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Navigating the Terrain of Agricultural Education in Africa: Current State, Gaps, and Future Directions

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Abstract. With Agriculture being the major economic activity on the African continent, Agricultural Education Research (AER) should be an important priority for Africa's young population with its abundant largely fertile land resources. There is a scarcity of research on AER that unpacks trends, challenges and opportunities especially in a changing global space. This mixed methods bibliometric study examines AER in Africa. Using an appropriate search string, and the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA), a dataset of 265 research outputs was extracted and then analysed using VOSviewer. While annual research outputs have increased between 2004 and 2024, they remain low compared to other disciplines. A significant portion of research is funded by external organisations, underscoring a reliance on international support. The analysis highlights a small group of prolific African authors contributing to the field, though inter-African collaboration is weak. Instead, there is significant collaboration with researchers from the United States, reflecting the global nature of AER partnerships. Research outputs are highly concentrated in a few countries, notably South Africa, Egypt, and Kenya, while several African nations register no publications, revealing marked disparities across the continent. Author keyword analysis indicates a strong focus on themes such as curriculum development, food security, sustainability, and climate change, issues critical to the continent's agricultural and educational development. The findings emphasize the need for greater intra-African collaboration, more equitable research contributions, and increased investment in locally driven research. Policy makers could increase local funding in research directed towards integrating technological innovations in agricultural education and research.

Keywords: agricultural education; bibliometrics; research trends; research metrics; research outputs

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1. Introduction

Agricultural Education Research (AER) is a critical component of global educational systems (Amuda & Alabdulrahman, 2024; Adamsone-Fiskovica & Grivins, 2022; Lindner et al., 2020; Mössinger et al., 2022; Sakho-Jimbira & Hathie, 2020). This is because agriculture education plays a pivotal role in equipping individuals with the knowledge and skills necessary for sustainable agricultural practices, food security, and economic development (Amuda & Alabdulrahman, 2024). It is imperative to distinguish between AER, which is the subject of this study, and agricultural education. This study uses 'agricultural education' as a term that includes the formal and informal teaching and learning of agriculture, agriculture teacher education, and agricultural extension education (Lindner, 2020). This includes primary and secondary education, vocational training and higher education to adult education and farmer literacy programmes, aiming to develop technical expertise and critical thinking among individuals engaged in agricultural activities (Maïga et al., 2020; Simões & do Rio, 2020).

AER is the systematic study of teaching, learning, and related practices within the context of agriculture and its associated fields (Lindner, 2020). Research in agricultural education is essential for understanding the challenges and opportunities facing the sector and for developing evidence-based strategies to improve the quality and impact of agricultural education (Maïga et al., 2020; Simões & do Rio, 2020). Globally, AER has evolved significantly over the past few decades, reflecting the changing needs of the agricultural sector, technological advancement and the growing importance of sustainable development (Amuda & Alabdulrahman, 2024; Maïga et al., 2020).

Agriculture education and agriculture research both stand as a cornerstone of economic activity across the African continent, playing a pivotal role in the livelihoods of millions (Shilomboleni, 2022). With its vast expanses of fertile land, and youthful population, Africa possesses immense potential for agricultural productivity and sustainability. As the continent's young population continues to grow, equipping them with knowledge and skills in agricultural education becomes not just an educational priority but a strategic imperative for sustainable development and economic resilience (Shilomboleni, 2022). For such an education to achieve the envisaged goals, curriculum planning and implementation for such an education should be research led.

Despite its importance, AER research in Africa faces several challenges that hinder its effectiveness and impact (Food and Agriculture Organization [FAO], 2019; Lindner, 2020). These challenges include inadequate infrastructure, limited funding, a shortage of qualified educators, and outdated curricula that do not reflect the current needs of the agricultural sector (FAO, 2019; Lindner, 2020). African universities and colleges often struggle to attract and retain qualified faculty, invest in research, and provide students with access to modern agricultural technologies and practices (Connell, 2019). Research on AER in Africa remains limited, with many gaps in the literature that need to be addressed. For example, there is lack of comprehensive studies on the effectiveness of different AER approaches, the factors influencing student outcomes, and the impact of AER

on agricultural productivity and rural development (Khatri et al., 2024). While there have been some studies on agricultural research more broadly, few have focused specifically on the education and training aspects, which are crucial for developing the human capital needed to drive agricultural innovation and sustainability (Klerkx et al., 2019). Additionally, there is a need for more research on the role of AER in promoting gender equality, addressing the needs of marginalised communities, and fostering innovation in the agricultural sector (Gilley, 2021).

