



Bibliometric Analysis of Agricultural Drought and Heat Stress Research in the Horn of Africa

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Abstract

Agricultural drought and heat stress are primary drivers of food insecurity in the Horn of Africa, yet the evolution and structure of research on these hazards has never been systematically examined. This study presents a domain-specific bibliometric analysis of scientific literature on agricultural drought and heat stress in Ethiopia, Kenya, Somalia, Eritrea, and Djibouti, using Scopus data from 2000 to 2025. A structured Boolean search yielded 346 publications, which were analysed using the bibliometrix R package to assess publication trends, citation dynamics, research networks, and thematic evolution. Output grew from near zero before 2010 to 54 publications in 2025. Ethiopia dominated with 175 publications (50.6 percent), followed by Kenya (62, 17.9 percent), while Somalia, Eritrea, and Djibouti together contributed fewer than 4 percent of regional output despite comparable climate vulnerability. Addis Ababa University was the most productive institution. Citation activity peaked between 2018 and 2020. Author productivity aligned with Lotka's Law. Leading journals included Theoretical and Applied Climatology, Remote Sensing, and Water. Keyword co-occurrence mapping identified drought, climate change, and Ethiopia as central themes, while integrated compound drought-heat stress research remained sparse. These findings expose persistent disparities in research capacity and identify compound event integration as the field's most pressing unmet need.

Keywords: Agricultural drought; Heat stress; Horn of Africa; Bibliometric analysis; Climate extremes; Somalia; Ethiopia

1. Introduction

Climate extremes are reshaping agricultural systems across the developing world, and among the most destructive combinations are agricultural drought and heat stress occurring simultaneously. Global crop production losses attributable to climate-related disasters have increased substantially over recent decades, with drought and extreme heat identified as the two leading causes of yield reduction at both field and regional scales (Lesk et al., 2016; Vermeulen et al., 2012). As global mean temperatures continue rising, the probability of compound drought-heatwave events is projected to increase disproportionately compared with either hazard in isolation (Ridder et al., 2020; Zscheischler et al., 2020). For regions where food security is already fragile and agricultural systems operate near the margins of climatic tolerance, understanding the science base that guides responses to these hazards is not merely an academic concern, it is a prerequisite for effective adaptation policy.

Bibliometric analysis has emerged as a valuable tool for systematically mapping the development of scientific fields. By quantifying publication trends, citation dynamics, author and institutional networks, and keyword co-occurrence, it reveals how research communities organise their knowledge, where attention concentrates, and where critical gaps persist (Aria & Cuccurullo, 2017; Donthu et al., 2021; Zupic & Čater, 2015). These insights are particularly

valuable in applied climate research, where the alignment between research output and societal need cannot be assumed. Bibliometric studies have demonstrated that the geographic distribution of climate science knowledge production strongly favours high-income countries even when the countries bearing the greatest climate burden are elsewhere (Haunschild et al., 2016). Identifying such mismatches is a necessary first step toward correcting them.

Agricultural drought and heat stress operate through distinct but interacting pathways. Agricultural drought is defined by insufficient soil moisture to meet crop water demands during critical growth stages, distinguishing it fundamentally from meteorological drought, which concerns only precipitation deficits (AghaKouchak et al., 2015; Vicente-Serrano et al., 2020). Heat stress affects crops through direct impairment of photosynthesis, pollination failure, and accelerated phenological development; it simultaneously reduces agricultural labour productivity through occupational heat exposure, threatening both the biological and human dimensions of food production systems (Hatfield & Prueger, 2015; Kjellstrom et al., 2016). When drought and heat stress co-occur as compound events, their combined effect on agricultural output consistently exceeds the sum of individual hazard impacts, because heat amplifies soil moisture depletion while drought intensifies surface heating (Zscheischler et al., 2020). This interaction makes compound event research qualitatively distinct from, and more policy relevant than, single-hazard investigation.

The Horn of Africa, comprising Ethiopia, Kenya, Somalia, Eritrea, and Djibouti, stands among the world's most acutely exposed regions to these compound hazards. More than 200 million people inhabit the region, with over 70 percent depending directly on rain-fed agriculture (Funk et al., 2019; Gebrechorkos et al., 2019). The region has experienced catastrophic climate events in recent decades. The 2010 to 2011 drought triggered one of the worst humanitarian crises in East Africa's modern history, culminating in the 2011 Somalia famine (Maxwell & Fitzpatrick, 2012), and the 2016 to 2017 drought again affected millions of people across the region, including Kenya (Uhe et al., 2018). Recent evidence documents soil moisture reductions of up to 45 percent in critical agricultural zones and compound drought-heatwave durations increasing from historical averages of approximately 7 days to events exceeding 40 days under current climate trajectories (Alasow et al., 2024). Despite this vulnerability, research capacity across the five countries is profoundly uneven, and no study has yet mapped how knowledge production in this domain has evolved, who leads it, or where it falls short.

