

Smallholder farmers' coping and adaptation strategies to climate change: Evidence from a bibliometric analysis

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ABSTRACT

Climate change threatens smallholder farmers' productivity, revenue generation, and increases household food insecurity. Thus, adaptation and coping strategies are paramount for smallholder farming households to mitigate these impacts of climate change. This study used a bibliometric analysis to examine smallholder farmers' coping and adaptation strategies to climate change (SFCA-SCC) research trends from 2010 to 2022. A total of 1635 papers were analysed from Scopus and Web of Science (WoS) databases to characterize the field and observe research trends. The articles from these databases demonstrate an upward trend in publications (54–300) over the period under study, signifying the importance of research on adaptation and coping strategies of climate change. The research findings showed that majority of studies originated from institutions in industrialized countries, while very few did so from emerging economies. According to the findings, smallholder farmers have embraced a range of adaptation and coping mechanisms to mitigate the impacts of climate change, such as altering planting schedules, and diversifying crop varieties among others. It is imperative for African researchers and institutions to engage in more research aimed at developing strategies to mitigate the risks posed by climate change.

1. Introduction

Climate change (CC) is the biggest environmental hazard intimidating the entire world's populace (Aryal et al., 2020). The growing anthropogenic greenhouse gas emissions that cause global warming (IPCC, 2018) are mostly related to expanding individual incomes without pondering the cost to public goods, such as the ambient. As a result, the average global temperature is rising, and rainfall patterns are changing unpredictably. Moreso, societies are enduring protracted heat stress, floods, drought and a rise in pestilence and illnesses (Aryal and Marenja, 2021). CC lowers agricultural productivity and revenues, disrupts markets, and increases risks (Cacho et al., 2020). In many regions of the world, livestock and crop production are already being impacted by CC, creating significant obstacles to achieving SDG2 (IPCC 2014). Although CC affects everyone, resource impoverished families living in emergent countries totally reliant on climate sensitive areas for their incomes are the most susceptible (Aryal et al., 2020).

Smallholder farmers cultivate less than a hectare of land during a cropping period, engage in labour-intensive farming, utilize primitive technology, particularly hand hoes, have a small number of livestock, and produce primarily for household consumption with a tiny surplus for the market (Atube et al., 2021). They face numerous challenges along the agricultural value chain, including a lack of understanding and expertise for value addition, limiting their ability to access markets and increase output (Mathinya et al., 2022), thereby forcing them to reduce both the quantity and quality of their food consumption. In light of the aforementioned effects of CC, strategies to strengthen agricultural systems' resilience are required to lower the risk of food insecurity both now and in the future (Smith and Frankenberger, 2018).

Although the study of CC adaptation is receiving more attention, the majority of studies focus on a single problem, and there are relatively few papers that discuss the overall development trend and research focus in the area of smallholder farmers' coping and adaptation strategies to CC. Thus, this study focuses on reviewing the available scientific

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literature on smallholder coping and adaptation strategies globally. This study will fill in the literature gaps, help identify current research on SFCA-SCC and enhance understanding on scientific knowledge of coping and adaptation strategies to CC on agricultural productivity.

2. Materials and data collection methods

The present study considered different search subjects to locate academic papers on climate coping and adaptation research worldwide via bibliometric technique. In the context of literature reviews, bibliometric analysis is a useful innovation because it tries to compile all pertinent documents required for the study. The bibliometric approach utilises numerous databases, including Web of Science, Scopus, etc. In order to show the past and present organisation of the relevant and related field of study through co-authorship, bibliographic coupling, citation, keyword occurrences, and cluster analysis, bibliometric can be said to be one of the most rigorous approaches that have been widely accepted for analysing the various aspects of published academic materials, including highly-cited documents, most influential journals, countries, and organizations (Ogundeji and Okolie, 2022; Okolie et al., 2023). This approach uses three basic bibliometric indicators to measure academic progress: structural indicators, which assess the trends and patterns of scholarly research, qualitative indicators, which evaluate performance, and quantitative indicators which measure productivity (Paletto et al., 2020). This approach is encouraged by a number of factors, including the fact that a data-driven study is more useful and precise than subjective assessments (Nobanee et al., 2021).

