Climate Change Adaptation Interventions for Enhancing Food Security and Livelihood in Sub-Saharan Africa: Network Analysis

ICED

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Summary

This network analysis builds on the Evidence and Gap Map (EGM) of Climate Change Adaptation Interventions for Enhancing Food Security and Livelihoods in Sub-Saharan Africa. The analysis examines authorship patterns and collaboration structures among studies included in the EGM, highlighting key contributors and the extent of research collaboration within the climate change adaptation evidence base.

The network comprises 1,457 authors whose studies were published between 2000 and 2024. Although the primary focus of the studies is on climate change adaptation in Sub-Saharan Africa, the analysis shows that authors are affiliated with institutions across both the Global South and the Global North. This reflects the international nature of climate change research, while also revealing important dynamics in where knowledge production and leadership are concentrated.

Within the co-authorship network, a small group of authors emerge as particularly influential. Clifton Makate (Tongji University, China) and Nelson Mango (CSIR-Savanna Agricultural Research Institute -Ghana (CSIR-SARI) each authored seven publications and display strong collaborative engagement, each with high total link strength of 22. Philip Antwi-Agyei, with six publications, also occupies a central position in the network. Other highly connected authors, including Leslie Lipper, Henry Neufeldt, Dawit Solomon, and Mark T. van Wijk, combine moderate publication volumes with high link strengths, indicating their roles in connecting multiple research groups.

Notably, some authors play critical bridging roles despite having fewer publications. Maren Radeny, Mathieu Ouedraogo, and Solomon, Dawit, exhibit particularly high total link strengths relative to their number of studies. For instance, Radney, Ouedraogo and Dawit, had total link strengths of 48, 42 and 41 respectively, but have co-authored 4, 3, and 5 studies. This suggests that such authors serve as key connectors across otherwise distinct clusters of researchers. These authors contribute significantly to knowledge integration and cross-network collaboration within the climate change adaptation research landscape.

The findings indicate that while climate change adaptation research is geographically diverse, collaboration is structured around a relatively small number of highly connected authors. Strengthening and broadening collaborative networks, particularly those led by researchers and institutions based in Sub-Saharan Africa could enhance knowledge exchange, reduce fragmentation, and support more locally grounded evidence generation for climate-resilient development.

1.1 Background

The International Centre for Evaluation and Development (ICED), with support from the Science for Africa Foundation (SFA) has developed an Evidence and Gap Map (EGM) on climate change adaptation interventions in agriculture and food security and Livelihood in sub-Saharan Africa (SSA). The EGM builds on a published protocol and applies systematic and transparent methods to identify, map, and categorize the existing evidence on adaptation strategies and their outcomes. The map comprises studies identified through comprehensive searches of academic bibliographic databases and relevant organizational and institutional websites, capturing both completed and ongoing research that met predefined eligibility criteria.

The inclusion criteria were guided by a clearly defined PICOS framework (Population, Interventions, Comparisons, Outcomes, and Study designs). Study identification and screening were conducted using the EPPI-Reviewer software, with studies independently screened at the title, abstract, and full-text stages to ensure consistency and rigor. The EGM includes a wide range of quantitative, qualitative, and mixed-methods studies, as well as reviews, reflecting the diverse methodological approaches used to evaluate climate adaptation interventions.

The EGM categorizes climate change adaptation interventions across multiple intervention systems relevant to agriculture and food systems. These include crop production systems, soil and land management, water and land management systems, livestock production systems, fisheries and aquaculture management, natural resource management, energy systems, risk and support systems, and income diversification strategies. The screening results show that the evidence base is heavily concentrated in crop production and soil and land management interventions, with relatively fewer studies examining adaptation in fisheries, energy systems, and integrated risk and support mechanisms. Most studies focus on adaptation-related outcomes such as productivity, resilience, food security, income, and wellbeing, with fewer studies examining institutional, equity, or long-term adaptive capacity outcomes.

In terms of study design and evaluation type, the evidence base is dominated by non-experimental and quasi-experimental studies, alongside qualitative research and reviews. Impact and summative evaluations constitute the majority of included studies, while process and formative evaluations are comparatively limited. This distribution reflects a strong emphasis on assessing adaptation outcomes, with less attention paid to implementation processes, learning, and systems-level adaptation dynamics.

In addition to developing the EGM, ICED conducted a network analysis of authors, their institutional affiliations, and the countries in which these institutions are based. Network analysis provides insights into the structure of the research and collaboration landscape within the climate change adaptation field. Specifically, it sheds light on patterns of collaboration among researchers producing evidence on adaptation interventions and highlights how knowledge production is distributed across institutions and regions.

The network analysis identifies key authors and institutions that have contributed substantially to the climate adaptation evidence base. By examining publication and authorship patterns, the analysis helps to identify influential researchers, leading institutions, and collaboration clusters within the field. It also

highlights the geographic distribution of authors' institutions, enabling comparison between the countries where adaptation interventions are implemented and the countries where the research is led. A central question guiding this analysis is: *Where are the lead authors of climate change adaptation studies based - within the Global South or predominantly in the Global North?* Addressing this question provides important insights into global research equity, ownership of knowledge production, and the extent to which local researchers and institutions are leading adaptation research in climate-vulnerable contexts. The findings are intended to inform discussions on research partnerships, capacity strengthening, and funding strategies, with the broader aim of supporting more equitable, locally led climate adaptation research and evidence generation.

