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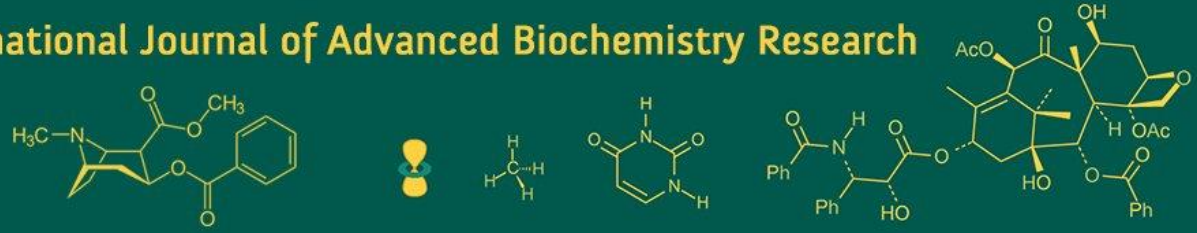

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Farmer perceptions and adaptation strategies to water scarcity in agriculture: A bibliometric analysis

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Abstract
Water scarcity presents a critical challenge to global agriculture, threatening food security, rural livelihoods, and sustainable development. Farmers' perceptions of and responses to water-related stress are increasingly recognized as pivotal factors in shaping effective adaptation strategies. This study employs a bibliometric analysis to systematically map the global scientific literature on farmer perceptions and adaptation strategies to water scarcity in agriculture. Using data retrieved from the Scopus database, the study analyzed 19 peer-reviewed articles published between 2000 and 2025 that met rigorous inclusion criteria. The analysis was conducted using Biblioshiny, a tool within the Bibliometrix R package, to identify research trends, key contributors, geographic distribution, and thematic evolution in the field. The results highlight a growing yet geographically uneven body of literature, with Ethiopia, India, and Brazil emerging as key contributors. Thematic analysis revealed that while drought and adaptation strategies are mature and central research themes, foundational areas such as farmer perceptions and attitudes remain underdeveloped. Co-authorship and keyword co-occurrence networks further reveal a fragmented research landscape, with limited interdisciplinary and international collaboration. This study underscores the importance of expanding research efforts, particularly in underrepresented regions, and integrating socio-economic dimensions into adaptation planning. The findings provide a valuable roadmap for future research and policymaking aimed at enhancing climate resilience in agriculture.

Keywords: Water scarcity, farmer perception, climate change adaptation and bibliometric analysis

Introduction
Water scarcity poses a significant threat to global agriculture, directly impacting food security, rural livelihoods, and sustainable development. According to the Food and Agriculture Organization (FAO), agriculture accounts for approximately 70% of global freshwater withdrawals, making it highly sensitive to water availability (FAO, 2021) [5]. The World Bank (2023) [13] estimates that by 2050 water scarcity exacerbated by climate change could cost some regions up to 6% of their GDP primarily due to impacts on agriculture, health, and income.

The United Nations World Water Development Report (2021) highlights that over 2 billion people live in countries experiencing high water stress, with agricultural regions in South Asia, Sub-Saharan Africa, and the Middle East particularly vulnerable. Additionally, groundwater depletion in major agricultural basins such as the Indo-Gangetic Plain and the Central Valley of California has reached critical levels, threatening long-term agricultural viability (Wada *et al*., 2016) [15].

Farmers' perceptions of water scarcity play a pivotal role in shaping their responses (Bhadwal et.al,2019) [3]. These perceptions are influenced by their socio-economic background, farming experience, education level, institutional support, and access to information (Below *et al*., 2012; Niles & Mueller, 2016) [2, 10]. Empirical evidence suggests that farmers who perceive greater risks from water scarcity are more likely to adopt adaptive measures such as drip irrigation, mulching, water harvesting, drought-tolerant crop varieties, and changes in cropping calendars (Ngigi *et al*., 2017; Mertz *et al*., 2009) [9, 8].