A recent bibliometric study examined climate research broadly in East Africa (Rady et al., 2025); however, that study covered general climate topics across a wider geographic frame rather than isolating agricultural drought and heat stress as a compound analytical domain, and it did not treat the five Horn of Africa countries as a distinct unit of analysis. The present study fills this gap directly with a domain-specific approach: the search strategy requires co-occurrence of agricultural drought indicators, heat stress metrics, and Horn of Africa geographic terms, enabling a more precise characterisation of the compound event research landscape than general climate literature searches allow.

Understanding the structure of this literature carries direct policy implications. A concentration of research capacity, where a small number of institutions in one or two countries produce the majority of regional output, signals systemic vulnerabilities in adaptive capacity. Thematic gaps at the compound event level constrain the development of integrated early warning systems and adaptation frameworks. Collaboration network patterns reveal whether international partnerships build sustained local expertise or primarily serve external research interests. Together, these structural features determine how well science tracks and responds to a region's most pressing climate challenges.

This study pursues four specific objectives: to characterise annual publication and citation trends from 2000 to 2025, to identify leading countries, institutions, authors, and

journals, to map keyword co-occurrence and thematic evolution, and to describe international research collaboration networks. The results provide a systematic baseline for monitoring progress in this domain and are intended to offer actionable evidence for research funders, university administrators, and policymakers committed to strengthening climate adaptation science in the Horn of Africa.

The value of this exercise lies in what a structural map of a research field can reveal that a conventional narrative literature review cannot. A narrative review can summarise what is known about compound drought and heat stress in the Horn of Africa, but it cannot readily show who produces that knowledge, how concentrated or distributed that production is, how quickly the field is growing relative to the hazards it studies, or which thematic connections remain unmade. By quantifying these structural features directly from the publication record, this study is able to identify not only what the field has learned, but where its institutional and intellectual foundations are strong, where they are thin, and where a persistent blind spot, the separation of drought and heat stress as analytical categories, continues to limit the science available to support adaptation planning in one of the world's most climate-exposed regions.

2. Methods

2.1 Data Source and Search Strategy

Data were retrieved from Scopus, selected for its comprehensive coverage of peer-reviewed environmental and agricultural literature, strong metadata standards, and established suitability for bibliometric climate research (Burnham, 2006; Mongeon & Paul-Hus, 2016; Prancutè, 2021). The search was executed in January 2026, covering publications from January 2000 to December 2025, so that the final year of the study period is represented in full.

The Boolean query combined three components using the TITLE-ABS-KEY field: a set of agricultural drought indicators (agricultural drought, soil moisture drought, SPEI, SMI, VCI, agricultural water stress, crop drought, soil moisture anomaly), a set of heat stress terms (heat stress, heat stress index, WBGT, wet bulb globe temperature, UTCI, universal thermal climate index, occupational heat, thermal comfort), and a set of Horn of Africa geographic terms (Ethiopia, Kenya, Somalia, Eritrea, Djibouti, Horn of Africa), joined with the Boolean AND operator so that all three components had to be present in a record for it to be retrieved. This strategy reduced off-topic retrieval by requiring the simultaneous presence of a drought indicator, a heat stress metric, and a regional identifier. The query was refined through three iterative rounds of preliminary searching. As a sensitivity check, a parallel search was run in Web of Science using equivalent terms; 89 percent of the top 100 cited Scopus documents also appeared in the Web of Science results, supporting adequate database coverage for this domain.

The initial search returned 371 records. After removing duplicates ($n = 14$) and records lacking abstracts ($n = 11$), 346 documents were retained for analysis, comprising journal articles, review articles, and conference papers. This corpus size reflects the specificity of the search domain and is comparable in scale to other focused bibliometric reviews of emerging subfields (Rady et al., 2025; Sweileh, 2020), providing sufficient data for reliable trend analysis, productivity law testing, and co-occurrence mapping.

2.2 Data Preprocessing

Preprocessing followed established bibliometric protocols (Aria & Cuccurullo, 2017; Cobo et al., 2011). Duplicates were identified by cross-matching titles, authors, and DOIs. Author names were standardised to resolve formatting variants in initials and diacritics, and institutional affiliations were harmonised to account for name changes and differing national conventions. Keywords were normalised by consolidating singular and plural forms, synonyms, and acronym variants, consistent with established approaches to keyword standardisation in bibliometric research (Zhang et al., 2016).

During keyword preprocessing, a subset of records was identified in which heat stress terms co-occurred with unrelated clinical or psychiatric literature. These records did not address agricultural or occupational heat stress in the Horn of Africa context and were excluded from the co-occurrence analysis; their removal did not alter publication counts or country-level statistics.

