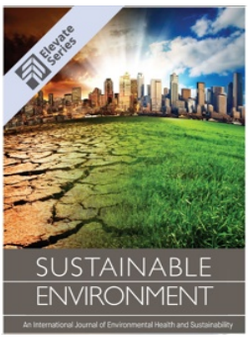

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Energy research in East Africa: A bibliometric analysis

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ABSTRACT

East Africa faces significant energy challenges due to the growing demand for sustainable power sources. Although the past decades have revealed an increase in global energy research, a comprehensive analysis of energy research is lacking in East Africa. To this end, we conducted a bibliometric analysis of energy research in East Africa over the past 25 years using the Scopus database, examining 905 publications from 412 journals. The results revealed a significant increase in energy research, with an annual growth rate of 10.07% in publications. The top contributing institution is Addis Ababa University (Ethiopia), accounting for 41 studies, followed by Makerere University (Uganda) and the University of Rwanda with 29 and 26 publications, respectively. The keyword analysis revealed a strong regional emphasis on East African countries, particularly Ethiopia, Kenya, and Tanzania, with a significant focus on energy policy, economic analysis, and technological aspects including solar and wind power. International collaboration patterns showed the UK, USA, and Ethiopia as leading contributors, with dense research networks connecting East African institutions to partners in Europe, Asia, and North America. The Engineering and Physical Sciences Research Council and World Bank Group were the top funding sources, demonstrating significant international investment in the region's energy research. While Ethiopia and Kenya contributed the most to energy research, Somalia and South Sudan had a lower role in energy research in the region. The findings highlight the need for more balanced energy research efforts across the region by identifying regions that require further attention.

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Renewable Energy; East Africa; Review; Energy Access; Sustainable Development

1. Introduction

The rising energy is identified as a critical challenge for developing regions, significantly impacting economic growth, environmental protection, and quality of life. Access to modern energy services is essential for human development, particularly in areas like East Africa, where a significant portion of the population lacks reliable energy sources (Barnes et al., 2010; Lemaire, 2015). This lack of access not only hinders productivity but also increases poverty, as nearly one billion people are projected to remain without electricity by 2030 (Warner & Jones, 2018). Accordingly, the integration of sustainable energy technologies is vital for addressing these challenges. These technologies can provide energy while adhering to sustainability principles, considering both environmental protection and economic development (Luthra et al., 2015). Consequently, developing countries can enhance their energy management, reduce greenhouse gas emissions, and support long-term economic viability (Warsame et al., 2024).

Literature on global energy trends highlights the issues related to energy access, particularly in Sub-Saharan Africa, where electrification rates and access to clean cooking fuels remain low (Blimpo et al., 2020; Murshed, 2022). Researchers have identified the reliance on traditional biomass for cooking as a significant challenge in the region. Over 900 million people lack access to clean cooking fuels, leading to severe health and environmental consequences (Dagnachew et al., 2020; Hamed et al., 2024). For instance, Batchelor et al. (2019) highlighted how unsustainable energy sources contribute to deforestation and indoor air pollution. On the other hand, the literature demonstrates progress in renewable energy development across East Africa. The region is provided with numerous renewable resources, including solar, wind, geothermal, and hydroelectric potential. For instance, Kong'ani and Kweyu (2022) reported Kenya's advancement in geothermal energy, with its Olkaria Geothermal Power Plant being one of the largest in the world. Similarly, Kazimierczuk (2019)

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analyzed the significance of the Lake Turkana Wind Power project, the largest wind farm in Africa. Furthermore, Yihdego et al. (2017) examined Ethiopia's hydroelectric projects, including the Grand Ethiopian Renaissance Dam.

Studies on renewable energy adoption across various countries in the region reveal a range of advanced strategies, including diverse policies, technologies, and investments. Hagumimana et al. (2021) analyzed Rwanda's targets for universal electricity access, with a significant focus on solar sources. Aly et al. (2019) explored Tanzania's solar potential and ongoing large-scale solar projects. Likewise, Fashina et al. (2018) demonstrated Uganda's efforts to increase its renewable energy sources through investments in solar, hydropower, and biomass energy.

In recent decades, advancements in bibliometric analyses have provided powerful tools in various fields to map and analyze scholarly output, highlighting research hotspots, trends, and gaps in the literature (Afuye et al., 2022; De Natale et al., 2023; Rady et al., 2025). Geng et al. (2017) conducted a global bibliometric analysis of energy research trends. Likewise, Mao et al. (2015) focused on energy research in developing regions. Despite the efforts of these studies, little attention is paid to the state of energy research in East Africa. Therefore, the present study aims to address this gap by providing a comprehensive overview of energy research trends in East Africa in the past 25 years (2000–2024). Accordingly, we seek to map the growth and distribution of energy research publications focused on East Africa, while identifying key research themes and sources receiving attention in the literature. Moreover, we analyze the collaboration patterns between institutions and countries involved in East African energy research to demonstrate the international and regional networks driving knowledge production in this field.

2. Study area

This study focuses on energy research in East Africa. According to the African Development Bank Group (AfDB), East Africa consists of 13 nations: Djibouti, Eritrea, Kenya, Rwanda, Ethiopia, Comoros, Burundi, Somalia, Seychelles, Sudan, South Sudan, Uganda, and Tanzania. Figure 1 illustrates the study area. These nations collectively face significant challenges in energy access and development along with economic conditions and natural resources.

East African countries included in this analysis had an average GDP per capita of 1003.327 USD, indicating relatively low economic output per person (East African Power, n.d.). Despite the economic constraints, many of these countries explore energy development goals, as demonstrated by their national energy policies and participation in international initiatives such as sustainable development goals (Schwerhoff & Konte, 2020). The energy situation in East Africa is characterized by significant disparities in access to modern energy services. According to East African Power (East African Power, n.d.), more than 363 million people in the region lack access to clean cooking fuels. This widespread reliance on traditional biomass for cooking has significant implications for health, environmental sustainability, and quality of life across all 13 countries, though the severity of the issue varies from nation to nation (Andrews et al., 2018). Electricity access also remains a critical challenge throughout East Africa. As of 2021, only 50.9% of the total population in the studied East African countries had access to electricity (East African Power, n.d.). In rural areas, almost 38.2% of the population has access to electricity, while urban areas fare better with 81.7% access (East African Power, n.d.).