The strongest case for conducting this study stem from the rapid changes that have occurred in research spaces in the last two decades and the implications of these changes. From the 1960s, research metrics have gained more importance in research (Lindmer, 2020). The proliferation of the internet means that research outputs can reach to wider audience and time and distance seem to be transcended (Alperin et al., 2019). In more recent times, the rapid production of vast variety of research, a phenomenon known as "Big Data", has challenged the use of traditional methods and tools in making sense of research data and research metrics (Daniel, 2019). This has led to the surge in the use of advanced analytical tools (such as bibliometrics) that can handle huge amounts of data. While these tools have been used to unpack research dynamics and metrics in other disciplines such as chemistry education (de Oliveira Barbosa & Galembeck, 2022), evidently, there is a scarcity of research that have employed bibliometrics in understanding research dynamics in AER. For example, the specific trajectories and impact of AER have not been comprehensively mapped or analysed, in Africa or elsewhere.

This study seeks to fill this void by conducting a thorough bibliometric analysis of agricultural science education research outputs published from 2004 to 2024. within African institutions. The period between 2004 to 2024 was chosen as it represents the initial period of the impact of "Big Data", when research products and research metrics increased rapidly in most disciples (Bronson & Sengers, 2022). A bibliometric analysis can help to shed light on the areas of research that have received the most attention, the key contributors to the field, and the extent to which research is aligned with the needs of local communities and the extent to which the research meets sustainability expectations. Furthermore, a bibliometric analysis can inform the development of more targeted and effective AET programmes, guide funding and policy decisions, and identify opportunities for collaboration and capacity building (Bertoglio et al., 2021).

This study seeks to address the following research questions:

1. What are the trends and patterns in agricultural science research in Africa over time?
2. What are the metric characteristics in AER in Africa, including author productivity, influential institutions, and country-level contributions?
3. How are the collaboration patterns among countries and academics in AER in Africa?
4. What organisations, if any, are funding AER in Africa?
5. What are the main research domains within agricultural education and research in Africa?

6. What are the key gaps in the current research on agricultural education and research in Africa, and how can future research address these gaps?

2. Literature Review: The State of Research in Agricultural Education

The modern agricultural education has its roots in the early 19th century, when formal agricultural training was first introduced in Europe and the United States (Focacci & Perez, 2022). During this period, educational institutions began to recognise the need for systematic agricultural training to increase productivity and efficiency on farms (Lubell et al., 2023). The establishment of agricultural colleges, land-grant universities, and vocational schools laid the foundation for modern agricultural education, focusing on both theoretical and practical aspects of farming. In the United States, the Morrill Act of 1862, which led to the creation of land-grant colleges, played a pivotal role in the institutionalisation of agricultural education. These institutions became centres for research, innovation, and dissemination of knowledge to farmers and rural communities. This model was later replicated in many parts of the world, contributing to the professionalisation and advancement of agriculture as a science and practice.

2.1 Agricultural Education in Africa

In Africa, the development of agricultural education followed a different trajectory, largely influenced by colonial policies and post-independence nation-building efforts (Kidane & Worth, 2017). During the colonial era, agricultural training was limited and mainly aimed at serving the needs of the colonial administration. Post-independence, several African countries introduced significant initiatives, with some African countries prioritising the establishment of agricultural colleges and universities to build a skilled workforce capable of addressing local agricultural challenges (Amuda & Alabdulrahman, 2024). The Comprehensive Africa Agriculture Development Programme (CAADP), launched in 2003, further emphasised the importance of agricultural education by advocating for investment in research and extension to enhance food security and agricultural growth. Countries like Kenya, South Africa, and Ghana have since developed robust agricultural education systems, integrating research, extension, and community engagement to address local needs and improve agricultural productivity (Osumba et al., 2021).