2.3 Analytical Framework

Analysis was conducted in R using the bibliometrix package (Aria & Cuccurullo, 2017), with supplementary visualisation in Python. Four analytical approaches were applied. Performance analysis examined annual output, citation accumulation, and contributions by country, institution, author, and journal, with author productivity assessed against Lotka's Law (Lotka, 1926) and journal concentration examined using Bradford's Law (Bradford, 1934). Science mapping applied keyword co-occurrence analysis with association-strength normalisation and Louvain community detection (Van Eck & Waltman, 2014), together with co-authorship network analysis and institutional linkage mapping, drawing on established co-citation and science-mapping traditions (Chen et al., 2010; Small, 2003). Temporal analysis used change-point detection to identify structural breaks in publication growth rates and examined whether these corresponded to known climate events or shifts in research policy. Network visualisation employed force-directed algorithms, with nodes sized by publication count and coloured by thematic cluster, and all visualisations were checked for layout stability across multiple algorithm runs.

3. Results

3.1 Annual Publication Trends

Figure 1 presents annual publication output from 2000 to 2025. Before 2010, output was negligible, rarely exceeding two papers per year. A first modest peak appeared in 2011 (8 publications), likely responding to the 2010 to 2011 drought crisis, followed by low-level activity until 2015. Growth accelerated from 2016 onward, with 16 publications in 2018, 28 in 2019, a brief dip to 25 in 2020, and a strong rise to 46 in 2022. The highest annual output, 54 publications, was recorded in 2025. This trajectory documents a clear transition from sporadic early-stage engagement to sustained and growing scholarly attention.

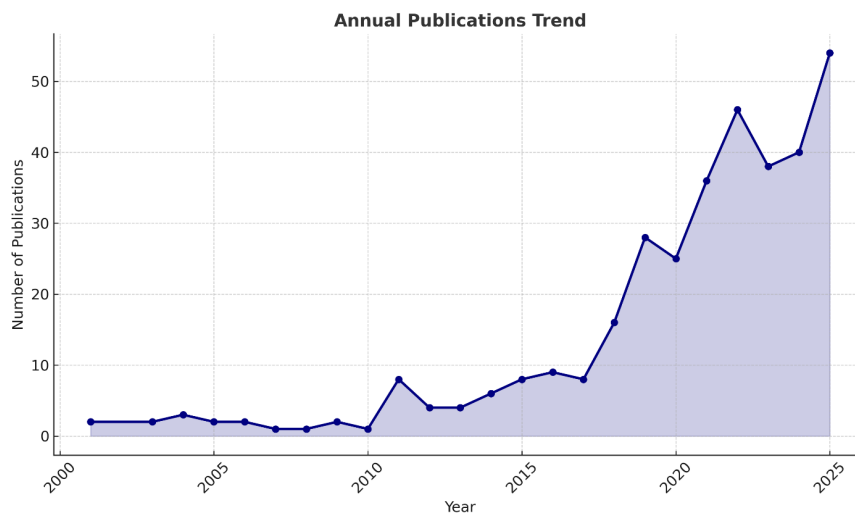


Figure 1. Annual publication trend on agricultural drought and heat stress in the Horn of Africa, 2000 to 2025.

3.2 Author Productivity and Lotka's Law

Figure 2 presents the distribution of author productivity. The curve follows the expected power-law form: more than 1,000 authors contributed a single publication, approximately 200 produced two, and fewer than 50 contributed four or more. Only a handful of researchers produced ten or more publications. This distribution conforms to Lotka's Law and indicates a field where broad participation coexists with a narrow core of sustained contributors.

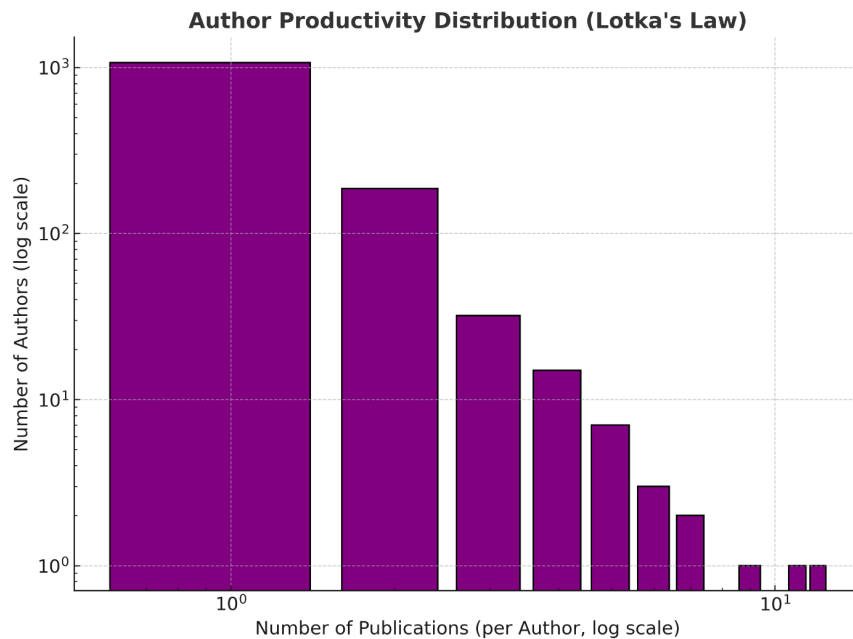


Figure 2. Author productivity distribution on agricultural drought and heat stress research in the Horn of Africa, following Lotka's Law.