3. Methodology

In this study, we employed a bibliometric analysis to examine research trends and patterns in energy-related publications focusing on East Africa. To this end, we employed a systematic approach to data collection and analysis of energy research in East Africa. The initial literature search was conducted using the Scopus database due to its comprehensive coverage of scientific literature (Mongeon & Paul-Hus, 2016). The original search focused on research articles containing 'Energy' in their titles and references to East African nations in their titles, abstracts, or keywords. To ensure comprehensive coverage while maintaining relevance, we employed both specific country names and regional descriptors such as 'East Africa' and 'Horn of Africa' in our search terms.

To refine our analysis and focus specifically on energy-related research, we applied several filters to the initial search results. The search was limited to English-language articles and reviews published between 2000 and 2024. We excluded subject areas not directly related to the intended meaning of energy in our research papers such as medical and health-related fields (including biochemistry, veterinary science, nursing, pharmacology, immunology, and psychology) to focus on energy-specific research. Moreover, we removed articles focusing on human and animal studies by excluding specific keywords such as 'Human', 'Male', 'Female', 'Animal', and related terms. Table 1 presents the advanced search query employed to achieve the research objectives.

Figure 1. Study area.

The filtered data was extracted to a CSV file containing fields such as title, abstract, keywords, affiliations, and funding information, which served as the input for analysis. The filtered data is provided in the supplementary materials. Our analysis focused on several key metrics: the total number of publications and the frequency of annual publications to track research development over time; the spatial distribution of publications across East Africa to identify research hotspots; and publication types to understand the nature of research outputs. Eventually, we reported the top ten lists for institutes, countries, authors, and journals based on their contributions to energy research in East Africa by sorting the filtered document information from the Scopus database.

We used the Bibliometrix package in R, developed by Aria and Cuccurullo (2017), to process and analyze the CSV file obtained from the Scopus database. This tool generates a variety of bibliometric indicators and visualizations, as follows:

- Thematic map: Generated using the co-occurrence matrix of keywords, clustering them based on density and centrality measures.
- Word cloud: Created from keywords' relative frequencies to highlight the most common research topics.
- Three-field plot: Generated to show connections between the top countries, journals, and keywords based on co-occurrence.
- Global Collaboration Map: Used to construct co-authorship networks from Scopus affiliation data, highlighting international research collaborations.

4. Results

Figure 2 summarizes the main information of the reviewed publications based on the aforementioned methodology. The analyzed data consists of 905 publications from 412 journals, demonstrating an annual

Table 1. Advanced search query

Filters		Query
String	Energy East African nations	((TITLE (Energy) AND TITLE-ABS-KEY('horn of africa' OR 'east africa*' OR burundi OR comoros OR djibouti OR ethiopia OR eritrea OR kenya OR rwanda OR seychelles OR somali* OR 'South Sudan' OR sudan OR tanzania OR uganda))
Timeframe	2000–2024	PUBYEAR >1999 AND PUBYEAR < 2025
Document type	Article Review	(LIMIT-TO (DOCTYPE,'ar') OR LIMIT-TO (DOCTYPE,'re'))
Language	English	(LIMIT-TO (LANGUAGE, 'English'))
Exclude Subject areas	Medicine Biochemistry, Genetics and Molecular Biology Veterinary Nursing Pharmacology, Toxicology and Pharmaceutics Immunology and Microbiology Psychology	(EXCLUDE (SUBJAREA,'MEDI') OR EXCLUDE (SUBJAREA,'BIOC') OR EXCLUDE (SUBJAREA,'VETE') OR EXCLUDE (SUBJAREA,'NURS') OR EXCLUDE (SUBJAREA,'PHAR') OR EXCLUDE (SUBJAREA,'IMMU') OR EXCLUDE (SUBJAREA,'PSYC'))
Exclude Keywords	Human ScanningElectronMicroscopy ControlledStudy Male Female Nonhuman PriorityJournal Humans Economics Animal Animals Adult Infant India Animalia Commerce	(EXCLUDE (EXACTKEYWORD,'Human') OR EXCLUDE (EXACTKEYWORD,'ScanningElectronMicroscopy') OR EXCLUDE (EXACTKEYWORD,'ControlledStudy') OR EXCLUDE (EXACTKEYWORD,'Male') OR EXCLUDE (EXACTKEYWORD,'Female') OR EXCLUDE (EXACTKEYWORD,'Nonhuman') OR EXCLUDE (EXACTKEYWORD,'PriorityJournal') OR EXCLUDE (EXACTKEYWORD,'Humans') OR EXCLUDE (EXACTKEYWORD,'Economics') OR EXCLUDE (EXACTKEYWORD,'Animal') OR EXCLUDE (EXACTKEYWORD,'Animals') OR EXCLUDE (EXACTKEYWORD,'Adult') OR EXCLUDE (EXACTKEYWORD,'Infant') OR EXCLUDE (EXACTKEYWORD,'India') OR EXCLUDE (EXACTKEYWORD,'Animalia') OR EXCLUDE (EXACTKEYWORD,'Commerce')))

Figure 2. Main review information.

growth rate of 10.07% in publications. The analysis shows that a total of 2582 authors contributed to energy research in East Africa, with 143 single-authored publications. The research shows strong international collaboration, with 39.23% of documents involving co-authorship across borders, and an average of 3.45 co-authors per document. Furthermore, the impact of this research is significant, as indicated by the average of 20.69 citations per document.

Figure 3 illustrates a thematic map of energy research in East Africa based on the title. The map reveals the central importance of 'Renewable Energy' as the most frequent keyword, with this term positioned at the center of the map. The map also highlights the diverse themes and subfields that are closely associated with renewable energy research. For instance, there is a strong link between renewable energy and the concept of sustainable development. The map also shows nodes for 'Solar Energy' and 'Energy System' indicating that these are two major areas of focus within renewable energy research. The centrality of solar energy implies a strong emphasis on this renewable technology and its integration into wider energy infrastructure and systems.