A bibliometric analysis can provide a comprehensive overview of global research trends, identifying influential studies, collaboration networks, emerging themes and gaps in knowledge. Such an approach is essential to support targeted interventions, inform policy and promote evidence-based strategies for climate-resilient agriculture. Therefore, this study

aims to analyze global research on farmer perceptions and adaptation strategies to water scarcity in agriculture, using bibliometric techniques to systematically map the literature and guide future research and policy directions.

Research Methodology

This study employs a bibliometric analysis approach to systematically examine the global scientific literature on farmer perceptions and adaptation strategies to water scarcity in agriculture. Bibliometric methods are widely used to evaluate research output, identify trends, and visualize the intellectual structure of a research domain using quantitative techniques (Donthu *et al*., 2021) [4].

The bibliometric data were retrieved from the Scopus database, which is one of the largest and most comprehensive abstract and citation databases for peer-reviewed literature. Scopus was selected due to its wide coverage of high-quality journals across disciplines, particularly in agricultural and environmental sciences.

The literature search was conducted using a combination of keywords related to the core themes of the study. The search strategy used for the study include "Farmer perception", "Farmer Attitude", "Farmer View", "Water Scarcity", "Drought", "Adaptation Strategies" and "Adaptive Measure".

Inclusion and Exclusion Criteria

The inclusion and exclusion criteria for the review is given in the Table 1. The study focuses on literature published between the years 2000 and 2025, excluding works released before 2000. Only documents classified as articles were included, while other types such as book chapters, reviews, conference papers, books, notes, and editorial board contributions were excluded. The analysis was limited to publications in the English language, omitting non-English documents. Furthermore, only final published versions were considered, excluding articles that were still in press. In terms of accessibility, the study prioritized open access articles, specifically those published under gold and hybrid access models. Lastly, only sources from peer-reviewed journals were included, while publications from books, conference proceedings, book series, and trade journals were excluded.

Table 1: Inclusion and Exclusion Criteria

Criteria	Inclusion	Exclusion
Initial Identification		
Timeline	2000 -2025	<2000
Document Type	Article	Book Chapter, Review, Conference Paper, Book, Note, Editorial Board
Language	English	Non - English
Publishing Type	Final	Article in Press
Access Type	Open Access	Gold, Hybrid
Source Type	Journal	Book, Conference Paper, Book series, Trade Journal
Screening		
Title and Abstract	The study considered publications that contained predefined keywords within their titles and abstracts	
Full Text	This study incorporates relevant publications that specifically address the predefined keywords.	

Screening and Selection Process

The initial search produced a substantial number of articles. To identify studies relevant to the research objectives, titles and abstracts were carefully screened. Selected articles were then subjected to a thorough full-text review to confirm their suitability. The entire selection process was systematically documented in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and is illustrated in Figure 1.

Data Analysis

The bibliometric analysis was conducted using Biblioshiny, a web-based interface of the Bibliometrix R package, which provides comprehensive tools for quantitative research in bibliometrics. Biblioshiny facilitated the extraction and visualization of key bibliometric indicators, including annual scientific production, most relevant authors and sources, country-wise contributions, collaboration networks, and thematic evolution.