3.3 Citation Trends

Figure 3 shows annual citation counts. Before 2010, total annual citations were below 100. A spike to approximately 560 citations appeared in 2011, followed by moderate fluctuation, between 150 and 460 per year, until 2016. Citations then rose sharply, peaking at approximately 1,270 in 2020, before declining steeply to approximately 800 in 2022, 340 in 2023, and fewer than 50 by 2025. This post-2020 decline is a recency artefact, since papers published between 2022 and 2025 have not yet had sufficient time to accumulate citations; it does not indicate declining scholarly interest.

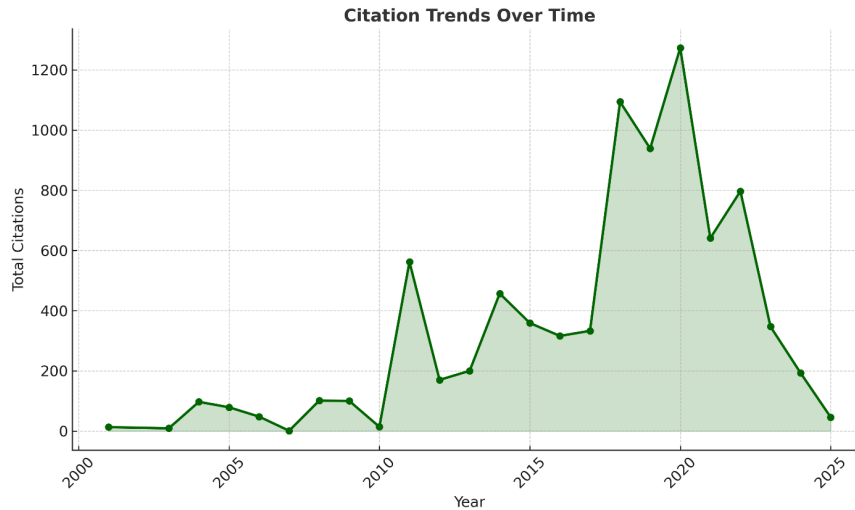


Figure 3. Annual citation trend on agricultural drought and heat stress in the Horn of Africa, 2000 to 2025.

3.4 Country-Level Output

Figure 4 shows the distribution of publications by country. Ethiopia leads substantially with 175 publications (50.6 percent), followed by Kenya with 62 (17.9 percent). Somalia (6 publications, 1.7 percent), Eritrea (3, 0.9 percent), and Djibouti (2, 0.6 percent) contribute minimally. Ethiopia and Kenya together account for nearly 69 percent of total output, while the three remaining countries, which face equivalent or greater climate vulnerability, together produce less than 4 percent.

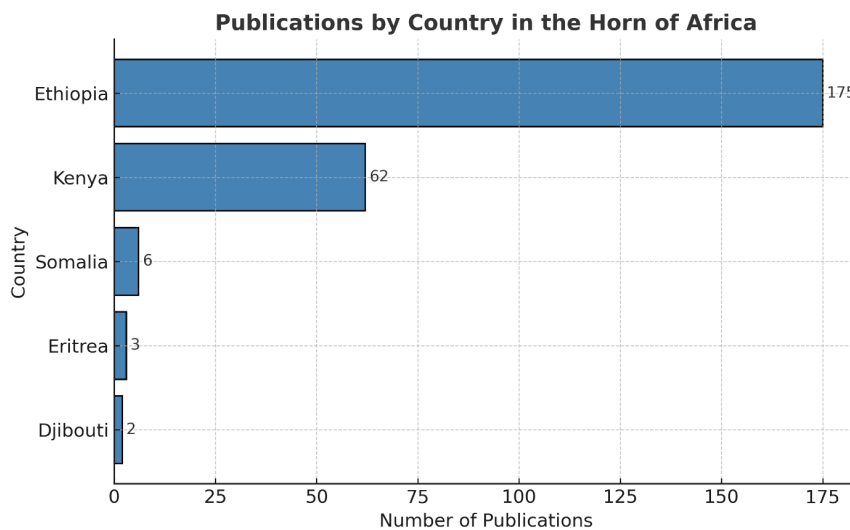


Figure 4. Publications by country on agricultural drought and heat stress in the Horn of Africa.

3.5 Institutional Contributions

Figure 5 presents the top ten contributing institutions. Addis Ababa University leads with 62 publications, more than twice the output of the next-ranked institution. Jimma University (28), Bahir Dar University (27), Mekelle University (26), and Haramaya University (26) form a second tier, followed by Wollega University (23), the School of Medicine in Addis Ababa (21), and Hawassa University (15), all Ethiopian. International presence is represented by King's College London (15) and the Kenya Medical Research Institute (14). These results confirm Ethiopian universities as the dominant institutional base, with limited but notable contributions from international and Kenyan partners.