Figure 4 depicts a thematic map of energy research in East Africa based on abstracts. The map demonstrates

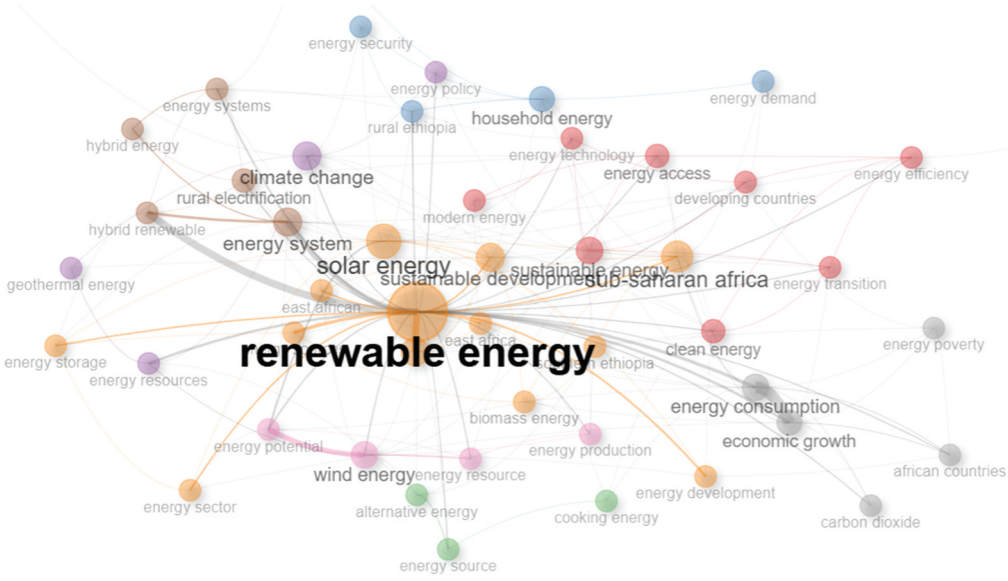

Figure 3. Thematic map based on title.

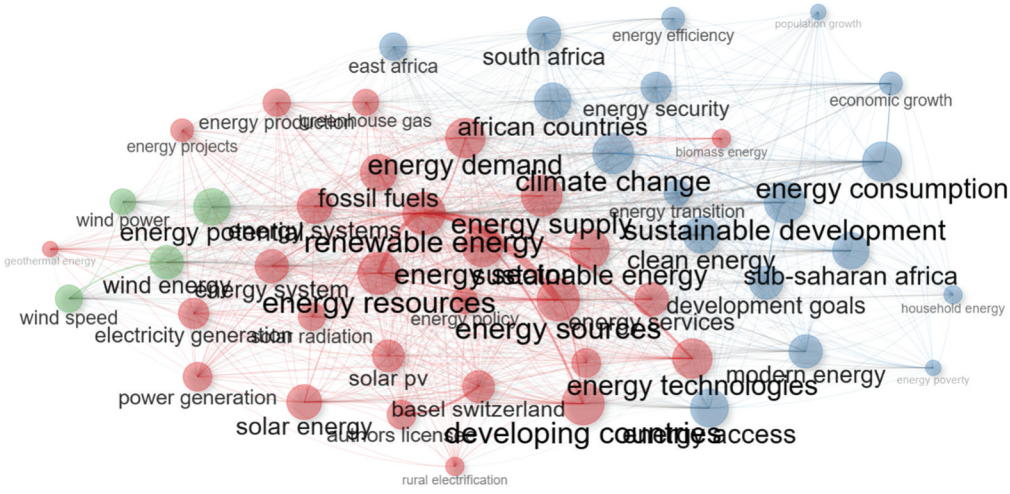

Figure 4. Thematic map based on abstract.

the central importance of 'renewable energy' as the dominant keyword within energy research. This key position is reflected in the map, with renewable energy directly connected to a range of significant topics, including energy resources, clean energy, energy consumption, and energy systems. These relationships highlight the role of renewable energy research in addressing various aspects of energy production, sustainability, and systems integration. A cluster around the term 'sustainable development' further highlights the growing research interest in the intersection between renewable energy and sustainability. The map also shows a technology-focused cluster, with significant nodes for solar energy, wind energy, and energy efficiency.

Figure 5 shows a thematic map of energy research in East Africa based on keywords. The terms 'renewable energy' 'sustainable development', and 'alternative energy' serve as the focal points around which numerous other interconnected research themes and topics are organized. The map reveals a strong regional emphasis, with a significant cluster of keywords focused on East African countries, such as Kenya, Tanzania, and Uganda, as well as the broader region of Sub-Saharan Africa. Furthermore, the thematic map also highlights the growing attention to the economic and policy dimensions of renewable energy deployment. Keywords such as 'energy policy', and 'economic analysis' are featured.

The technological aspects of renewable energy are also well-represented, with keywords like 'solar energy',

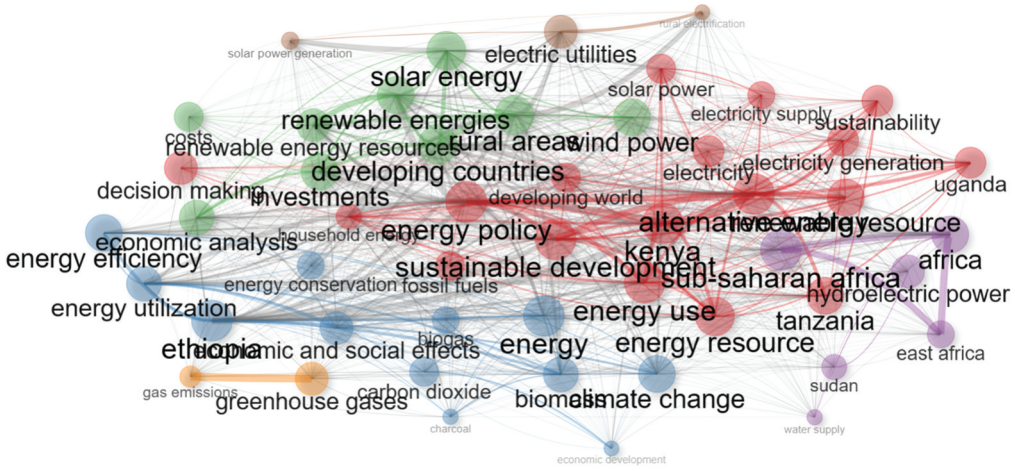

Figure 5. Thematic map based on keywords.

'wind power', and 'renewable energies' becoming key areas for research. These technological themes are closely connected to the regional and policy-related keywords. Furthermore, the map reveals the role of renewable energy in addressing climate change, indicated by keywords like 'climate change', 'carbon dioxide', 'fossil fuels', and 'greenhouse gases'. Moreover, the emphasis on 'energy efficiency' and 'energy utilization' highlights the research focus on optimizing the use of renewable energy resources, reflecting efforts to improve the overall efficiency and sustainability of energy systems. Similarly, the importance of 'household energy' and 'rural areas' indicates a strong interest in expanding energy access and improving the quality of life in underserved communities through renewable energy solutions.