2. 1 Method

2.1.1 Data

Following the development of the Evidence and Gap Map (EGM), which includes 376 eligible studies, the research team extracted additional metadata from the EPPI-Reviewer software to support the network analysis. Specifically, we coded information on authorship for each included study, capturing the full names of lead and co-authors, the institutional affiliations of lead authors, and the countries in which these institutions are based.

Additional bibliographic information was also extracted, including the study title, year of publication or reporting, journal name, volume, page numbers, and Digital Object Identifier (DOI), where available. These data enabled both descriptive analysis and the construction of co-authorship and institutional collaboration networks.

The extracted data were exported from EPPI-Reviewer into Microsoft Excel in CSV format, which is compatible with the VOSviewer software used for network analysis. Prior to analysis, extensive data cleaning was undertaken to ensure consistency and accuracy in author names, institutional affiliations, and country identifiers. This process minimized duplication and misspellings, thereby avoiding double counting of authors, institutions, and countries across studies.

2.1.2 Analysis

Network analysis was conducted using VOSviewer, a software tool widely used for bibliometric and co-authorship analysis. As a preliminary step, descriptive statistics were generated to summarize the distribution of publications across authors. This was followed by network analyses focusing on (i) co-authorship relationships among authors and (ii) institutional and country-level collaboration patterns based on lead authors' affiliations.

For the co-authorship analysis, VOSviewer calculated the total link strength for each author, reflecting the extent of their collaborative relationships with other authors in the dataset. Authors with the highest total link strength were included in the co-authorship network visualization.

The resulting co-authorship map highlights the giant components of the network , clusters of authors who have collaborated extensively with one another. To enhance interpretability, authors with only a single publication or minimal collaboration links were excluded from the visualization. The co-authorship network consists of nodes and edges, where each node represents an individual author with at least two publications, and each edge represents a co-authored publication between two authors.

The size of each node is determined by the author's betweenness centrality, a measure indicating how frequently an author acts as a bridge or connector between other authors in the network. Authors with high betweenness centrality play a critical role in linking otherwise separate groups of researchers. For example, an author who co-authors multiple papers with different sets of collaborators will exhibit higher betweenness centrality than an author who repeatedly publishes with the same group. Such authors occupy strategically important positions in the knowledge network, facilitating information flow and collaboration across the research community.

3.1 Results and discussion

3.1.1 Figure 1 presents a descriptive analysis of the distribution of publications among authors included in the network analysis. In total, 1,457 authors were identified across the included studies. Of these, 1,286 authors contributed to only one publication, indicating a highly fragmented authorship landscape in this area of research.

Among authors with multiple publications, one author had the highest number of publications, contributing to seven studies. This was followed by one author with six publications, six authors with five publications each, and nine authors who each contributed to four studies. In addition, thirteen authors co-authored three publications each, while 140 authors co-authored two publications each.

Generally, the findings show that the majority of research on climate change adaptation and outcomes related to food security and livelihood is produced by authors who contribute only once to the literature. Authors with at least two publications who form the basis of the co-authorship network analysis are summarized in Table 1 in the Appendix.

Figure 1 **: Number of publications among authors**
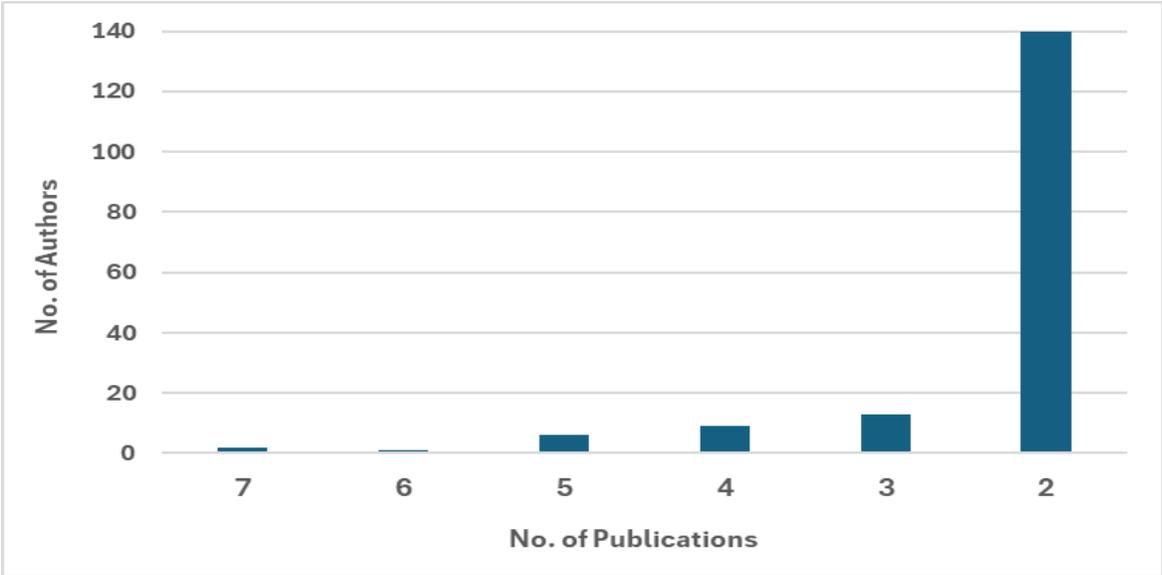
Source: Data from EPPI reviewier analysed in Excel