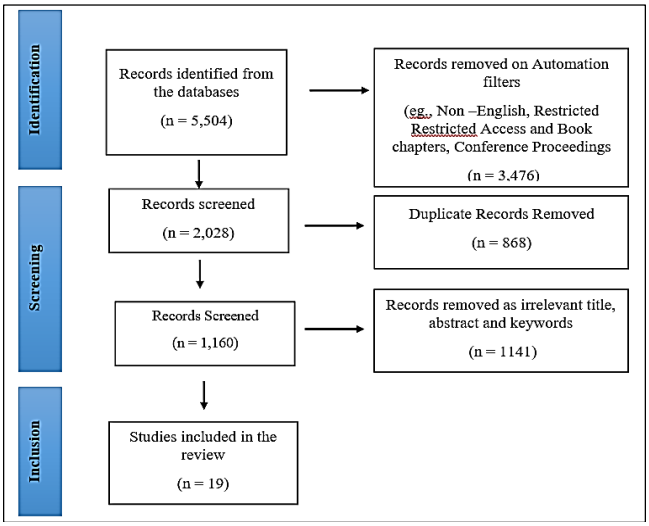

Fig 1: PRISMA Flowchart

Results and Discussion

Three Plot Diagram

The Three-Field Plot generated from Biblioshiny visually presents the interconnection between the most cited references (CR), top contributing authors (AU) and key documents or keywords (DE) in research related to farmers' perceptions and adaptation strategies to climate change and water scarcity in agriculture. On the left, highly cited references such as Abid *et al*., Deressa *et al*., and Yamane demonstrate their foundational importance in shaping the literature on vulnerability, perception, and adaptation strategies.

The central column features prolific authors like Abrah MG, Abrah AZ, and Abbas Q, whose works are frequently cited and contribute significantly to studies focusing on regions such as Northern Ethiopia and Punjab, Pakistan. The right column, labeled DE, showcases dominant research themes and journals, including terms like climate change, drought, climate variability, and smallholder farmers, as well as key outlets such as the Journal of Agricultural Science and Science of the Total Environment.

The interconnecting arcs highlight the citation pathways, revealing how specific authors link to foundational references and prevalent research themes. This visualization effectively captures the scholarly network and thematic focus of the field, indicating a concentration of research on smallholder farmers' adaptive capacities in response to climate risks in developing regions.

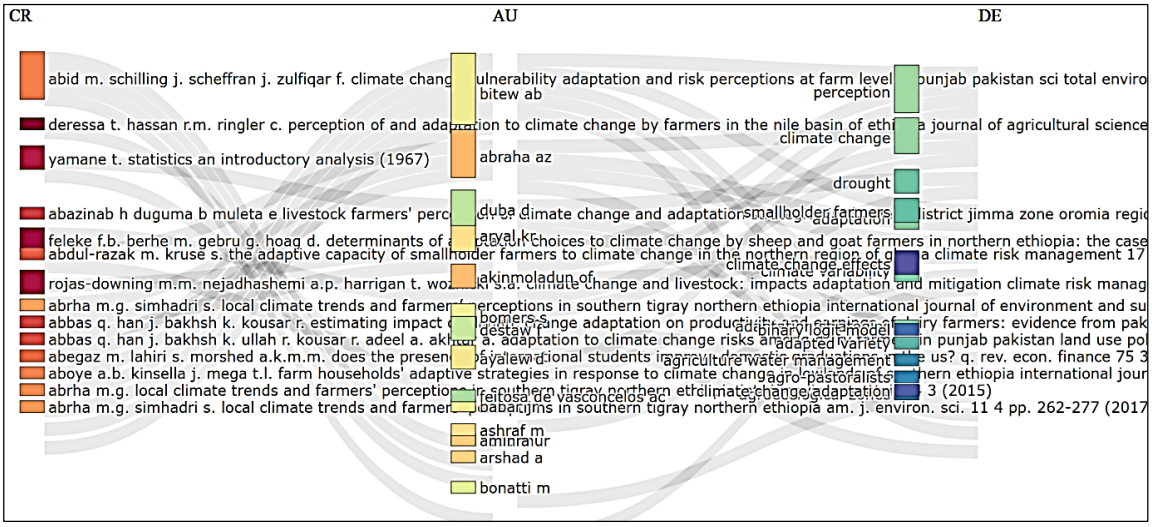

Fig 2: Three Plot Diagram

Most Relevant Sources

The "Most Relevant Sources" chart from Biblioshiny highlights the academic journals that have contributed publications to the dataset on farmers' perceptions and adaptation strategies to climate change and water scarcity. Each source listed in the chart such as Advances in Meteorology, Agricultural Water Management, Climate Services, and Applied Geography has contributed exactly one document to the collection. This uniform distribution indicates that the research is spread across a wide range of journals, with no single journal dominating the field. Such dispersion suggests that the topic is interdisciplinary, engaging scholars from various domains including meteorology, agriculture, geography, climate science, and sustainability. It also implies a growing interest across different platforms rather than concentration within a specific publication. This pattern may reflect the evolving and multifaceted nature of research on climate adaptation and agricultural resilience, requiring inputs from diverse academic perspectives.