Figure 6 illustrates the most frequent words in the titles and abstracts of research articles related to energy research in East Africa. The results show that energy research can be divided into five clusters based on the top keywords: renewable energy, energy systems and efficiency, geography, economy and policy, and sustainability and climate. The most dominant word in clouds is 'renewable energy', which reflects its central importance in the titles of the articles analyzed. Other terms such as 'energy consumption' and 'economic growth' indicate that a significant portion of the research explores the relationship between renewable energy usage and broader economic outcomes. The importance of technological terms, like 'solar energy', 'energy system', and 'wind energy' highlights the attention given to specific renewable energy technologies. The presence of terms such as 'sustainable development', 'Sub-Saharan Africa', and 'energy access' points to a focus on sustainability and the application of renewable energy solutions to improve energy access in developing regions,

Cluster	Terms	Title	Abstract
Renewable Energy	renewable energy	131	538
	solar energy	45	118
	wind energy	36	105
	energy sources	14	197
Energy Systems and Efficiency	energy consumption	49	265
	energy potential	29	64
	energy system	28	54
	energy access	27	107
	energy technologies	25	92
Geography	sub-saharan africa	28	104
Economy and Policy	economic growth	29	147
	developing countries	10	119
Sustainability and Climate	climate change	18	116
	sustainable development	17	114

Figure 6. Most frequent themes in the abstracts and titles.

particularly in East Africa. Furthermore, the presence of words like 'climate change' and 'energy efficiency' indicates that the research often extends beyond technology to include policy, environmental impact, and the societal implications of renewable energy deployment.

Figure 7 illustrates the most frequent words in keywords in energy research in East Africa. The most frequent keyword is 'Ethiopia', followed closely by 'energy policy', 'alternative energy', and 'sustainable development'. Countries like Kenya, Tanzania, and Uganda, and regions such as Sub-Saharan Africa are frequently mentioned, indicating a considerable research interest in the energy research of these African countries. The focus on East Africa, especially Ethiopia, highlights the importance of renewable energy in the context of regional development, energy access, and rural electrification. 'energy policy' and 'energy utilization' are among the most frequent keywords. Terms like 'solar energy', 'wind power', 'biomass', and 'electric utilities' point to a significant focus on various renewable energy technologies and their potential applications. 'Energy resources' and 'energy efficiency' are also significant, reflecting ongoing research into optimizing renewable energy systems and improving resource management.

Figure 8 shows the connections between top contributors to energy research in terms of corresponding

Figure 7. Most frequent words in the keywords.

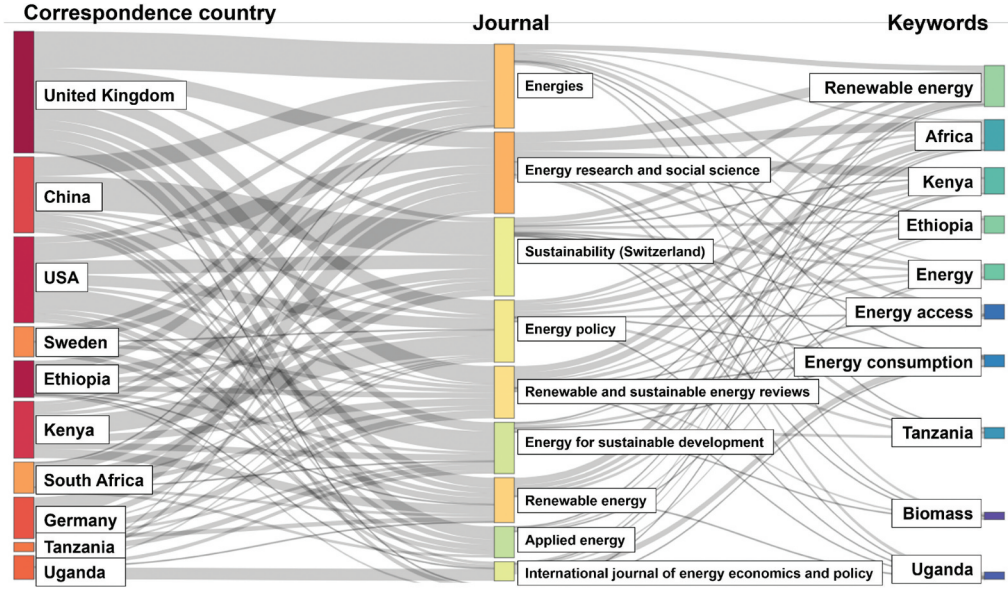

Figure 8. Three-field plot showing connections between top countries, journals, and keywords.

authors' countries, journals, and keywords associated with the studies. The results provide details into the global studies of energy research, highlighting the diverse geographical distribution of research contributions and the thematic focus areas within the field. The figure shows the top contributing countries, including the United Kingdom, China, the United States, Sweden, and several African nations, such as Ethiopia, Kenya, South Africa, Tanzania, and Uganda. Energies, Energy Research and Social Science, and Sustainability (Switzerland) are the leading journals. Additional key journals include Energy Policy, Renewable and Sustainable Energy Reviews, and Energy for Sustainable Development.

Figure 9 shows the spatial distribution of studies focusing on energy research in East Africa based on the occurrence of the country in the title, abstract, or keywords. The results reveal that Ethiopia, Kenya, and Tanzania have the highest frequency of occurrences, with 240, 216, and 134 occurrences, respectively. In contrast, Comoros, Burundi, South Sudan, Seychelles, Eritrea, and Djibouti appear less frequently in the energy research literature. Uganda and Tanzania exhibit a moderate level of research attention, with 123 and 134 occurrences, respectively.

Figures 10–12 rank the top institutes, subject areas, and countries contributing to energy research in East Africa. The figures show the evolution of research over three sub-periods: 2000–2009, 2010–2019, and 2020–2024. The results show that energy research has dramatically increased over time, especially in the last 5 years.