3.1.1 Network analysis among authors of the included studies

The co-authorship map illustrates patterns of collaboration among authors involved in academic and research publications. It examines relationships between authors based on shared authorship of studies, thereby revealing the structure of co-authorship networks within the evidence base.

In this analysis, a total of 1,457 authors were included using the VOSviewer software. The lead authors among these contributors are affiliated with 241 organizations across 46 countries, highlighting the broad institutional and geographical spread of research related to this evidence base.

### 3.1.2 Collaboration among authors

Figure 2 illustrates the co-authorship network among authors included in the climate change adaptation EGM, generated using VOSviewer. In this visualization, nodes represent individual authors, with node size reflecting the number of documents authored, while edges indicate co-authorship relationships. The total link strength captures the overall intensity of an author's collaboration with others in the network. The network reveals a number of well-defined collaboration clusters, indicating recurring partnerships among groups of researchers. Several authors stand out due to their high publication counts and strong collaborative linkages.

Among the most central authors is Clifton Makate, who authored seven publications and has a total link strength of 22, placing him among the most connected authors in the network. Nelson Mango similarly authored seven studies with a total link strength of 22, reflecting strong collaborative engagement. Philip Antwi-Agyei follows closely with six publications and a total link strength of 17, indicating consistent collaboration across multiple studies. Authors such as Leslie Lipper (five publications; total link strength 26), Henry Neufeldt (five publications; total link strength 25), Dawit Solomon (five publications; total link strength 41), and Mark T. van Wijk (five publications; total link strength 43) also occupy prominent positions within the network. Their relatively high total link strengths suggest that, beyond productivity, they play important roles in linking different author groups and research efforts.

Notably, Maren Radeny (four publications; total link strength 48) and Mathieu Ouedraogo (three publications; 42) exhibit particularly strong collaborative ties, indicating their importance as connectors within and across clusters. Similarly, James Hansen (three publications; 39) and Julian Ramirez-Villegas (two publications; 36) show high total link strengths despite fewer publications, underscoring their bridging roles within the co-authorship network.

Largely, the co-authorship map highlights a concentrated collaboration structure, where a relatively small group of highly connected authors anchors the network. These authors contribute not only through repeated publication but also by linking multiple research teams, thereby shaping the knowledge base on climate change adaptation within the EGM.

Figure 2: Co-authorship map among authors
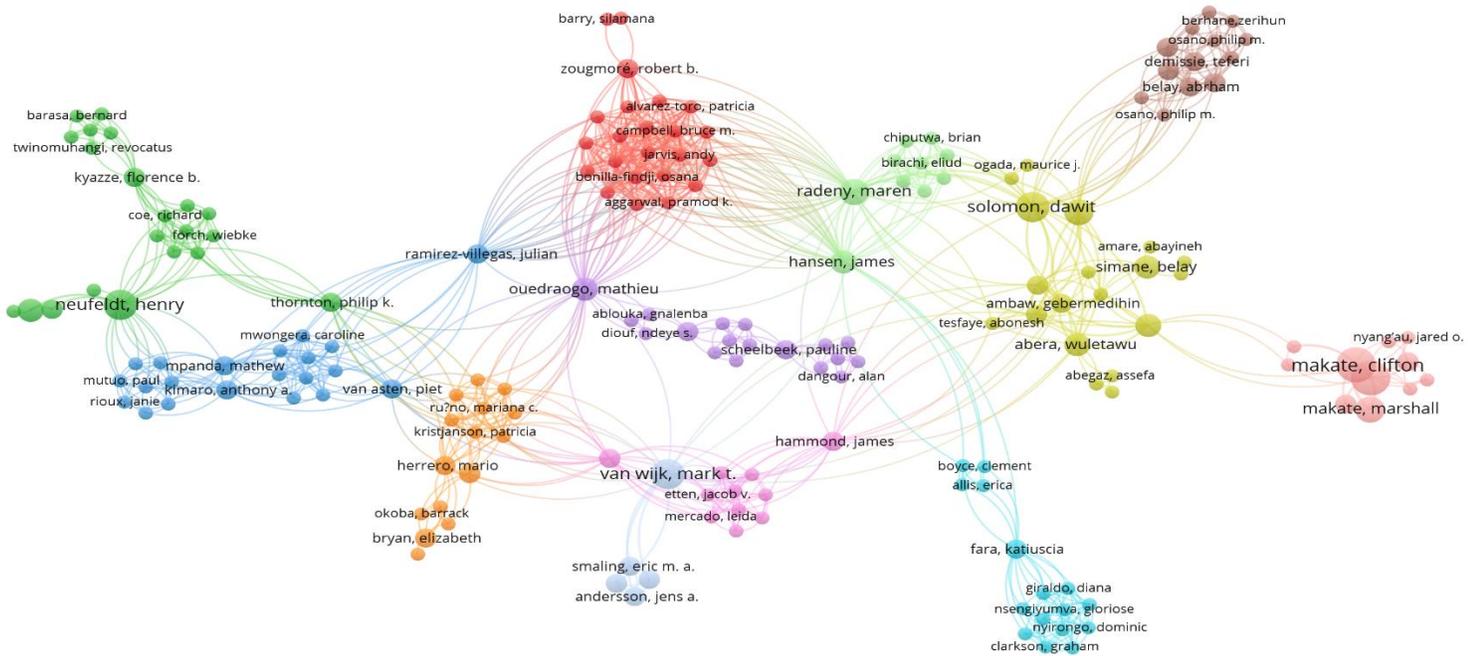
Source: Data on authors of the included studies from EPPI reviewer analyzed using VOSviewer software