The review relied on two main journal databases: (WoS) and Scopus. The WoS is a thorough database with 33,000 journals covering more than 256 fields such as interdisciplinary social sciences, biological and physical sciences, environmental studies, planning and development studies. The Scopus database is one of the largest citation databases and an abstract of peer-reviewed literature, which contains data from about 22,800 journals from 5000 publishers worldwide. (Shaffril et al., 2018). The Scopus repository is the top multidisciplinary database of research that has been peer-reviewed in the field of social science, and it is widely used for statistical evaluations (Baker et al., 2021). A variety of eligibility and exclusion criteria are taken into consideration for the quick visibility and retrieval of relevant materials. Table S₁ (see the supplementary data) displays the eligibility and exclusion criteria used to identify suitable articles.

2.1. The methodology and systematic review process

According to Rethlefsen et al. (2021), the systematic analysis should adhere to a clearly established methodology, strategy, and criteria explicitly specified before the review process is undertaken. In this regard, the preferred reporting items for the systematic review and meta-analysis (PRISMA) statement, first published in 2009, with updated guidelines in 2020, clearly reflects advances in strategies, methods, and transparency to identify, appraise, select, and synthesized studies (Page et al., 2021).

The bibliometric analysis is a widely used and acceptable systematic approach for evaluating knowledge structure and development of specific research fields (Donthu et al., 2021a). According to Islam et al. (2022), this method is ideal for displaying research trends, activity, development, and density in the research field. The technique identifies critical research issues, active researchers, institutions, and regions for future planning and funding (Sweileh et al., 2017). In addition, researchers can gain a deeper understanding of an established topic, recognize emerging trends, and assess their progress over time by

identifying the focal areas highlighted by researchers and addressing the gaps in existing research (Donthu et al., 2021b).

Also, it helps to monitor the periodic evolution of the subject areas and guide research from micro to macro focus (Islam et al., 2022). Consequently, this offers researchers the opportunity to examine the dynamic manifestation of the research field from a broader perspective. A search protocol was developed in advance to determine articles' exclusion and eligibility for analysis. The review process followed the PRISMA guidelines for reporting systematic review. This study used six steps in the systematic review process (Figure S₁ in the supplementary data). The search string was based on prior researches "coping and adaptation strategy to climate among smallholder farmers" (Table S₂ in the supplementary data).

3. Bibliometric analyses and results

This section reports on the analysis of 1635 papers published on SFCA-SCC during the research period (Table 1). In the evaluation of journals, books, and other publications, there are 466 journal sources with 7039 author appearances, 0.30 documents per author, 3.41 authors per document, and 4.3 co-authors per document. With a collaboration index of 3.60, there were 5579 authors involved, 5476 of whom published authors of papers with multiple authors, and 103 of whom published authors. Research collaboration, particularly international collaboration, is usually believed to benefit both the organizations and the researchers involved and improve the superiority of the research (Van den Besselaar et al., 2012), leading to higher citations (impacts) and higher numbers of scholarly publications (Khor and Yu, 2016). Lotka's law produced a constant of 0.79 with a beta coefficient of 3.31. The constant value suggests a consistent pattern in the distribution of authorship. The beta coefficient indicates the degree of inequality in authorship distribution, with higher values indicating greater inequality. The findings indicate a constant and uneven distribution of authorship in publications, with a small number of writers contributing disproportionately more to the scholarly literature. Thus, understanding these trends can help to shape conversations about research productivity, cooperation dynamics, and initiatives for promoting diversity and inclusion in academia.

Fig. 1 shows that the study output varied over time, reaching its peak in 2021 with 18.35% of the total study output. Then, in 2020, 214 research papers represented 13.1% of the total study output were also published. Note that 2022 until May 2022 are included in our study, but we have chosen to exclude these from the figure since we do not have

Table 1
The most critical elements of the WoS and Scopus datasets.

Description	Results
Documents	1635
Sources (Journals)	466
Authors	5579
Author Appearances	7039
Authors of single-authored documents	103
Author of multi-authored documents	5476
Documents per Author	0.30
Authors per Documents	3.41
Co-Authors per Documents	4.30
Collaboration Index	3.60
Lotka's law of scientific output	
Constant L\$C	0.79
Beta coefficient L\$B	3.31