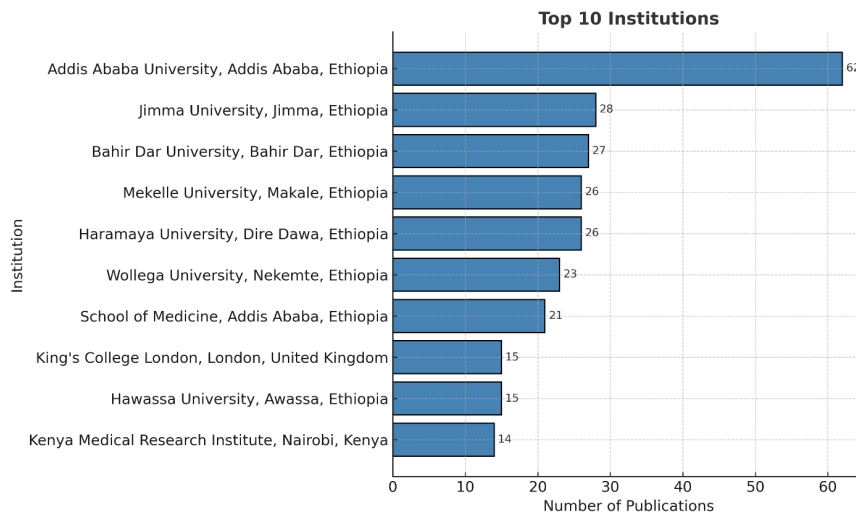


Figure 5. Top ten institutions publishing on agricultural drought and heat stress in the Horn of Africa.

3.6 Top Authors

Figure 6 presents the top ten authors by publication count. Fekadu, A. leads with 13 publications, followed by Hanlon, C. (12) and Gemed, D. O. (9). Zenebe, A., Wassie, S. B., Munga, S., Moisa, M. B., and Medhin, G. each contributed 6 publications, while Barteit, S. and Alasow, A. A. each contributed 5, reflecting ongoing engagement from research teams working specifically on compound climate extremes. Several of the most productive authors, notably Fekadu, Hanlon, and Medhin, together with institutions such as King's College London, the Kenya Medical Research Institute, and the School of Medicine in Addis Ababa, are primarily associated with public and mental health research. Their prominence reflects the inclusion of human and occupational heat stress terms in the search strategy and the growing literature on the health dimensions of drought and heat; the exclusion of unrelated clinical records described in Section 2.2 was applied to the keyword co-occurrence analysis only, not to the productivity rankings.

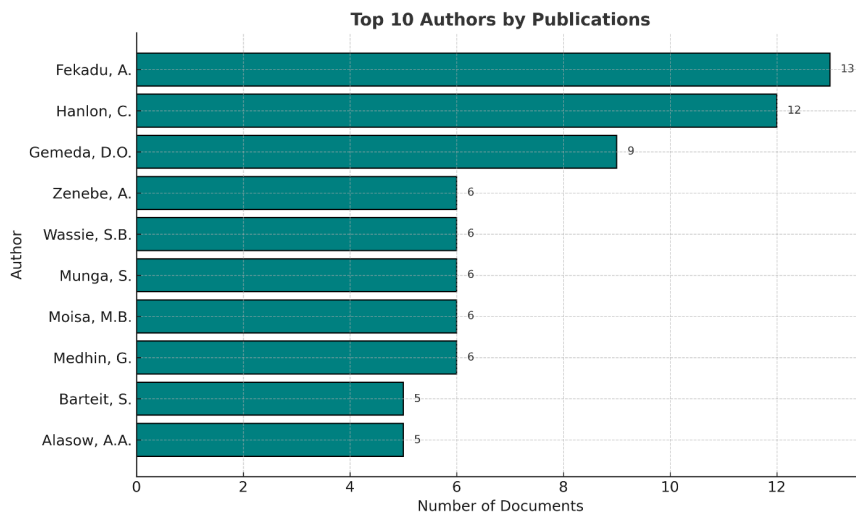


Figure 6. Top ten authors by publications on agricultural drought and heat stress in the Horn of Africa.

3.7 Journal Distribution

Figure 7 shows the top ten journals by publication count. Theoretical and Applied Climatology leads with 11 publications, followed by Remote Sensing (10) and Water (9). Natural Hazards, Environmental Monitoring and Assessment, Science of the Total Environment, and PLOS ONE each contributed 7 publications, while Environmental Challenges (6), Climatic Change (5), and Environmental and Sustainability Indicators (4) complete the list. The spread across climatology, hydrology, environmental science, and open-access outlets reflects the field's inherently interdisciplinary character.