3.1.3 Geographical distribution of where studies were done

The studies included in the EGM were conducted across 31 countries in sub-Saharan Africa, as illustrated in the heat map in Figure 3. The geographic distribution of the evidence shows a strong concentration of studies in East and West Africa, with comparatively fewer studies in parts of Central and Southern Africa.

East Africa accounts for a substantial share of the evidence base, led by Ethiopia, which recorded the highest number of studies (77), followed by Kenya (51), Tanzania (33), Uganda (17), and Rwanda (5). This pattern highlights the region's prominence in climate change adaptation and agriculture research.

In West Africa, Ghana emerged as a major study site with 69 studies, alongside Nigeria (44), Burkina Faso (18), Mali (15), Senegal (11), Niger (11), and Benin (7). Other West African countries, including Togo (6), Guinea (3), Guinea-Bissau (2), Côte d'Ivoire (1), Liberia (1), Sierra Leone (1), and The Gambia (1), were represented to a lesser extent.

In Southern Africa, South Africa (30) and Zimbabwe (28) featured prominently, while Malawi (21), Zambia (17), Mozambique (10), Namibia (2), Botswana (2), and Eswatini (2) showed more moderate or limited representation. Evidence from Central Africa was notably sparse, with only one study each conducted in Cameroon, Burundi, and the Democratic Republic of Congo, pointing to significant geographic gaps in the literature.

In sum, the heat map underscores an uneven distribution of research effort across sub-Saharan Africa, with

evidence heavily concentrated in a small number of countries. These patterns suggest important gaps in coverage, particularly in Central Africa and smaller West African states, where additional research is needed to support context-specific climate change adaptation policy and practice.

Figure 3: Geographical distribution of countries studies' sites
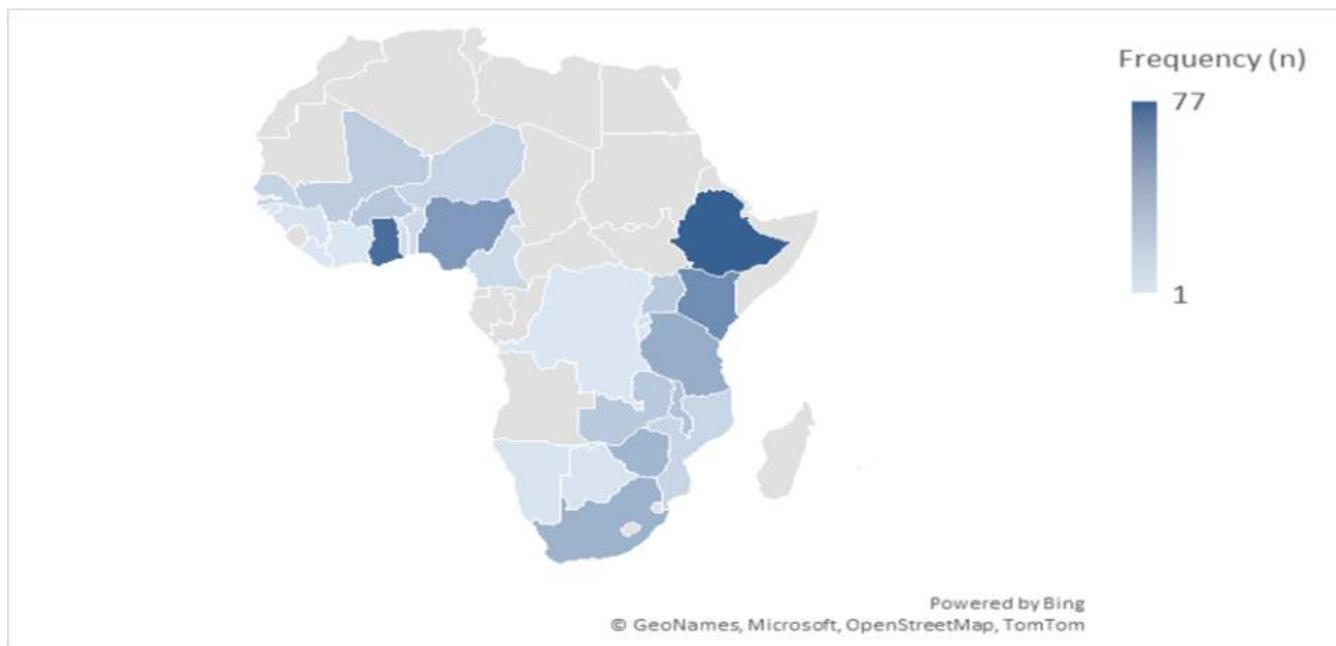
Source: Data on studies included in the EGM in EPPI reviewer