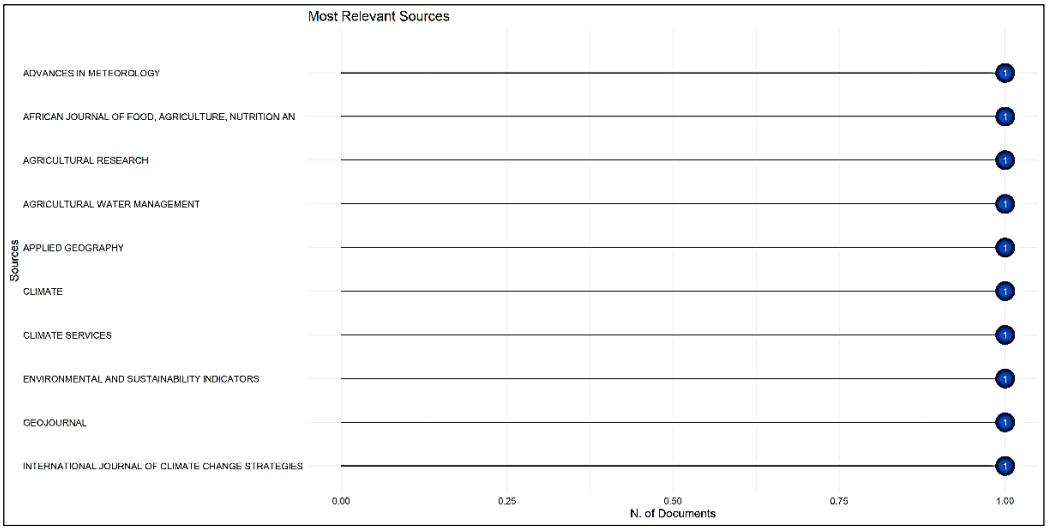

Fig 3: Most Relevant Sources

Countries Scientific Production

The "Country Scientific Production" map provides a global overview of the geographical distribution of scientific publications related to the selected research topic likely climate change, water scarcity and farmers' adaptation strategies. Countries are shaded in varying intensities of blue, with darker shades indicating a higher number of publications.

From the visualization, Ethiopia stands out as the most prolific contributor indicated by the darkest blue shade. This suggests a significant research interest or institutional focus on climate-related agricultural challenges in Ethiopia. Other countries with notable contributions include India, China, Brazil, South Africa, and the United States, all of which are shaded in medium to dark blue tones. These countries may be actively engaged in addressing climate adaptation strategies due to their large agricultural sectors and vulnerability to climate change impacts.

The presence of countries from Africa, Asia, Europe, and the Americas highlights the global relevance and concern around this issue. However, several regions, particularly parts of Central Asia, the Middle East, and much of Eastern Europe, appear underrepresented or inactive in this specific research domain, as indicated by the absence of color (gray areas). This map underscores the need for increased global collaboration and research efforts, especially from regions currently underrepresented, to develop a comprehensive understanding and collective response to climate change and its effects on agriculture.