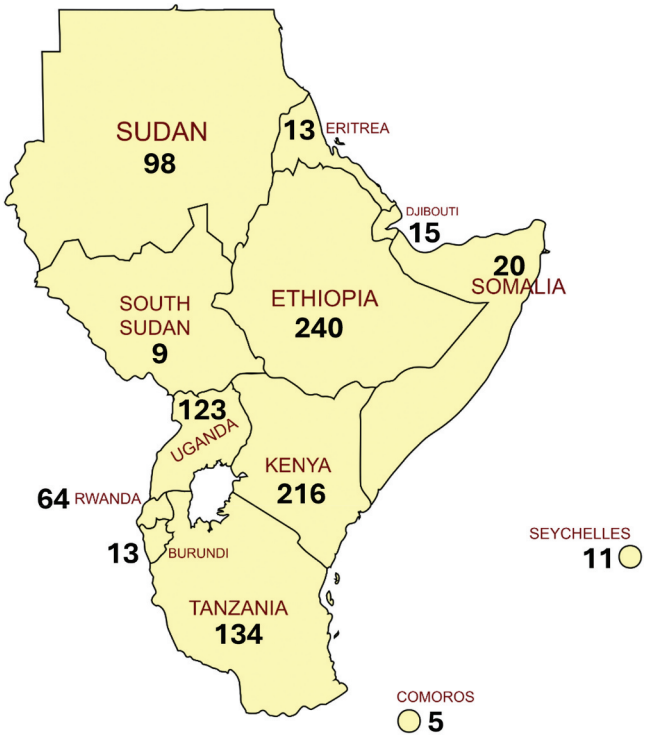

Figure 9. Spatial distribution of studies focusing on energy research based on the occurrence of the country in the title, abstract, or keywords.

Figure 10 depicts the top ten institutes contributing to energy research in East Africa. At the forefront of this list is Addis Ababa University in Ethiopia, the most significant contributor with an impressive 41 published studies. Closely following Addis Ababa University are two other institutions: Makerere University in Uganda, with 29 publications, and the University of Rwanda, with 26 publications. The chart further reveals several other Ethiopian institutions that rank among the top contributors, including Mekelle University (19 publications), Bahir Dar University (18 publications), and Hawassa University (17 publications).

Figure 11 shows the top ten subject areas contributing to energy research in the East Africa region. The results reveal the diverse academic disciplines and fields of study that are actively engaged in exploring and addressing energy-related challenges within this context. The Agricultural and Biological Sciences category emerges as the dominant contributor, with an impressive 386 publications. Environmental Science (246 publications) and Earth and Planetary Sciences (192 publications) categories demonstrate a robust focus on environmental sustainability and the understanding of Earth's systems concerning energy production and consumption. The chart also reveals the contributions of more specialized disciplines, such as Computer Science (56 publications) and Biochemistry, Genetics, and Molecular Biology (54 publications). Directly involved in the study and application of energy systems, the Engineering (39 publications) and Energy (31 publications) subject areas provide practical solutions and innovations necessary for the energy transitions taking place in East Africa. The presence of Social Sciences (28 publications) in the top ten subject areas highlights the recognition of the socio-economic implications of energy transitions, energy access, and policy development. The chart also includes Multidisciplinary research (26 publications) and Mathematics (25 publications).

Figure 12 depicts the spatial distribution of publishing countries to energy research in East Africa based on affiliations. The map's color gradient reflects the number of publications, ranging between 1 and 148 publications. The top country is the United Kingdom (148 publications). The second most contributing country is Ethiopia, an East African nation that produced 146 publications. Ranking third, the United States makes a substantial contribution with 120 publications, reflecting its global research capacity and active involvement

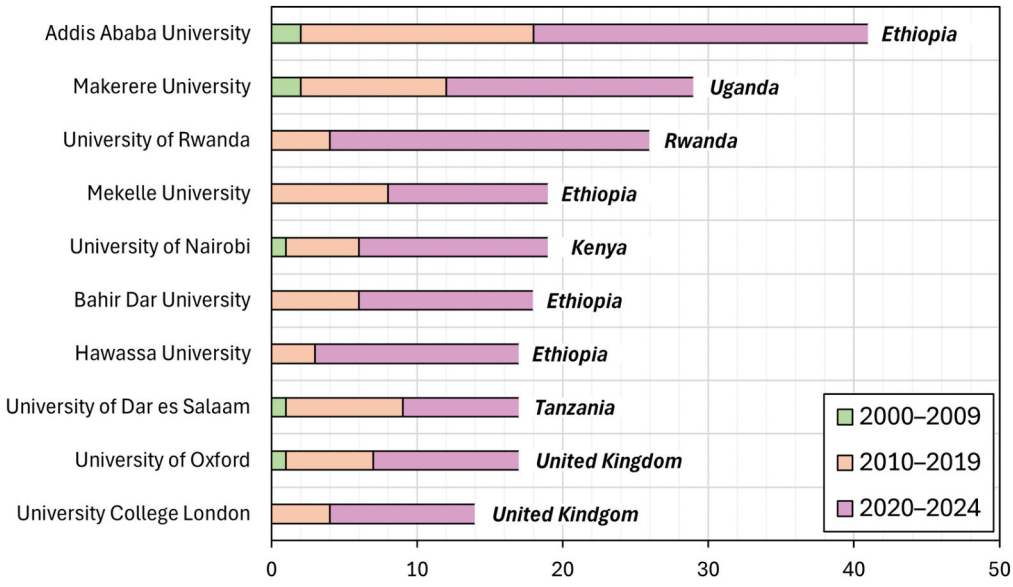

Figure 10. Top ten institutes contributing to energy research in East Africa.

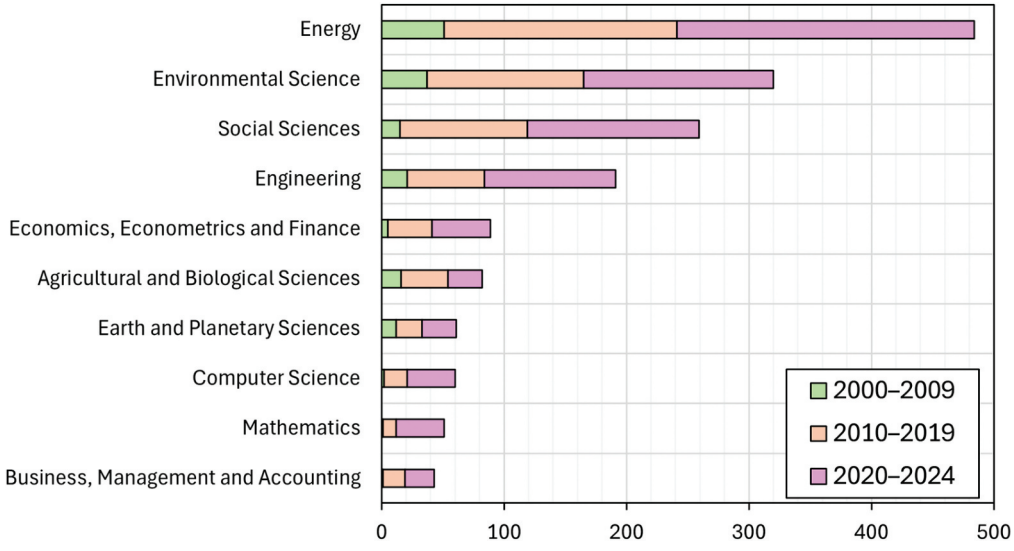

Figure 11. Top ten subject areas contributing to energy research in East Africa.