3.1.4 Distribution of lead author's countries

Figure 4 illustrates the geographical distribution of lead authors' institutional affiliations for the studies included in the EGM. Overall, the analysis shows that lead authors are affiliated with institutions located in 53 countries worldwide, highlighting the global nature of research on climate change adaptation and agriculture.

Institutions based in Ethiopia contributed the highest number of studies (53), making Ethiopia the most prominent country in terms of lead-author affiliations within Africa. This reflects a strong national research presence and sustained academic engagement on climate change adaptation and related agricultural interventions. South Africa follows closely, with 45 studies, further underscoring its central role in the African research landscape.

Outside Africa, institutions based in the United States of America contributed 25 studies, indicating a significant research output and continued engagement by U.S.-based institutions in this field. Germany also made a substantial contribution with 24 studies, reflecting strong European involvement in climate and agriculture research.

Within sub-Saharan Africa, additional notable contributions came from institutions based in Nigeria (25

studies), Kenya (28 studies), Ghana (41 studies), Tanzania (13 studies), and Zimbabwe (13 studies). Institutions in Italy and the United Kingdom each contributed 10 studies, while the Netherlands accounted for 8 studies, further demonstrating the role of European research institutions.

Several other countries, including Burkina Faso (6 studies), China (6), Norway (5), Uganda (5), Cameroon (5), and Zambia (4), made moderate contributions. The remaining countries were represented by fewer studies, often one or two, indicating more limited but geographically diverse participation.

These patterns are also reflected in the density visualization map presented in Figure I of the Appendix, which highlights clusters of research activity concentrated in Eastern and Southern Africa, as well as selected countries in Europe and North America. Overall, the distribution underscores both the growing research leadership within Africa and the continued influence of institutions based in the Global North

Figure 4: Geographic Distribution of Lead Authors' institution's Country
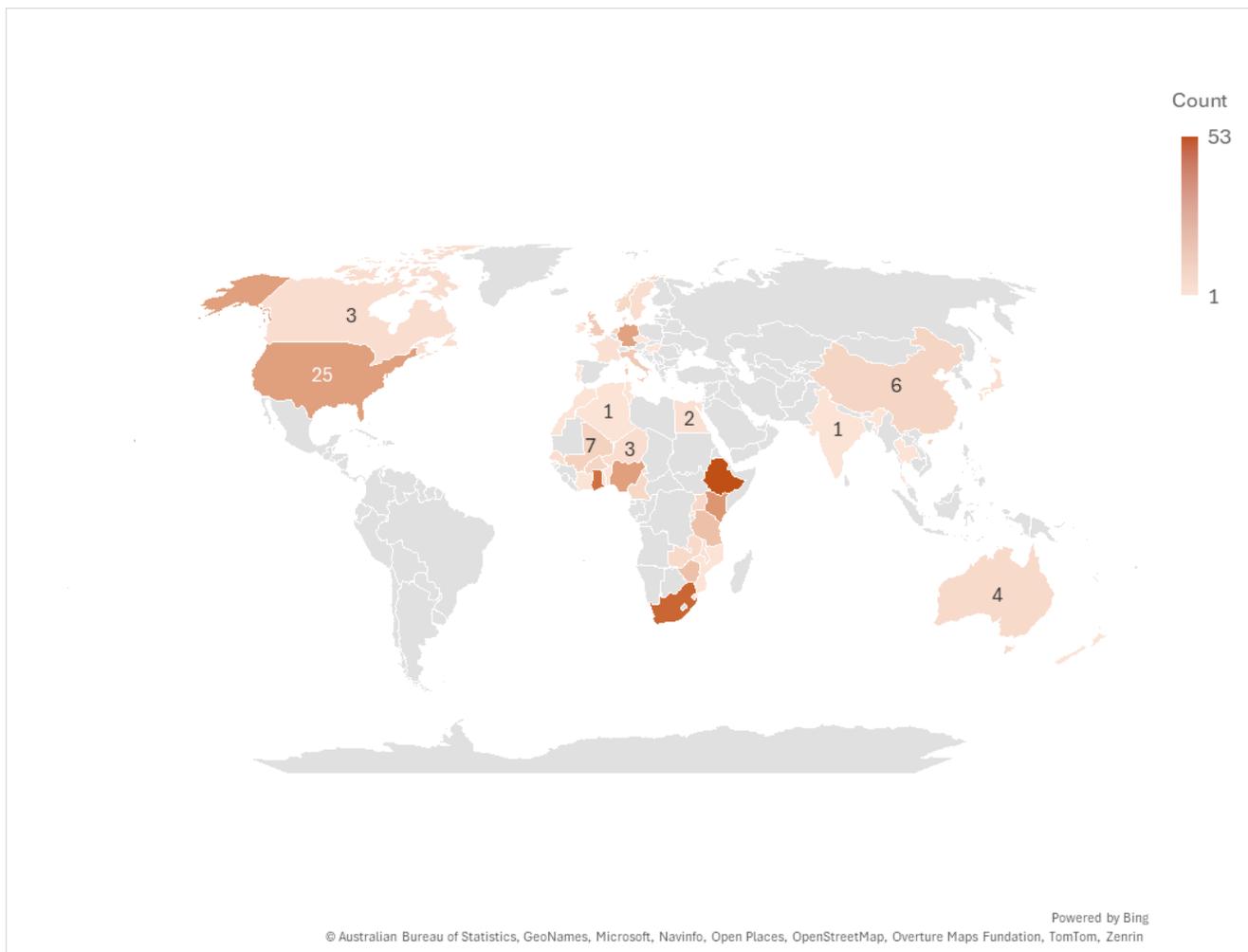
Source: Data from EPPI reviewer analyzed using VOS viewer software