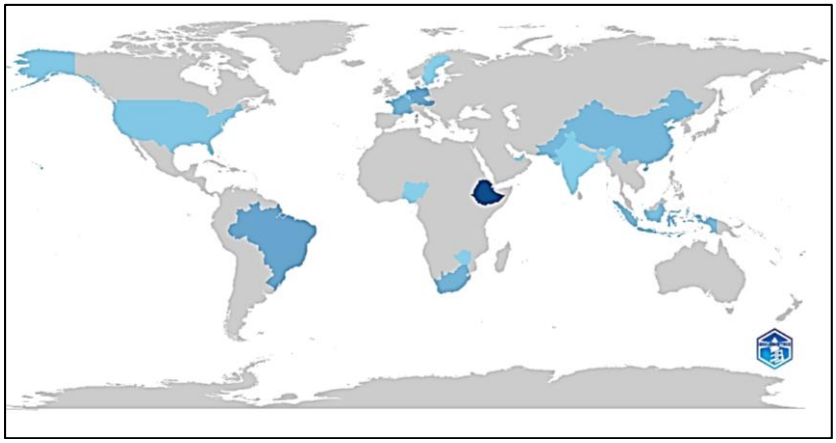

Fig 4: Countries Scientific Production

Countries Production Over Time

The "Countries Production over Time" graph illustrates the longitudinal trend in scientific publication output from selected countries like Austria, Brazil, Ethiopia, Germany, and the Netherlands on a specific research topic, likely related to climate change and agricultural adaptation. Among these, Ethiopia demonstrates the most significant upward trajectory, with a consistent rise in publication output from 2016 onward, culminating in over 20 articles by 2025. This trend indicates a growing research emphasis and possibly increasing institutional or policy-driven focus on the topic within the country (Hossain et.al,2025) [6].

Brazil shows a notable increase beginning around 2022, reaching a plateau at approximately 8 articles, suggesting a recent surge in research engagement. Germany and the Netherlands have maintained steady outputs, each consistently contributing around 7 articles since 2022 and 2020, respectively. Meanwhile, Austria entered the research landscape later, with its publication activity starting only in 2022 and remaining constant since.

The graph highlights Ethiopia's dominant and accelerating role in the research domain, with other countries either maintaining consistent output or gradually increasing their involvement in recent years. This trend suggests both geographic diversity in research interest and the emergence of Ethiopia as a key contributor to this academic field.

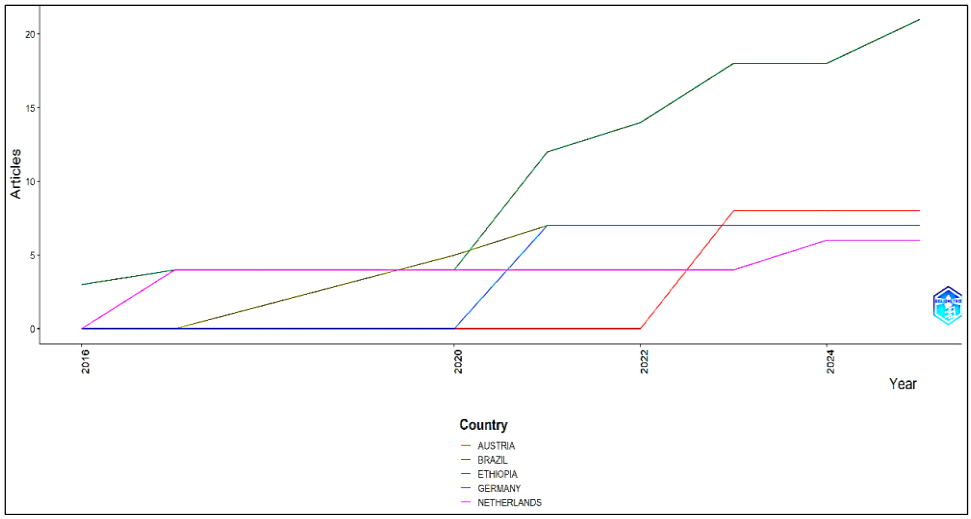

Fig 5: Countries Production Over Time

Thematic Map

This thematic map provides a strategic visualization of research themes in the domain of agriculture and climate change, mapped across two dimensions: the relevance degree (centrality), which indicates the theme's importance in the overall field, and the development degree (density), which shows how mature and specialized a theme is. The map is divided into four quadrants that help categorize the themes based on these two dimensions.

