spatial Analysis	17

Co-concurrence analysis of all keywords applied to conceptualise the development, traditional and cultural beliefs in climate adaptation strategies for food security in the semi-arid regions. Ten (10) most cited publications were filtered and presented in Table 2. The result show that traditional and cultural beliefs vary from place to place in adaptation strategies. Results from the reviewed literature show that farmers in the semi-arid region of Nigeria uses different adaptation strategies as a way of responding to the vagaries of climate change (Ikpe, 2021). The adaptation strategies vary from place to place and from time to time. The results further show that traditional and cultural beliefs practices is commonly used in the semi-arid region of Nigeria where rainfall amount is low. Co-occurrence analysis of all keywords was applied to conceptualize the traditional and cultural development growth of sustainability studies published in Environment, Development and Sustainability. To arrive at a meaningful analysis, following Khan et al. (2022), a minimum threshold of two for the co-occurrence of a particular keyword was required and filtered. This resulted in 551 words, for a total of 3,577 words. The results are reported in Fig.8 and reveal

six major clusters: (1) traditional adaptation (red), (2) sustainable development (green), (3) urban sustainability (blue), (4) ecological footprint (yellow), (5) environment (purple), and (6) climate change (turquoise). These clusters reflect the need for research on sustainability in response to the main interest in the environment and climate change. In addition, the topic of sustainability is of great importance to help farmers/economies ensure sustainable development and growth, as well as to improve stakeholders' perceptions and public attitudes (Figure 9).

Studies in the traditional and cultural adaptation strategies cluster have primarily focused on climate change indicators. There were three major groups of studies in this cluster. The first group focused on the types of traditional and cultural adaptation strategies. The second group focused on the determinants of adaptation strategies in the semi-arid regions. The third group focused on food security and economic development.

Figure 9: Word cloud

Data on the trending topic is presented in Figure 10. The data show that among the 14 trending topics, Nigeria trended most (25) followed by semi-arid region (20) and arid region (15) and sustainable development (150. This implies that part of Nigeria lies in the arid and semi-arid zones.