3.1.5 Distribution of lead author's institutions

Figure 5 presents the distribution of lead authors' institutional affiliations using a bubble visualization. In the figure, larger bubbles represent institutions with a higher number of publications, while smaller bubbles indicate fewer publications.

The analysis shows that Kwame Nkrumah University of Science and Technology (KNUST) emerged as the most prominent institution, contributing 13 studies as lead author affiliations. This highlights KNUST's strong research presence in climate change adaptation and related development outcomes. Addis Ababa University followed with 9 publications, reflecting Ethiopia's broader leadership in the evidence base.

Several institutions contributed a substantial number of studies, including the University of KwaZulu-Natal (8 studies), Egerton University (7 studies), the International Maize and Wheat Improvement Center (CIMMYT) (7 studies), and the University for Development Studies (7 studies). The International Food Policy Research Institute (IFPRI) and the University of South Africa each accounted for 6 publications, underscoring the role of international research organizations and large public universities.

Institutions such as Haramaya University, ICRISAT, the University of Bonn, Wageningen University, and the World Agroforestry Centre (ICRAF) each contributed 5 studies, indicating consistent engagement across African and international research hubs. A further group of institutions—including the Food and Agriculture Organization of the United Nations (FAO), University of Ghana, University of Nairobi, University of Johannesburg, and University of Zimbabwe—each contributed 4 studies.

Beyond these leading institutions, a long tail of universities, research institutes, NGOs, and international organizations contributed between one and three studies, illustrating a highly diverse and decentralized research landscape. This breadth of institutional participation reflects wide-ranging interest in climate change adaptation across regions, while also indicating that research leadership is concentrated within a relatively small number of institutions.

4.1 Implications for stakeholders

The findings have important implications for a range of stakeholders.

Grant managers can use the analysis to make more strategic funding decisions by identifying key authors and institutions with strong research output and collaboration networks, helping to channel resources toward impactful and well-connected research teams.

Policymakers can draw on these insights to guide research funding priorities and strengthen international and regional collaboration. The findings highlight areas where targeted policy interventions could help address gaps and promote more balanced research partnerships.

Practitioners can use the report to stay informed about emerging research trends and leading contributors in the field, supporting evidence-based decision-making and the adoption of best practices.