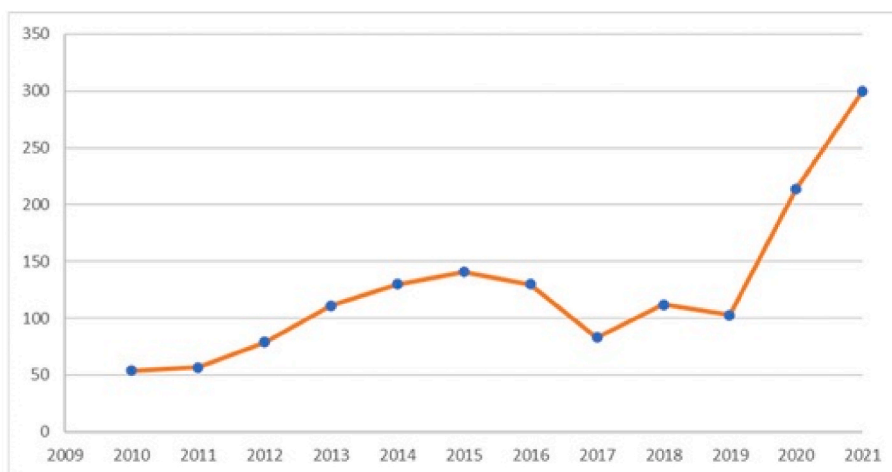


Fig. 1. Annual scientific production.

Table 2
Most relevant keywords.

S/N	DE	Articles	ID	Articles
1	Climate change	765	Climate change	1092
2	Adaptation	451	Adaptive management	423
3	Climate change adaptation	115	Agriculture	254
4	Adaptation strategies	114	Adaptation	245
5	Agriculture	111	Vulnerability	200
6	Climate variability	92	Climate effect	175
7	Vulnerability	90	Perception	157
8	Perception	63	Strategic approach	145
9	Resilience	60	Adaptation strategies	119
10	Food security	47	Decision making	114
11	Drought	44	Drought	114
12	Mitigation	40	Crop production	110
13	Smallholder farmers	40	Crop yield	107
14	Coping strategies	39	Water management	96
15	Livelihoods	29	Food security	93

data for the entire year. As of May 2022, there were 121 research papers from 2022, representing 7.4% of our data material. The quantity of academic publications reveals the calibre and strength of the research (Wang et al., 2018). Table 2 displays the most important keywords associated with SFCA-SCC study comprising of the Author Keywords (DE) and Keywords-Plus (ID). Climate change, adaptation, adaptation strategies, agriculture, vulnerability, perception, food security, and drought are the common keywords to DE and ID. The remaining author unique keywords explain the medium that is pretentious by CC as well as the methods or components that are engaged in the process. This result shows that SFCA-SCC research has consistently recognized these agricultural production and food supply difficulties and identified the CC role in the process.

Table S_{3a} reports on the top 10 most productive authors within the period under study. The study identified Liu Y as the author who has been the most productive throughout time, with 16 articles. Khan M placed second on the list with 14 articles. Li Y placed third on the list with 13 articles while Hoogenboom G placed fourth on the list with 11 papers, Islam M, Liu D, and Wang J each published 9 papers while a total of 8 papers each were published by Aggarwal P, Islam A, and Olesen J throughout the study period. The number of a scientist’s intellectual production reveals their ability as well as their willingness to undertake high quality study (Orimoloye et al., 2021). Table S_{3b} lists the most relevant sources of studies on SFCA-SCC. With 83 scientific articles, climatic change ranked first on the SFCA-SCC. A total of 50 articles from

the International Journal of Climate Change Strategies and Management, 46 papers from the Regional Environmental Change journal, and 43 articles from Climate and Development placed second through fourth, respectively. The top papers on SFCA-SCC are published in gazettes correlated to geology, climate, environment, ecology, and biology, with some gazettes classified in the worldwide biogeochemical cycle, like multidisciplinary organizations, and nature climate change, like Science of the Total Environment and Quaternary International, focusing on this area of study (Li et al., 2011).

Table S_{3c} displays the top 10 countries with the greatest number of corresponding authors associated to SFCA-SCC. For the topmost active nations in both developing and developed nations, production is measured in terms of the overall number of papers. USA has the largest number of papers (n = 152), followed by China with an overall number of papers (n = 146) and then Australia ranked third with a total number of (n = 96). Germany rated fourth with an overall number of papers (n = 91). However, USA has the greatest document of research papers in SFCA-SCC and is the leading country in terms of frequency of publication, single country publications, and multiple country publications. Table 3 shows the total citations per country. Although the country’s total citation of academic papers varied during the study period. According to the total citations per country result, the most cited countries were industrialized. USA rated first with a total citation and average article citation of 7219, Australia ranked second with 3232, Germany rated third with 3211 and so on. The total citations per country shows that the academic successes of scientists in USA, Australia, and Germany have a very significant impact on the field.