In the top-right quadrant, labeled as Motor Themes, we find the most significant and well-developed topics. Themes such as drought, adaptation strategies, and adaptation fall into this category. These are both central and well-researched topics, suggesting that they are driving the field of climate change and agriculture research. Their presence in this quadrant indicates strong interconnectivity with other themes and a mature body of knowledge, making them essential focal points for current and future studies (Prabakaran & Azeez,2024) [11].

The top-left quadrant, representing Niche Themes, usually contains topics that are well-developed but not very central to the broader field. Interestingly, this quadrant is sparsely populated in the current map, suggesting that the research field may not yet have many highly specialized but peripheral topics. This might indicate a current consolidation around core issues rather than branching into isolated, niche areas.

The bottom-left quadrant, which includes Emerging or Declining Themes, highlights underdeveloped and marginal topics. Themes such as risk assessment and strategic approach are located here. These may represent either early-stage research areas that have not yet gained traction or older themes that are losing relevance. Their future trajectory will depend on whether they begin to integrate with more central themes or fade from research focus.

The bottom-right quadrant, marked as Basic Themes, holds topics that are important to the field but still underdeveloped. This includes farmers' attitude, climate change, and perception. These are foundational themes that are central to understanding how climate change impacts agriculture, particularly in terms of behavioral and psychological responses of farmers. However, their low development suggests that they require more detailed exploration, providing rich opportunities for future research, especially in policy design, extension education, and social sciences.

In the central area of the map, we see transitional themes such as agricultural robots, Brazil, and crop production. These are moderately developed and moderately central themes, often acting as bridges between more developed and less developed areas. Their placement suggests increasing importance in the context of technology adoption and geographic case studies related to climate-resilient agriculture. Lastly, some themes such as Tigray, agriculture, and management practice are found in the lower-central portion of the map. These are less developed and less central, likely representing region-specific or narrowly focused topics that have yet to become integral to the broader discourse.

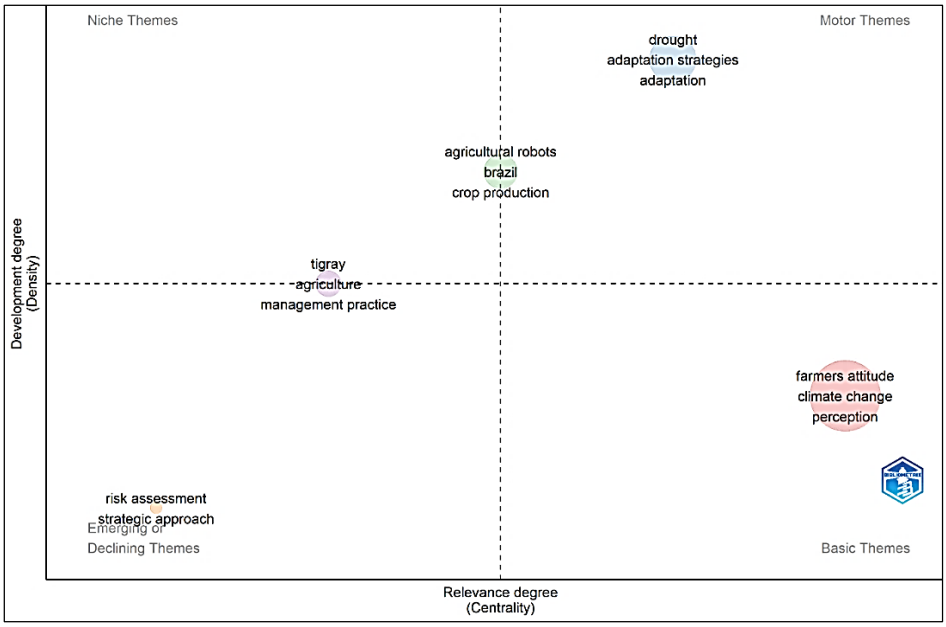

Fig 6: Thematic Map

Co-authorship Network Map

This visual represents a co-authorship network map, illustrating collaboration patterns among authors within the research field. Each cluster of nodes (authors) reflects a group that has published together, with the size of the node indicating the productivity or prominence of the author (based on number of publications or citation impact), and the thickness or closeness of links showing the strength of their collaborative relationships.