Finally, researchers can benefit by identifying influential authors and institutions for potential collaboration, enabling them to build on existing knowledge, expand professional networks, and strengthen future research efforts.
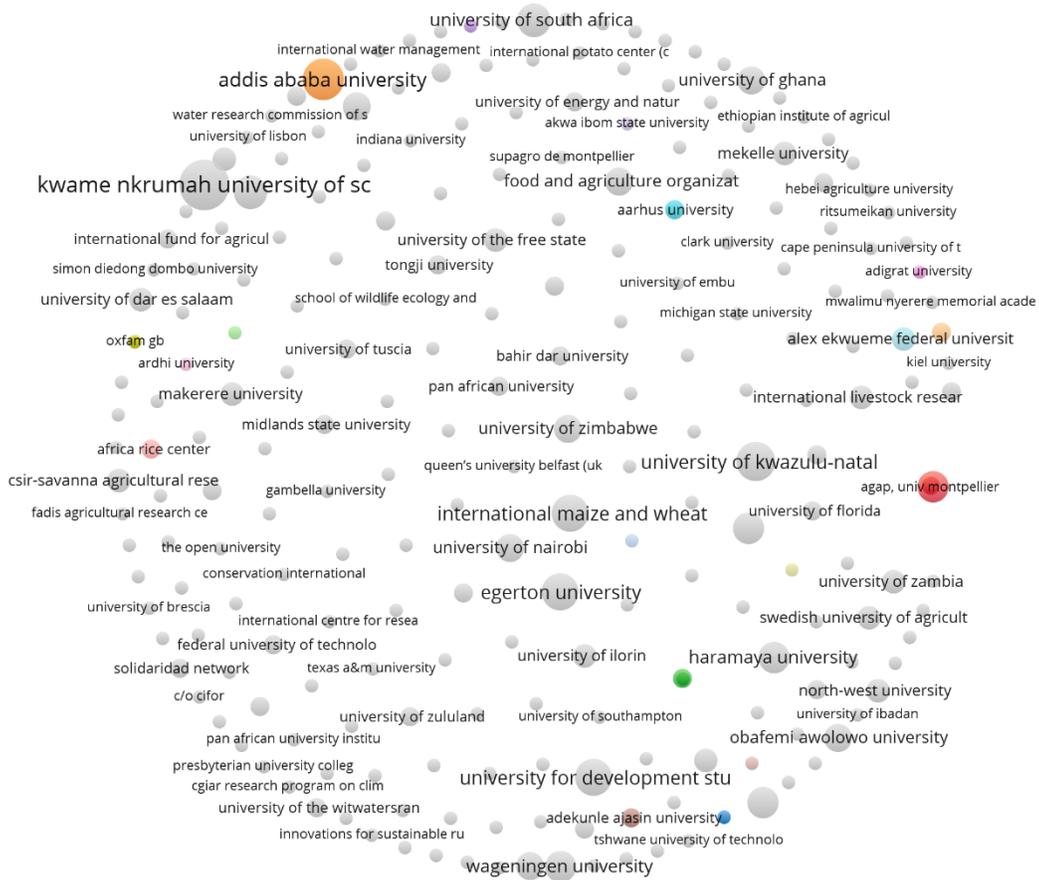
Source: Data from EPPI reviewer analyzed using VOS viewer software

5.1 Conclusion

The network analysis reveals that research production and collaboration are driven by a relatively small number of highly connected authors and institutions, many of which are based in a limited set of countries. While this reflects strong research capacity in these hubs, it also underscores persistent imbalances between the Global North and Global South in terms of leadership, funding access, and publication influence. At the same time, the presence of several African-based institutions and researchers among the most productive contributors highlights important opportunities to further strengthen South-led research and collaboration.

Taken together, these findings point to clear priorities for future investment. There is a need to expand research into underrepresented intervention areas and geographic contexts, to promote more diverse and inclusive research partnerships, and to strengthen the use of existing evidence through synthesis and translation into actionable products. For funders and policymakers, the map provides a strategic

tool to guide resource allocation and identify areas where additional evidence or capacity building is most needed. For researchers and practitioners, it offers a structured entry point into the existing literature and a basis for collaboration and learning.

Thus, the findings demonstrate the value of combining evidence and gap mapping with network analysis to not only understand *what* evidence exists, but also *who* is producing it and *how* knowledge is generated and shared. These insights are essential for advancing more equitable, impactful, and evidence-informed climate adaptation policies and practices.

5.1 Recommendations

Strengthening Collaboration Networks among Researchers
The network analysis shows that a large proportion of authors have contributed to only one publication, indicating weak or short-lived collaboration ties. Future research initiatives should encourage sustained collaboration through multi-institutional and multi-country research teams to strengthen knowledge continuity and reduce fragmentation in the evidence base.

Supporting Emerging and Less-Connected Authors and Institutions
A small number of authors and institutions occupy central positions in the co-authorship network, while many others remain weakly connected. Targeted funding and mentorship schemes can help integrate early-career researchers and less-connected institutions into established research networks, improving inclusivity and capacity development.

Promoting South–South and Regional Collaboration
Although many studies are implemented in sub-Saharan Africa, lead authorship and institutional concentration remain uneven across countries. Funders and research managers should support South–South and regional collaborations to strengthen research leadership within countries where interventions are implemented and to reduce dependency on a small number of highly connected institutions.