in international energy research collaborations in East Africa. The top African contributors include Kenya, Tanzania, and Uganda, which have produced 94, 66, and 55 publications, respectively. The chart also reveals the contributions of several European and Asian nations. For instance, Germany and Sweden are significant non-African contributors, with 69 and 58 publications, respectively. Similarly,

The global collaboration map presented in Figure 13 illustrates research partnerships across the world, focusing on energy research in East Africa. The map shows the geographic locations of contributing countries, connected by lines representing collaborative research relationships. The density and direction of these connections highlight the global nature of energy research partnerships. The United States, the United Kingdom, and several countries in Europe and Africa act as central nodes, with a high number of collaborative links extending to and from East African nations like Ethiopia, Kenya, and Tanzania. The map reveals a particularly dense web of research relationships centered around East Africa. Countries like Ethiopia, Kenya, and Tanzania are highly connected to international research institutions, reflecting strong partnerships aimed at addressing energy challenges in these regions. Furthermore, numerous connections are observed between East African countries and key players such as the United States, United Kingdom, Germany, Sweden, China, and Australia.

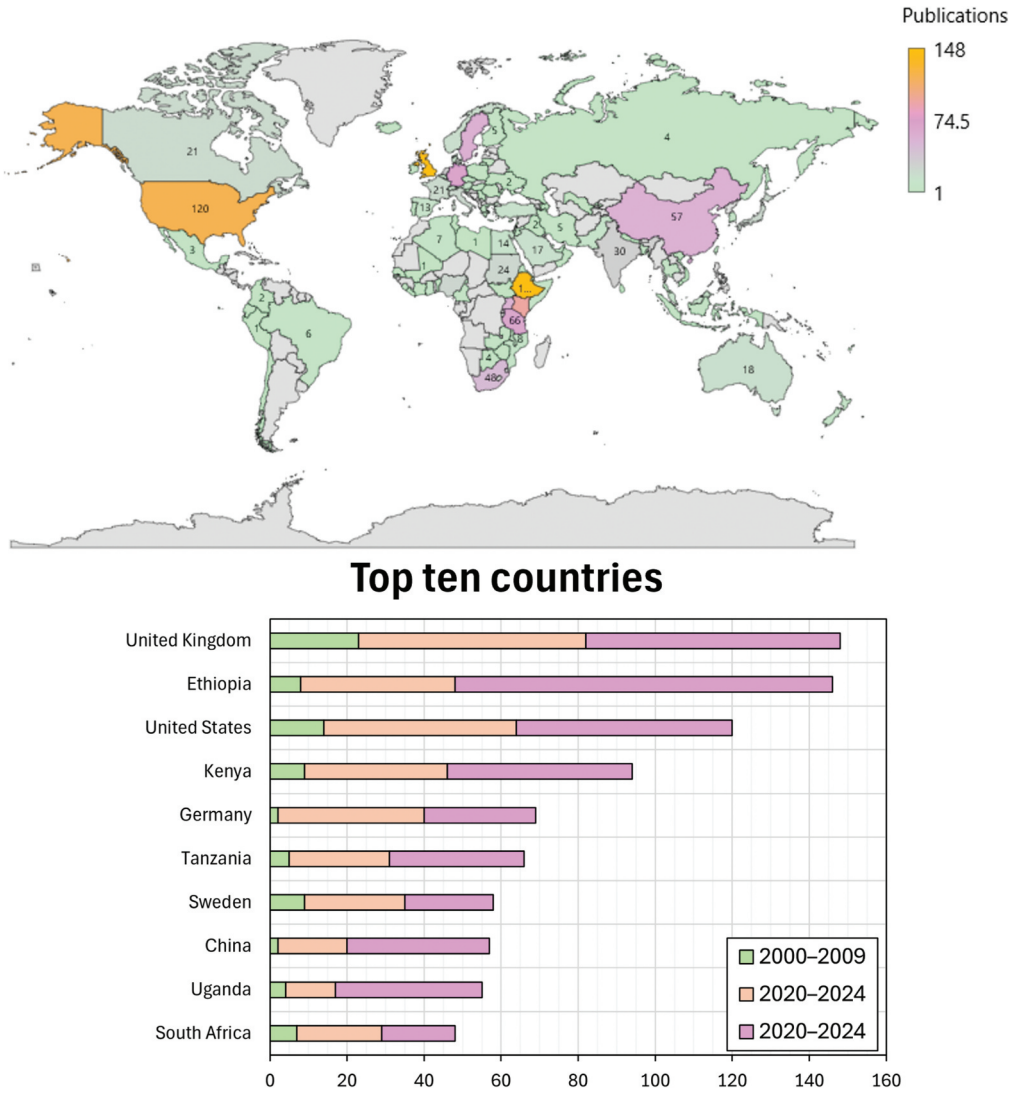

Figure 12. Spatial distribution of publishing countries.

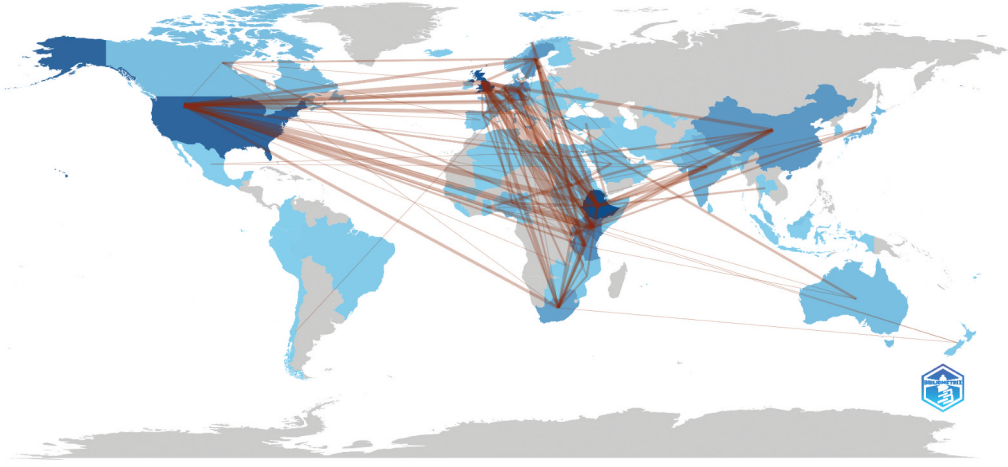

Figure 13. Global collaboration map.