A wide range of writers have contributed significantly to academic and national cooperation networks (Figure S₂ and Fig. 2). Figure S₂ and

Table 3
Total citations per country.

S/N	Country	Total citation
1	USA	7219
2	Australia	3232
3	Germany	3211
4	Netherlands	2758
5	China	2659
6	United Kingdom	2323
7	Spain	1517
8	Italy	1008
9	Kenya	885
10	India	834

Fig. 2 indicate that between 2010 and 2022, most SFCA-SCC studies were based in universities in both industrialized and emerging nations. Each university is represented by a circle, and some universities are also marked by a label (van Eck and Waltman, 2017), thus labels are visible only for some of the universities. The Stanford University (USA), the University of Rutgers (USA) and City University of New York (USA) have the largest alliance network on SFCA-SCC studies followed by Columbia University (USA), Aalborg University (Denmark) and University of Rhode Island (USA). This result is consistent with The Lancet (2019), who noted that it is understandable given that Sub-Saharan Africa typically devotes 0.4% of its Gross Domestic Product (GDP) to scientific research, compared to 27%, 31%, and 37%, for Europe, Asia, and North America, respectively.

In this study, the network map of nation co-authorship was visualized using VoSviewer (Version 1.6.18.exe). Fig. 3 illustrates network visualization of 30 co-authorship country collaboration in five clusters. The minimum number of documents co-authored by each country to meet the thresholds was set at three. The frequency of terms that co-occur representing each country contributes to the formation of clusters; the more frequently the terms tend to co-occur, the more colourful the clusters become. The number of publishing for the nation is represented by the circles size, while the size of the collaborations is shown by the thickness of the lines (Romero and Portillo-Salido, 2019). A cluster is formed by nations of a similar colour. The largest circle of the blue cluster is United States with a total link strength of 144 and have a strong collaboration with China, Pakistan, among others. The biggest circle of the red cluster is Germany with a total link strength of 179 and have a greatest collaboration with Netherland, United States, among others. The largest circle of the purple cluster is United Kingdom with a 116 total link strength, and have the highest collaboration with Canada, Sweden, among others.

Sub-Saharan Africa's economic growth dropped to 3.6% in 2022 from 4.1% in 2021 and is expected to dip to 3.1% in 2023 (World Bank, 2023). Global economic sluggishness, lingering inflation, and tough financial conditions with high debt contribute to this decline. There has been some growth in research output concerning smallholder farmers' coping and adaptation strategies to climate change in Africa (Batungwanayo et al., 2023; Osiru et al., 2023). The studies reveal that smallholder farmers are vulnerable to climate change and its impacts on agriculture, which is their main source of livelihood. The farmers have adopted various adaptation and coping strategies, including climate-smart practices, non-farm employment, and multiple on-/off-farm and diet-based adaptation strategies. The rest include sales of productive assets and reduction in food consumption rates, changing planting dates, growing crop variety mixtures, practicing soil and water conservation. However, the effectiveness of these strategies varies, and some farmers still face challenges due to resource constraints and low adaptive capacity. The studies suggest that promoting smallholder farmers' adaptation to climate change requires a policy shift, institutional, policy, and technology support, and creating opportunities for non-farm income sources. Additionally, better information on how smallholder farmers understand climate change and variability and what their adaptation strategies are is essential for promoting successful adaptation. Overall, the studies highlight the importance of understanding smallholder farmers' perceptions and adaptation strategies to develop effective policies and programs aimed at promoting successful adaptation in the agricultural sector. The yellow cluster, which is made up of African countries, has the least total linking strength (56) suggesting a low collaboration from Africa. This result is consistent with Olufadewa et al. (2020), who stated that there is frighteningly little cooperation among sub-Saharan African nations. Furthermore, according to data from the World Bank (2014), research collaboration ranges from 0.9% in central and west Africa to 2.3% in southern Africa. The low number of papers from underdeveloped countries, especially those in Africa, has important implications for policy.