The largest and most prominent clusters in this network are led by authors such as Allart L and Mosnier C, and Amin A, who appear to be central figures in their respective research groups. Their strong node size and position at the center of their clusters suggest that they are key contributors and potentially leaders in thematic research areas related to climate change, agriculture, or technology adoption (Ali et.al,2024) [1].

Another notable group includes Ikusika OO and Akinmoladun OF, who are closely associated, indicating a strong collaborative partnership. Similarly, smaller but tight-knit clusters such as Ayalew D and Habte A, or Bomers S, Prat N, and Kamptner A represent active co-authorship

teams, possibly working on focused regional or thematic studies.

The dispersed nature of some nodes, such as Martín-López B and Loos J, or Bitew AB, suggests limited collaboration with other groups, indicating either early-career researchers, niche topic specialists, or independent research efforts. The presence of many small, disconnected or loosely connected clusters implies a degree of fragmentation in the research community, where many researchers are working in silos rather than through broader interdisciplinary or international collaborations.

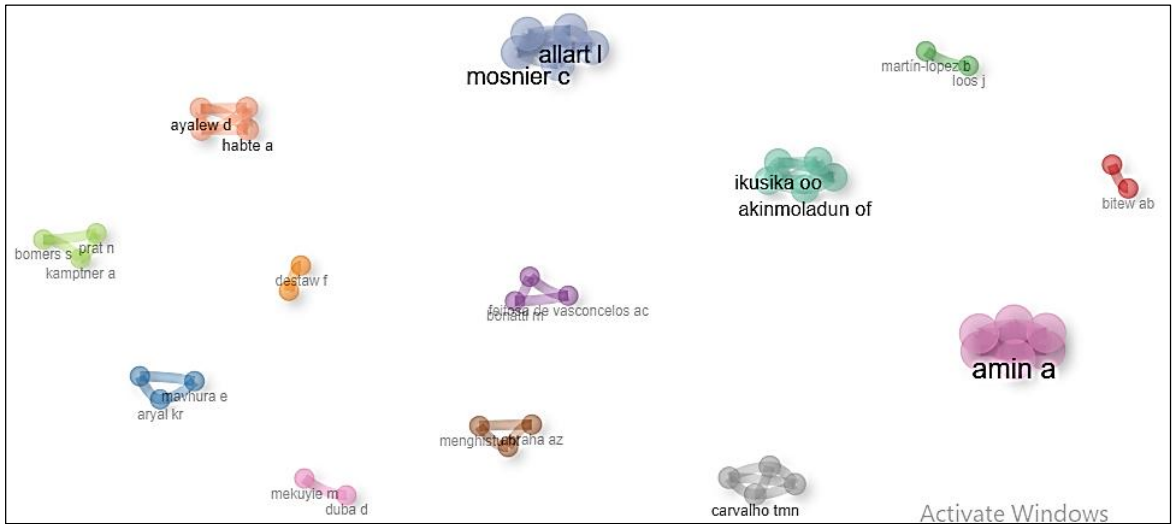

Fig 7: Co-authorship Network Map

Keyword Co-occurrence Map

The visualized network is a keyword co-occurrence map, which highlights the most frequent and interconnected terms used in a set of academic publications. This form of bibliometric analysis reveals the thematic structure of the research field, in this case likely centered on climate change, agricultural adaptation, and farmers' behavioral responses.

At the core of this network are dominant keywords such as "farmer's attitude," "perception," "climate change," and "adaptive management," which appear in large font size and bold connections, indicating they are central themes and highly co-occurring in the literature. These terms reflect a strong focus on understanding how farmers perceive and respond to climate-related challenges, particularly in the context of developing adaptive strategies.