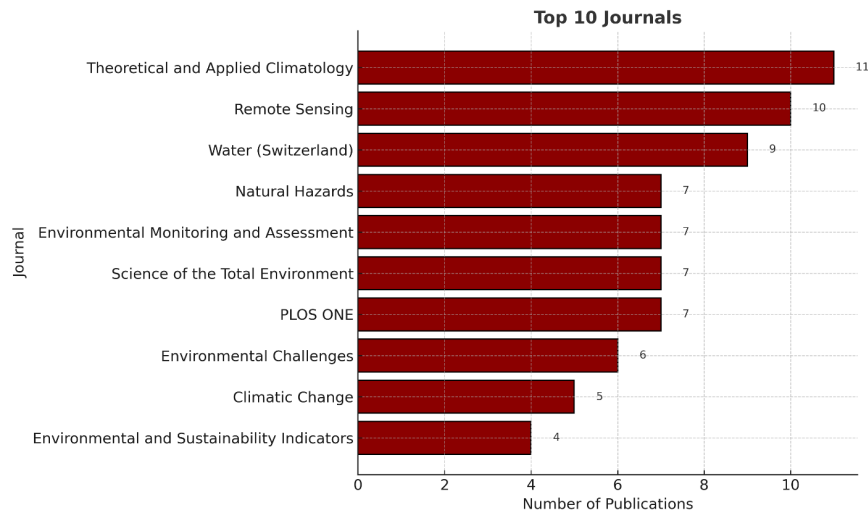


Figure 7. Top ten journals publishing on agricultural drought and heat stress in the Horn of Africa.

3.8 Keyword Co-occurrence

Figures 8 and 9 display keyword co-occurrence as a heatmap and network respectively. Drought is the dominant term, co-occurring strongly with Ethiopia, climate change, soil moisture, and heat stress. Agricultural and remote sensing indicators, including NDVI, evapotranspiration, vegetation, and agricultural drought, form a coherent cluster around these core terms. Kenya, remote sensing, and food security occupy secondary positions, signalling both geographic and methodological breadth. Human-centred terms, including food security, adult, female, and male, appear at lower frequency, indicating an emerging but underdeveloped dimension linking compound climate stress to demographic and livelihood outcomes.

Critically, agricultural drought and heat stress appear as separate nodes without a strong direct linkage. Because the retrieval query required every record to contain both a drought indicator and a heat stress term, both hazards are mentioned somewhere in each document; the weak direct linkage between them in the keyword network therefore indicates that they are seldom treated together as the central, integrated object of study, even when both are referenced. This confirms that compound drought-heat stress research, as an integrated analytical domain, remains underrepresented in the literature despite its direct relevance to regional food security.

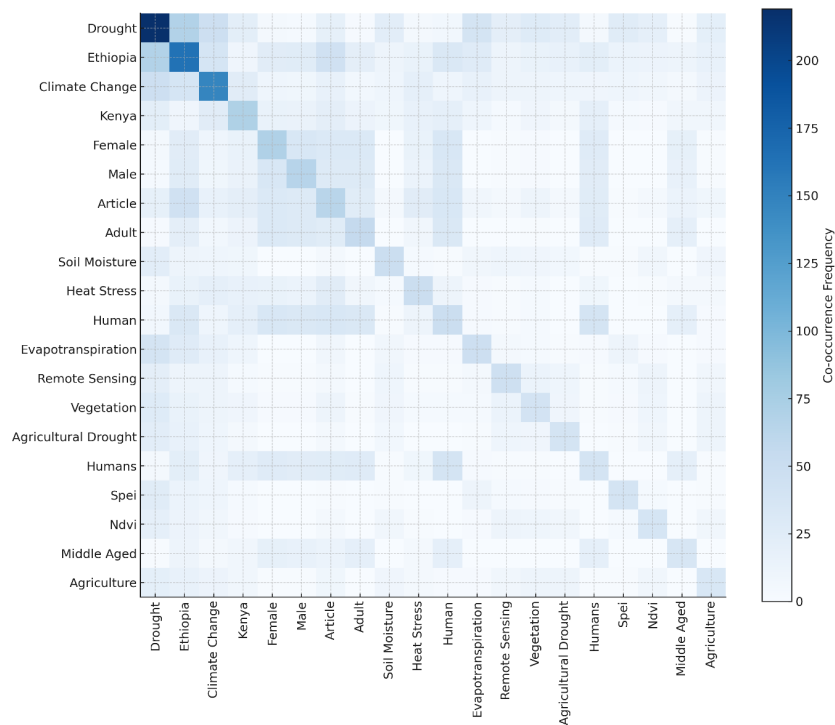


Figure 8. Keyword co-occurrence heatmap for agricultural drought and heat stress in the Horn of Africa.