Figure 14 illustrates the evolution of energy research publications focused on East Africa from 2000 to 2023, revealing a clear trend of accelerating growth over time. We omitted the data for 2024 to avoid misunderstanding the research patterns because the research is still ongoing. The data shows three distinct phases in research output. From 2000 to 2015, there was a period of gradual growth, with annual publications generally ranging between 5 and 24. The years 2016 to 2018 marked a dramatic increase, with publications rising from 28 to 55, indicating growing interest in energy-related topics in the region. However, the most significant rise occurred from 2019 to 2023. During this period, the number of publications rose dramatically, from 64 in 2019 to 120 in 2023, with a particularly sharp increase to 101 publications in 2021.

Figure 15 presents the top funding organizations supporting energy research in East Africa, ranked by the number of publications sponsored. The results show that the United Kingdom is the top contributor to energy research in the region. For instance, the UK Research and Innovation (UKRI), a key non-departmental public body that was founded in 2018, supports research through multiple councils, including the Engineering and Physical Sciences Research Council and the Economic and Social Research Council.

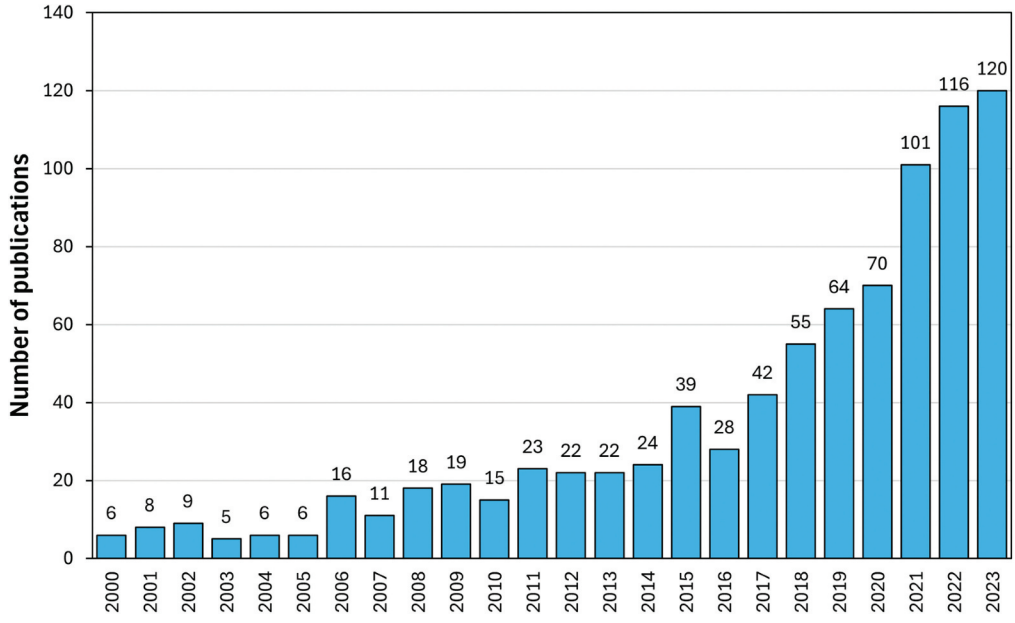

Figure 14. Frequency of annual publications.

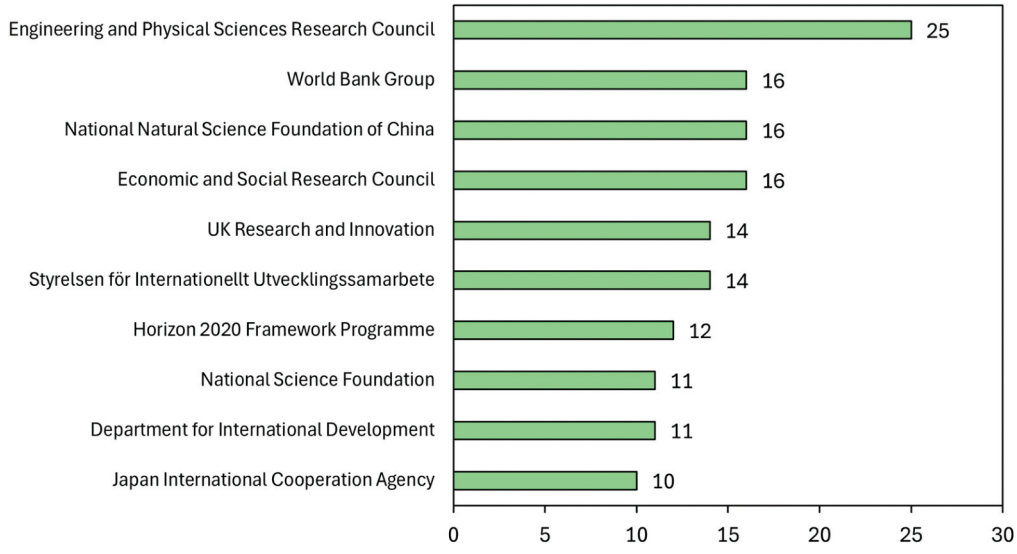

Figure 15. Top ten funding sponsors of energy research in East Africa.

Furthermore, the Department for International Development of the UK funded 11 publications. The US follows, with two major sponsors, the National Science Foundation and the World Bank Group. The European Union's Horizon 2020 Framework Programme, which funded research and innovation from 2014 to 2020, also plays a significant role in funding energy research in East Africa. Other sponsors include the National Natural Science Foundation of China, Japan's International Cooperation Agency, and Styrelsen för Internationellt Utvecklingssamarbete belonging to the Swedish International Development Cooperation Agency (SIDA).