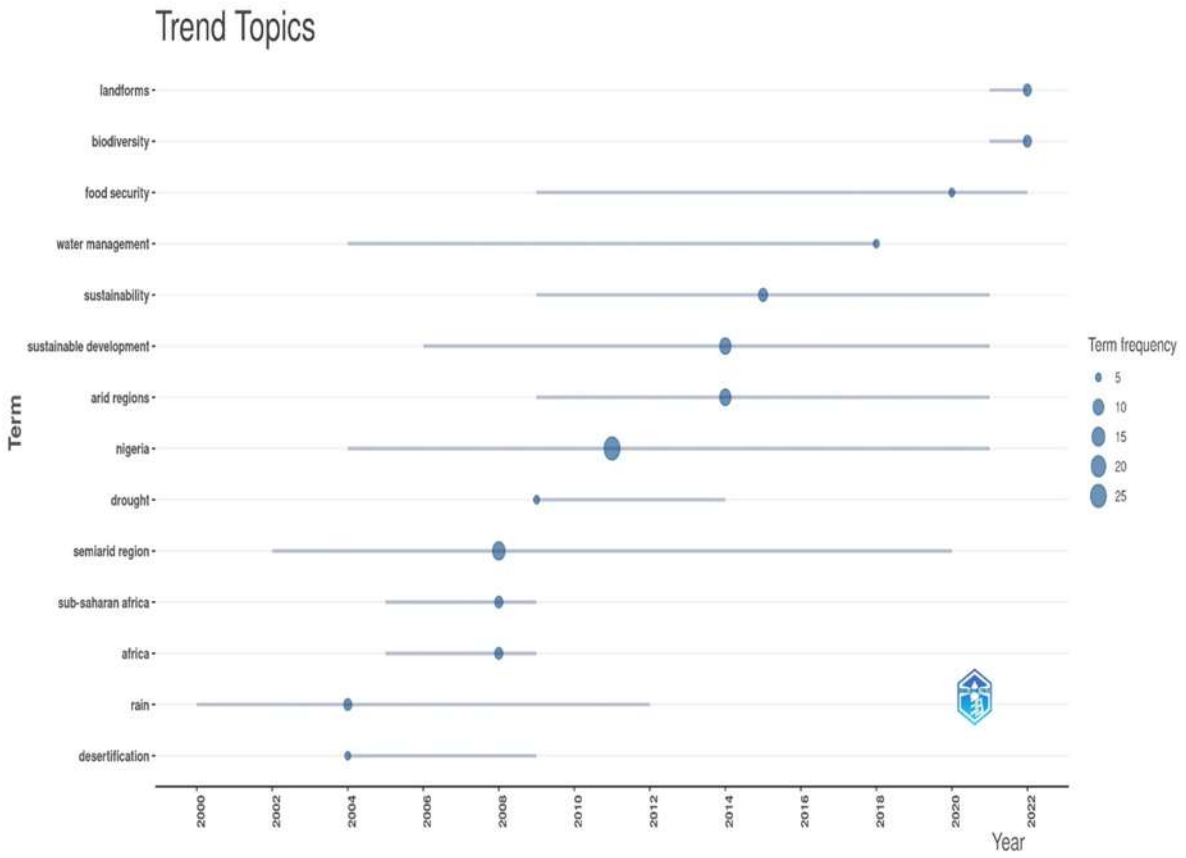

Figure 10: Trending topics

DISCUSSION

The religious belief/faith of people plays a major role on their perception of climate change and adaptation strategies, especially on what causes climate change. According to Constable (2016), the influence of religion, especially the Christian principles was evident in her study area (Jamaica) in the assertion that climate change is an act of God, a punishment for man's disobedience and a sign to end of the world.

Tucker and Grim (2001) proposed that nature is an integral component in many religious doctrines. They stated that religion provides explanations as to how the world was created, why; what humans' role is within it and even when natural disasters occur. They further explained that religion serves to bridge humans to their environment by using rituals to mark the rhythm of seasonal changes, expressing gratitude for bountiful harvests and praying to keep away destructive natural

forces. However, other studies e.g. Feder et al. (2013) also note that there may be instances in which religious belief hinder adaptation to natural disaster.

In the semi-arid region of Nigeria, traditional and cultural beliefs play a significant role in shaping climate change adaptation strategies. Here are some key aspects of traditional beliefs:

i. Spiritual connection to land and nature: Many communities believe that the land and natural resources are sacred and connected to their ancestors and spirits (Constable 2016).
ii. Rainmaking rituals: Some communities perform rituals to invoke rainfall, demonstrating their reliance on traditional practices to address climate-related challenges.
iii. Folklore and storytelling: Oral traditions and stories often contain valuable information about past climate events, adaptation strategies, and environmental management practices.

Cultural Beliefs:

i. Community-based decision-making: Decisions are often made collectively, considering the well-being of the entire community, which fosters cooperation and shared responsibility in adapting to climate change.
ii. Respect for elders: Traditional knowledge and wisdom from elderly community members are highly valued, providing valuable insights into historical climate patterns and adaptation strategies.
iii. Agricultural practices: Cultural beliefs influence farming practices, such as the use of traditional crop varieties, conservation agriculture, and agroforestry, which can enhance climate resilience (Feder et al. 2013).

Integration into Adaptation Strategies

Acknowledging and incorporating traditional and cultural beliefs into climate change adaptation strategies in the semi-arid region would help to ensure community ownership and acceptance among farmers. This would further help to make crop production become more effective, sustainable, and community-driven. Reviving and adapting traditional practices, such as rainmaking rituals, can enhance community resilience and complement modern adaptation strategies. While integrating traditional agricultural practices with modern climate-smart agriculture can improve crop yields, reduce vulnerability, and enhance food security (Umar et al. 2015).

Farmers in northern Nigeria employ various traditional and cultural adaptation strategies to cope with climate change. Here are some traditional and cultural adaptation strategies to climate change among farmers in northern Nigeria:

i. Shift in planting dates- farmers adjust planting times to coincide with changing rainfall patterns. Planting earlier or later than usual to avoid drought or floods. Nwosu et al. (2017) found

that 70% of farmers in Kano State adjusted their planting dates in response to changing rainfall patterns.

ii. Crop diversification- planting multiple crops to spread risk and ensure food security. Planting maize, sorghum, and cowpeas together to reduce dependence on a single crop (Ikpe et al. 2016). Eze et al. (2018) found that crop diversification increased farmers' resilience to climate-related shocks in northern Nigeria.

iii. Agroforestry- integrating trees into farming systems to enhance soil fertility and reduce erosion. Planting baobab trees alongside crops to provide shade and improve soil health. Tologbonse et al. (2017) found that agroforestry practices improved soil fertility and reduced erosion in farmers' fields in northern Nigeria.