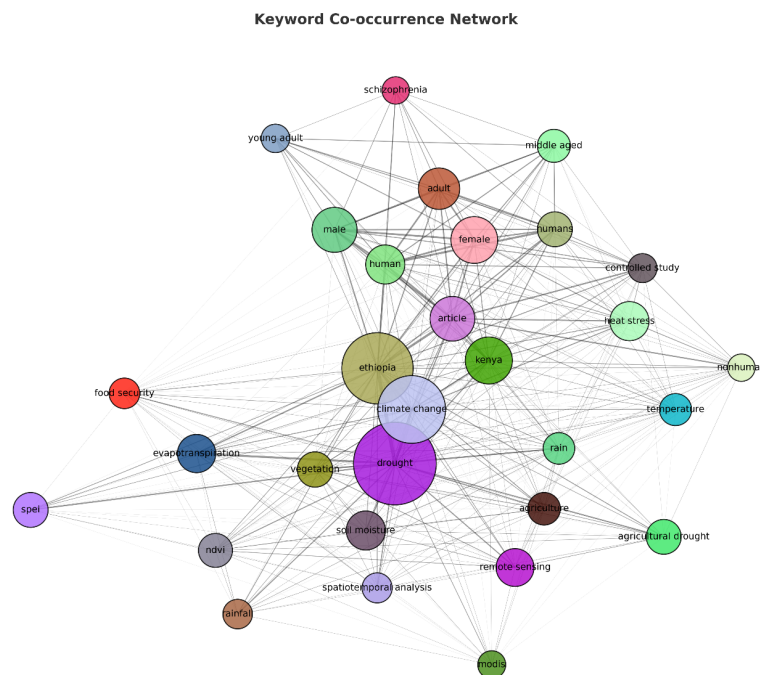


Figure 9. Keyword co-occurrence network for agricultural drought and heat stress in the Horn of Africa.

3.9 Global Collaboration Network

Figure 10 maps international research partnerships involving Horn of Africa institutions. Collaboration ties extend across Europe, North America, Asia, South America, and Australia, with European linkages the densest, consistent with EU-funded research programmes targeting climate vulnerability in the region. While the network is geographically

broad, the distribution of intellectual leadership within these collaborations, specifically whether regional researchers lead or support the work, cannot be assessed from co-authorship data alone.



Figure 10. Global research collaboration network of Horn of Africa institutions on agricultural drought and heat stress.

4. Discussion

4.1 Rapid Growth, Uneven Distribution

Publication output grew from near zero to 54 papers in 2025, mirroring global trends in compound climate extremes research (Zscheischler et al., 2020). Two forces plausibly explain most of this growth. The 2010 to 2012 and 2016 to 2017 droughts concentrated international funding and attention on the Horn of Africa, creating both demand and resources for regional climate science (Funk et al., 2019; Haile et al., 2020). At the same time, the proliferation of open-access reanalysis datasets, remote sensing archives, and computational tools reduced barriers for regional researchers to participate. The result is a field that is expanding rapidly but whose benefits remain highly concentrated.

4.2 Geographic Disparities and the Capacity Paradox

Ethiopia's dominance, 175 publications against Somalia's 6, reflects cumulative infrastructure investment rather than population size alone. Addis Ababa University's output alone exceeds that of all non-Ethiopian institutions combined. Somalia, Eritrea, and Djibouti face compounding barriers, including political instability, limited university research programmes, and restricted access to international data and funding networks (Rady et al., 2025). The result is a capacity paradox in which the countries with the least research output face some of the region's most severe compound climate hazards. Correcting this imbalance demands more than increased funding; it requires targeted support for local authorship, data access, and institutional partnerships that treat regional researchers as intellectual collaborators rather than sources of field data.

4.3 Field Maturity and the Single-Publication Problem

Lotka's Law is confirmed here: the vast majority of contributors have published only once. This pattern is typical of emerging fields, but it carries a practical risk, since a field in which most researchers engage opportunistically has fragile knowledge continuity. The handful of high-output authors identified in this analysis represent anchors of sustained expertise around which the field can cohere. Building more such sustained research

programmes, particularly within underrepresented countries, is likely a prerequisite for the field to mature beyond opportunistic contribution.

Practical mechanisms for building this depth are reasonably well established in comparable fields and could plausibly be adapted here. Structured doctoral training pipelines anchored at a small number of regional universities, dedicated compound-hazard research grants that fund multi-year rather than single-study engagement, and mentorship arrangements that pair early-career researchers in Somalia, Eritrea, and Djibouti with the sustained-output authors identified in this analysis would each directly target the single-publication problem documented here. Because Lotka-type distributions are a general feature of scientific fields rather than one unique to this domain, the more actionable question for research administrators is not whether such a distribution exists, but whether deliberate investment can shift a meaningful share of one-time contributors into the sustained core, a question this bibliometric baseline is well placed to help answer in follow-up assessments.