The ability of developing countries, especially those in Africa, to

participate to the global conversation may be hampered by their restricted access to resources including financing, technology, and research infrastructure (Olufadewa et al., 2020). The underrepresentation of these nations in international debate may continue because of this restricted access. Low contributions of papers from developing nations, especially those in Africa, may also be attributed to problems with connection, low economic growth, and little economic diversification (Usman and Landry, 2021). These difficulties may reduce the funds available for research and development, which may limit these nations' ability to contribute to the global conversation. The lack of papers from underdeveloped countries, especially those in Africa, emphasizes the necessity of capacity building initiatives to aid in research and development in these nations (Olufadewa et al., 2020). Through finance, human capital development, and research infrastructure building, these projects can help these nations contribute more to the global discussion.

In terms of bibliometric analysis, keywords are quite helpful when examining the knowledge structure of scientific areas because their primary goal is to enable quick access to scientific works (Vargas-Quezada et al., 2017). Research hotspots like the attention of numerous scientists focused on several connected research challenges and concepts are adequately described by keywords (Romero and Portillo-Salido, 2019). Fig. 3 show the keyword co-occurrence network visualization of SFCA-SCC with 62 terms in 8 clusters. In the keyword co-occurrence network visualization, thresholds were established at a minimum of five documents per article. A circle is used to represent each term, and the label's size and circle diameter indicate how many links there are between each keyword and others. As observed from Fig. 3, as it was the most popular keyword, climate change has the greatest connections with other keywords. As a result, climate change has the greatest degree of betweenness, which is consistent with the study's main result (Wang et al., 2018).

4. Conclusion

Climate change is the biggest environmental hazard intimidating the entire world's populace: the average global temperature is rising, sea levels are increasing, glaciers are melting, and rainfall patterns are changing in an unpredictable way. Smallholder farmers' adaptation and coping strategies are paramount to mitigate these impacts of climate change. The study results show clearly that the number of research papers has increased exponentially. According to the results of the study, climate change, adaptation strategies, among others are the keywords that are common to DE and ID. Furthermore, the countries with highest number of corresponding authors are USA, China, Australia and Germany, and the most productive author in the field of SFCA-SCC is Liu Y. The study findings indicated that majority of the studies came from industrialized nations with only a few from the emerging economies.

Farmers have used a variety of adaptation and coping techniques to reduce the adverse effects of climate change. These include adopting climate-smart farming methods, looking for non-farm job options among others. Moving forward, adaptation policies should build on current coping mechanisms while addressing challenges to the implementation of adaptation techniques at various scales. Policymakers may build a more resilient agriculture sector capable of overcoming climate change problems by leveraging current practices and eliminating barriers to adaptation adoption. This method would result in a more comprehensive and effective response to climate change-related concerns in agriculture.

Under all climate scenarios with a temperature increase of 1.5°C, Africa is the continent most susceptible to the effects of climate change. Despite being the region that contributes the least to global warming and emits the fewest greenhouse gases, Africa is facing growing harm that poses systemic risks to its economies, livelihoods, agriculture, public health, food systems, water, and infrastructural investments. If nothing is done, this damage could reverse the region's modest development progress and push it further into extreme poverty. Thus, the call for more

African countries' scholar and institutions to research on adaption and coping strategies to climate change, is crucial.

The low number of papers from developing countries, particularly those in Africa, can be addressed through programs for strengthening capacity building to aid in research and development. Grants and funds can be given to boost research and development since doing so can assist in supplying the required resources, which in turn can increase the contributions made by these nations to the global debate. Collaboration between scholars and institutions in developing countries, especially those in Africa, and those in wealthy ones may help these nations contribute more to the global conversation.

The bibliometric survey conducted in this research has some restrictions, including the usage of two database, the rigor with which search terms and method used, and the elimination of other article kinds (such as book, book series, so on) also divulged papers in languages other than English. Despite the restriction, bibliometric has been widely accepted as a way for assessing diverse study niche area throughout time. Future research, however, should consider extending the results of this study using different databases, such as JSTOR, google scholar etc.

CRedit authorship contribution statement

Collins C. Okolie: Writing – original draft, Software, Methodology, Formal analysis, Data curation. **Oluwasola T. Ogunleye:** Writing – original draft, Methodology, Investigation, Data curation. **Gideon Danso-Abbeam:** Writing – review & editing, Validation, Investigation, Formal analysis. **Abiodun A. Ogundeji:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Formal analysis, Conceptualization. **Ágoston Restás:** Visualization.

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.

Data availability

No data was used for the research described in the article.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.indic.2024.100451>.

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