iv. Soil Conservation- using traditional techniques like contour farming and terracing to reduce soil loss. Building ridges to prevent soil erosion on sloping land. Bukar et al. (2018) found that soil conservation techniques reduced soil loss by 50% in farmers' fields in northern Nigeria.

v. Rainwater harvesting- collecting and storing rainwater for irrigation during dry spells. Building ponds to store rainwater for irrigation is a viable adaptation strategy in the study area. Mashi et al. (2017) found that rainwater harvesting improved crop yields by 20% during dry spells in northern Nigeria.

vi. Fallowing- leaving land uncultivated to regain fertility and reduce pests and diseases. Leaving land fallow for a season to allow soil to recover is another strategy farmer use to adapt to climate change in the semi-arid areas of Nigeria. Eze et al. (2018) found that fallowing improved soil fertility and reduced pests and diseases in farmers' fields in northern Nigeria.

vii. Use of traditional crop varieties- planting drought-tolerant and climate-resilient crop varieties is another adaptation strategy used by farmers (Ikpe, 2021). Planting traditional sorghum varieties that are tolerant to drought. Nwosu et al. (2017) found that traditional crop varieties performed better than modern varieties during droughts in northern Nigeria.

viii. Community-based weather forecasting- using traditional knowledge to predict weather patterns. Observing changes in wind direction and temperature to predict rainfall. Tologbonse et al. (2017) found that community-based weather forecasting improved farmers' preparedness for climate-related shocks in northern Nigeria (Udeh and Ikpe 2021).

It has been reported that through viable adaptation strategies, it is possible for farmers to adapt to the effect of climate change in the semi-arid regions of Nigeria. Farmers are responding to climate risks in their own ways with the limited resources available to them. Mixed cropping is the

dominant cropping system used by small-holder farmers in the drought prone, semi-arid tropics of West Africa. The system is commonly practiced in northern Nigeria where cereals (maize, millet, and sorghum), legumes (beans) and nuts (groundnuts) are grown together (Udeh and Ikpe, 2021).

It was argued that farmer's awareness of change in climate attributes (temperature and precipitation) is important to adaptation decision making (Udeh and Ikpe, 2021). For example, Umar et al. (2015) reported that farmers awareness and perceptions of soil erosion problem as a result of changes in climate, positively and significantly affect their decisions to adopt soil conservation measures. Farmers affirmed that knowledge on climate change issues are crucial in the choice of adaptation strategies. They stated that a farmer must first noticed changes in the weather characteristics of the area before choosing the adaptation strategies to adopt.

CONCLUSION

As climate change impacts directly on agricultural production in the semi-arid areas of Nigeria, it is important that crop farmers in the semi-arid areas are conversant with viable adaptive strategies for food security and sustainable development. Based on the results, it is concluded that, there were several adaptation strategies that can be adopted in different situations. In general, the more adaptation there is, the less will be the impacts to which we will have to adjust, and the less the risk for which we will have to try and prepare. One important issue in agricultural adaptation to rainfall variability is the way farmers get their information on climate change adaptation strategies and update their expectations of the climate in response to unusual weather patterns. Our reactions to the effect of climate change are measured in terms of adaptation strategies.

Recommendations

Despite the challenges posed by climate change in the study area, there are possibilities for addressing the effects of climate change and assisting farmers to adapt to the effects of climate change. There is need for putting in place policies and programmes that will make the farmers to be proactive in the use of resources and at the same time adapting to climate change. Particularly the following has been recommended:

i. The Nigerian Meteorological Agency (NiMET) can do more in issuing seasonal forecasts weather and climate variables. Considering the sensitivity of crop yields to weather and climate variables, farmers should be encouraged to avail themselves of these services and apply such information in crop production;

ii. There is the need to employ researchers and Agricultural Extension Officers (AEOs) to guide farmers through routine visits, sensitization programmes on variability in rainfall

characteristics and use of viable adaptation strategies in other to achieve improved and sustained food security;

iii. There is the need for the government and NGOs to continue supporting the crop farmers to increase their adaptation capacities by providing credit/loan through micro finance institutions. Succour could also come by provision of grants, subsidies and agricultural inputs to the farmers; use of farm extension workers for agricultural education and updates; provision of improved seed varieties and the development of sustainable irrigation project to complement rainfall and for dry season farming.

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