5. Discussion

The bibliometric analysis of energy research in East Africa from 2000 to 2024 reveals a rapidly evolving field that reflects global trends in sustainable energy. The significant growth in publications, particularly in recent years, demonstrates the increasing recognition of East Africa's role in global energy transitions, aligning with the growing emphasis on renewable energy and sustainable development (Geng et al., 2017). The thematic view, centered around renewable energy and sustainable development, demonstrates the complex interconnection of technological, environmental, and socio-economic factors in addressing energy challenges in the region (Murshed, 2022). The geographical distribution of the research focus, concentrated on countries like Ethiopia, Kenya, and Tanzania, highlights both progress and disparities in regional energy research. Our analysis shows that these countries can be considered hubs of innovation, as evidenced by projects like Kenya's Lake Turkana Wind Power project (Kazimierczuk, 2019) and Ethiopia's hydroelectric ambitions (Yihdego et al., 2017). However, the uneven distribution of research attention may exacerbate existing inequalities in energy access across East Africa. This suggests a need for more comprehensive studies that include understudied nations to ensure a balanced approach to energy development in the region. The significant role of local universities, particularly Addis Ababa University (Ethiopia), in driving energy research underscores the importance of building local research capacity. However, the dominance of a few institutions also indicates a need for more distributed research capabilities across the region. The interdisciplinary nature of the research, spanning agricultural sciences, environmental studies, and engineering, reflects the complex networks between energy, agriculture, and environmental sustainability, crucial for addressing the water-energy-food nexus challenges (Dagnachew et al., 2020).

Global collaboration patterns reveal extensive international partnerships, bringing valuable expertise and resources. However, these collaborations also raise questions about research agenda-setting and the need for more equitable, locally-driven research priorities (Sovacool et al., 2018). The analysis of funding sources highlights a diverse landscape of support, including international agencies and national research councils. While this demonstrates global interest in the region's energy future, it also demonstrates the need for increased local and regional funding mechanisms to ensure research priorities align with local contexts and needs (Yihdego et al., 2017). The focus on renewable energy technologies presents both opportunities and challenges. While these technologies offer promising pathways for increasing energy access and reducing carbon emissions, their successful implementation requires careful consideration of local socio-economic conditions and environmental impacts. Future research should critically examine the long-term sustainability and social equity implications of renewable energy projects in the region (Batchelor et al., 2019).

Climate change has become a cross-cutting theme, highlighting the dual challenges of increasing energy access while building climate resilience. This suggests a need for more targeted studies on climate change adaptation within energy systems, focusing on the resilience of renewable energy infrastructure to changing climate conditions in East Africa (Takada et al., 2021). This bibliometric analysis reveals a field characterized by rapid growth, diverse contributions, and complex global collaborations. Moving forward, research efforts should focus on addressing geographical gaps in coverage, strengthening local research capacity, promoting equitable collaborations, developing comprehensive syntheses, and investigating the socio-economic and environmental implications of energy transitions. By addressing these areas, the research community can contribute to a detailed understanding of East Africa's energy challenges and opportunities, supporting more effective energy transitions in the region.

6. Conclusion

In this study, we conducted a bibliometric analysis to explore energy research trends in East Africa, employing a systematic approach to data collection and analysis using the Scopus database. Our search strategy focused on research articles that included 'Energy' in their titles and referenced East African nations in their titles, abstracts, or keywords. To ensure comprehensive coverage, we incorporated both country-specific and regional descriptors while applying filters to refine the dataset,

excluding non-relevant subject areas and human/animal studies. The filtered data, containing key bibliographic fields, was analyzed using the Bibliometrix package in R to generate various bibliometric indicators and visualizations. These included thematic maps of keyword co-occurrence, word clouds highlighting dominant research topics, three-field plots illustrating connections between top contributors, and global collaboration maps to reveal international research networks.

The thematic analysis of energy research in East Africa highlights the central role of renewable energy in addressing sustainability, climate change, and energy access challenges. Across titles, abstracts, and keywords, 'renewable energy' was the key theme, closely linked to 'sustainable development', 'solar energy', and 'energy systems', demonstrating the region's strong focus on clean energy solutions. Furthermore, the research trends reveal a growing focus on technological advancements, policy considerations, and economic analysis to integrate renewable energy into national and regional energy frameworks. Moreover, the frequency of keywords related to energy efficiency, carbon emissions, and rural electrification highlights the urgent need for sustainable energy solutions to support economic growth and climate resilience.

The spatial analysis of energy research in East Africa reveals significant variations in research contributions across countries. The results show that Ethiopia, Kenya, and Tanzania are the most frequently studied nations, whereas smaller states like Comoros and Seychelles receive comparatively less attention. The top contributing institutions are Addis Ababa University, Makerere University, and the University of Rwanda. Global collaborations play a crucial role in enhancing energy research in East Africa, with the United Kingdom, the United States, and Germany among the top contributing countries. The temporal analysis shows that energy research in the region has grown significantly, especially in the past five years. The results also show an interdisciplinary nature of energy research in the study area, with strong contributions from environmental science, engineering, and social sciences.

While the present bibliometric analysis is comprehensive in examining publication patterns and research themes, it has several limitations. First, the study focused on English-language publications indexed in the Scopus database, overlooking valuable research published in local languages or regional journals that may not be internationally indexed. Second, the analysis did not examine the quality indicators of individual publications beyond citation counts, such as the methodological approaches used (e.g. empirical vs. theoretical, quantitative vs. qualitative), the practical implementation of research findings, or the actual impact of the research on energy policy and development in East Africa.

Future research should address these gaps by incorporating publications from local repositories and non-English sources, analyzing the methodological details of studies, examining the translation of research into policy and practice, and investigating the demographics of contributing researchers. Additionally, future studies should employ advanced text mining techniques for deeper content analysis and utilize structural equation modeling to examine relationships between research themes, funding patterns, and collaboration networks. By addressing these gaps and promoting more holistic research, East Africa can better position itself to meet its energy demands, enhance sustainability, and contribute to global energy and development goals.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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CRediT authorship contribution statement

Mohammed Rady: Conceptualization, Visualization, Software, Formal analysis, Methodology, Data curation, Investigation, Writing—original draft preparation, Writing—review & editing, Supervision. **Ahmed Abdiaziz Alasow**: Conceptualization, Writing—original draft preparation. **Abdifatah Ahmed Hersi**: Writing—original draft preparation. All authors have read and approved the final manuscript.

Data availability statement

Data will be made available on request.

Generative Artificial Intelligence (AI)

The authors have used Chat GPT 3.5 and Claude 3.5 Sonnet to summarize the text and improve the language.

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