Figure I: Lead Author's Countries
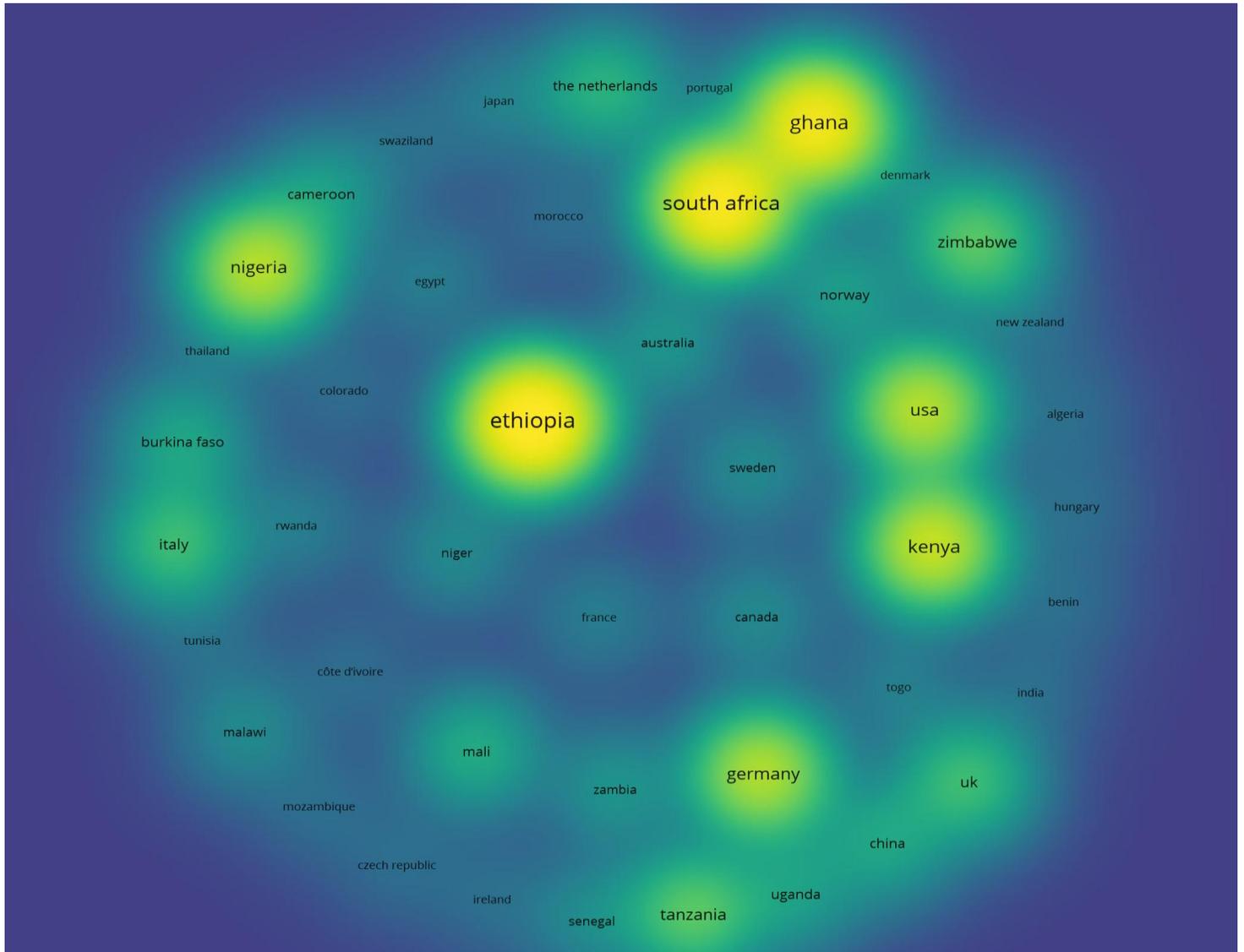
Appendix

Table 1: Authors with at least three (3) studies in the EGM

Name of Author	No. of documnets	Name of Author	No. of documnets
Makate, Clifton	7	Ogundeji, Abiodun A.	4
Mango, Nelson	7	Asare-Nuamah, Peter	4
Antwi-Agyei, Philip	6	Makate, Marshall	4
Van Wijk, Mark T.	5	Ouedraogo, Mathieu	3
Solomon, Dawit	5	Hansen, James	3
Lipper, Leslie	5	Tamene, Lulseged	3
Neufeldt, Henry	5	Abera, Wuletawu	3
Ojo, Temitope O.	5	Ng'ang'a, Stanley K.	3

Abdoulaye, Tahirou	5	Asante, Felix	3
Radeny, Maren	4	Arslan, Aslihan	3
Recha, John W.	4	Mutenje, Munyaradzi	3
Cattaneo, Andrea	4	Simane, Belay	3
Rufino, M. C.	4	Thierfelder, Christian	3
Van Wijk, M. T.	4	Stringer, Lindsay C.	3
Guodaar, Lawrence	4	Quandt, Amy	3

Table 2: Lead authors' country of institutions (top ten countries)

Countries of institutions of authors	No. of studies	Countries of institutions of authors	No. of studies
Ethiopia	53	USA	25
South Africa	45	Germany	24
Ghana	41	Tanzania	13
Kenya	28	Zimbabwe	13
Nigeria	25	Italy	10

Table 3: Lead authors' institutions (top ten institutions)

Organization	Documents
Kwame Nkrumah University of Science and Technology (Knust)	13
Addis Ababa University	9
University Of Kwazulu-Natal	8
Egerton University	7
International Maize and Wheat Improvement Center (Cimmyt)	7
University For Development Studies	7
International Food Policy Research Institute (Ifpri)	6
University Of South Africa	6
Haramaya University	5
International Crops Research Institute for the Semi-Arid Tropics (Icrisat)	5