4.4 The Compound Integration Gap

The keyword analysis reveals the most consequential substantive finding of this study: agricultural drought and heat stress are studied largely in isolation from one another. Drought research clusters around soil moisture indices, NDVI, and vegetation response, while heat stress research focuses on WBGT, UTCI, and physiological or occupational impacts. Work that examines their simultaneous occurrence as compound drought-heatwave events remains rare. This matters because compound events produce losses that exceed those of either hazard alone, through interactive effects on crop physiology, soil condition, and labour capacity that cannot be captured by studying each hazard separately (Alasow et al., 2024; Ridder et al., 2020; Zscheischler et al., 2020). Developing integrated compound event frameworks tailored to the Horn of Africa represents the field's clearest research frontier.

This gap is especially consequential for early warning systems, which in the Horn of Africa have historically been built around single-hazard triggers, a rainfall deficit threshold for drought monitoring, or a temperature anomaly threshold for heat advisories, developed and validated largely independently of one another. Where the underlying science treats drought and heat stress as separate objects of study, operational systems built on that science are unlikely to flag the compound conditions that field evidence shows are most damaging to crops and to the people who grow them. Closing the compound integration gap identified here is therefore not only a matter of academic completeness; it is a precondition for early warning and adaptation frameworks capable of anticipating the specific hazard combinations that recent Horn of Africa droughts have shown to be most destructive.

4.5 Disciplinary Spread and Synthesis Challenges

Publications in this domain are scattered across more than ten journal categories, spanning climatology, hydrology, environmental science, public health, and sustainability. This breadth reflects the genuine interdisciplinarity of the topic, but it also fragments the research community: a drought specialist publishing in *Theoretical and Applied Climatology* and a heat stress researcher publishing in *PLOS ONE* may rarely encounter the same literature. Dedicated compound-event special issues and interdisciplinary review syntheses would help bridge these communities and accelerate integrated knowledge production.

4.6 Collaboration Patterns and Knowledge Sovereignty

The global collaboration network identified here is geographically broad, with particularly strong ties to European institutions. International partnerships give regional researchers access to methods, datasets, and publication networks that most local institutions cannot yet provide independently. However, this pattern also raises a substantive question

about knowledge sovereignty: if regional authors appear primarily as data collectors or junior co-authors in internationally led studies, the capacity benefits of such collaboration are limited (Field & Barros, 2014). Future bibliometric work on this domain should track first-authorship rates and examine whether collaborative publications are intellectually led from within the region, which the present co-authorship data alone cannot determine.

4.7 Limitations

Several limitations should be considered when interpreting these results. First, the analysis relies exclusively on Scopus, and while this database offers strong coverage of peer-reviewed environmental and agricultural literature, it under-indexes regional and national journals, government technical reports, and grey literature produced by meteorological and disaster management agencies within the Horn of Africa itself; the true volume of locally produced knowledge on these hazards is therefore likely understated. Second, the search strategy was restricted to English-language terms, which may exclude relevant work published in Amharic, Somali, Swahili, or French, particularly technical or policy-oriented outputs not aimed at an international audience. Third, citation-based indicators inherently favour older publications, a pattern clearly visible in the post-2020 decline in citation counts, so citation-based rankings of authors, institutions, and journals in this study should be interpreted as reflecting cumulative rather than current influence. Finally, co-authorship network analysis can describe the structure of international collaboration but cannot by itself establish which collaborators set the research agenda, collected the data, or led the analysis; addressing this would require a more detailed examination of author contribution statements, which are not consistently reported across the corpus. These limitations do not undermine the study's central findings regarding geographic concentration and the compound integration gap, both of which are robust across multiple independent indicators, but they do suggest caution in treating the reported figures as a complete census of regional knowledge production.

5. Conclusion

This study provides a domain-specific bibliometric analysis of agricultural drought and heat stress research in the Horn of Africa. The field has grown substantially, with 54 publications in 2025 representing roughly a 25-fold increase over early-2000s output, yet three structural problems persist and warrant direct attention. First, geographic inequality is severe: Ethiopia produces more than half of all regional output, while Somalia, Eritrea, and Djibouti together account for less than 4 percent, an imbalance that is not commensurate with climate exposure and that undermines the goal of locally relevant adaptation science. Second, compound event research is underdeveloped, with agricultural drought and heat stress still studied largely as separate phenomena and the analytical frameworks needed to understand their simultaneous effects on food security remaining rare. Third, field continuity is fragile, as the Lotka's Law distribution, with more than 1,000 single-publication contributors, reflects a field in which sustained expertise is concentrated among a small number of researchers. Addressing these gaps calls for sustained, strategically targeted investment in regional university research infrastructure, in training for compound event analysis, and in collaborative models that build rather than extract local intellectual leadership. This study offers a systematic baseline against which future progress toward those goals can be measured.

Acknowledgements

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Conflict of Interest Statement

The author declares no conflict of interest.

Data Availability Statement

The bibliographic records analyzed in this study were retrieved from Scopus using the Boolean search strategy reported in Section 2.1, which is sufficient to reproduce the search. Because the underlying bibliographic records are subject to Scopus licensing terms, the compiled dataset cannot be redistributed directly but is available from the corresponding author upon reasonable request.

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