"Ethiopia" also emerges prominently, suggesting that a significant volume of research is geographically focused on this country, likely due to its vulnerability to climate variability and its strong reliance on agriculture. The connection between Ethiopia, Tigray, and terms like "water stress", "drought," and "livelihood" further supports this regional emphasis (Zwarteveen et.al,2023) [14]

Clusters of related but slightly peripheral terms, such as "agroforestry," "irrigation system," "climate effect," and "livestock farming," suggest diverse adaptation practices being studied, often in relation to managing environmental risks and maintaining productivity. The presence of "adaptive management" and "strategic approach" highlights an emerging interest in planning and governance mechanisms to enhance resilience.

On the fringes of the map, terms like "agricultural robots," "climate variability," "maximum temperature," and "farmers' perceptions" are less connected and likely represent either specialized or emerging areas of study. These nodes, especially in blue, seem to form smaller clusters potentially indicating technological or climate modeling approaches, less integrated into the social sciences-dominant cluster of farmer perception studies.

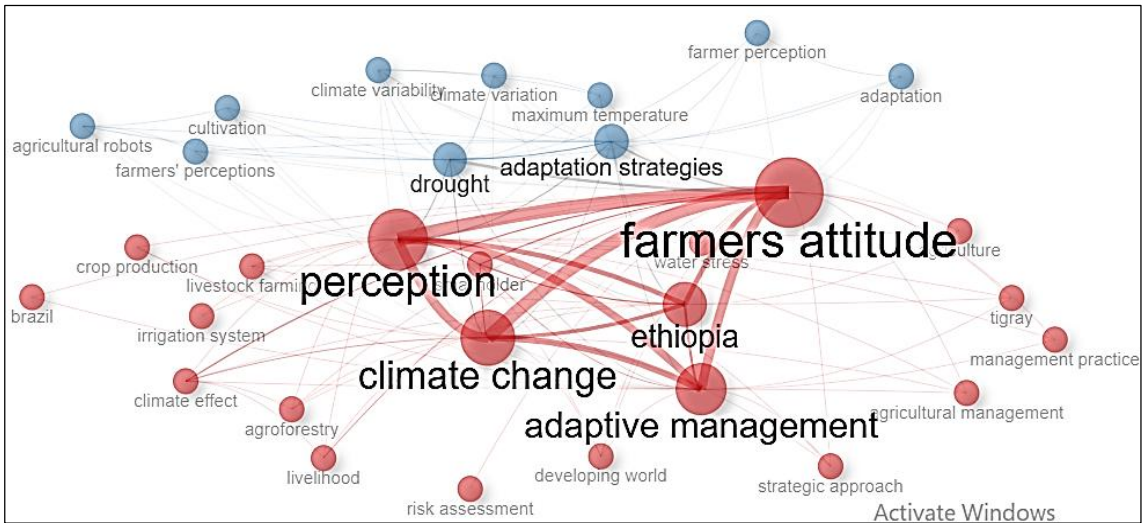

Fig 8: Keyword Co-occurrence Map

Conclusion

This bibliometric analysis offers a comprehensive overview of the global research landscape surrounding farmer perceptions and adaptation strategies to water scarcity in agriculture. The findings reveal a growing body of interdisciplinary literature addressing this pressing issue, with notable contributions from countries such as Ethiopia, India, and Brazil. Despite the broad geographical distribution, the research remains fragmented, with limited collaboration across regions and disciplines.

Key themes such as drought, climate change, and adaptation strategies dominate the literature, reflecting their central importance in shaping agricultural resilience. However, foundational areas like farmers' perceptions, attitudes, and behavioral responses remain underdeveloped, signaling significant opportunities for future research, particularly in integrating socio-economic dimensions with technical and environmental solutions.

The analysis also underscores the need for increased engagement from underrepresented regions and greater international collaboration to build a more cohesive and inclusive understanding of water-related agricultural challenges. Future research should aim to bridge existing knowledge gaps by exploring localized adaptation practices, fostering cross-disciplinary partnerships, and translating academic insights into actionable policy and grassroots interventions. As water scarcity continues to threaten global food systems, enhancing our collective understanding through targeted, evidence-based research is imperative for building climate-resilient agricultural communities.

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