Agricultural extension occupies an important part of agricultural education in Africa. Agricultural extension programmes have demonstrated a positive impact on farm productivity and household income (Ananda et al., 2024). For instance, the Association of Church-based Development NGOs (ACDEP) Programme in Northern Ghana improved maize yields and household incomes by linking farmers to output markets and training them on sustainable practices (Buala, 2020). Similarly, in Kenya, participatory extension approaches have empowered local communities to take ownership of soil and water conservation efforts, resulting in more sustainable and resilient agricultural systems (Mponela, 2023). Agricultural extension services are also critical for supporting smallholder farmers, who constitute most of the agricultural workforce. Extension programmes that incorporate training on climate-smart agriculture, agroecology, and market-oriented farming have been shown to significantly increase

agricultural productivity and contribute to poverty alleviation (Ananda et al, 2024).

2.2 Agricultural Education Research

Although indigenous communities began agricultural practices earlier in human history, modern scientific research is dated to around the beginning of the 19th century, when the Industrial Revolution spurred interest in scientific approaches to farming and rural development (Wallenstein, 2021). In the United States, the establishment of land-grant universities through the Morrill Act of 1862 marked a significant turning point in agricultural education and research, setting the stage for the development of agricultural experiment stations and cooperative extension services (Wallenstein, 2021). This framework allowed universities to conduct research on agricultural practices and disseminate findings directly to farmers, thereby bridging the gap between academic knowledge and practical application (Mössinger et al., 2022). During the mid-20th century, agricultural education had evolved into a specialised field of study with dedicated departments, journals, and professional associations. Research during this period focused on optimising crop yields, pest management, and soil conservation techniques, reflecting the global push for increased agricultural productivity and food security (Adamsone-Fiskovica & Grivins, 2022).

AER is confronting numerous challenges, including technological advancements, environmental sustainability issues, and the integration of modern farming techniques (Sakho-Jimbira & Hathie, 2020). These hurdles are compounded by the rapid transformations occurring globally, affecting how agricultural education is delivered and applied in practical settings. In the age of "Big Data", research outputs have increased rapidly such that traditional ways of making sense of them have become limited.

2.3 Agriculture Education Research in Africa

In Africa, AER has historically been shaped by colonial policies and the subsequent post-independence efforts to develop self-reliant agricultural systems (Awiti, 2022). During the colonial era, research was often geared towards export-oriented crops and large-scale commercial farming, with little attention given to the needs of smallholder farmers. After independence, several African countries established national agricultural research systems (NARS) to address local agricultural challenges and support rural development (Hall & Dorai, 2020). In the 21st century, AER in Africa has increasingly focused on sustainable development, climate resilience, and gender-inclusive practices (Awiti, 2022). However, research capacity across the continent remains uneven, with many countries facing challenges such as limited funding, inadequate infrastructure, and a shortage of trained researchers. As a result, partnerships with international research organisations and donor agencies have become crucial in driving agricultural research and innovation in Africa (Simelton & McCampbell, 2021).

Research in African agricultural education faces a myriad of challenges. As early as the late 20th century, it was recognized that the field was slow in responding to the evolving socio-economic and political environments (Lindner et al., 2020; Sakho-Jimbira & Hathie, 2020). In more recent years, experts have continued to

point out that African researchers and policymakers need to address changing patterns of donor support, the emergence of new training needs, and evolving audience demographics, and to develop and implement sustainable policy frameworks and relevant curricula (Imbuga et al., 2021; Sakho-Jimbira & Hathie, 2020). A wide range of recommendations around African AER have been articulated (Lindner et al., 2020; Sakho-Jimbira & Hathie, 2020). There is need for research directed towards curriculum reform, create and support sustainable funding models, and designing and implementing policies that are more adaptable to local contexts and needs (Lindner et al., 2020; Sakho-Jimbira & Hathie, 2020). How far education researchers and policy makers have addressed these challenges remains unclear and needs further interrogation. What is clear is that AER spaces have become more complex due to changes in recent times including technological advancements epitomised by the emergence of "Big Data", research metrics, and the demand for sustainable approaches, among other changes (Daniel, 2019).

In recent years, research in agricultural education has increasingly focused on addressing global challenges, particularly sustainability and food security (Lindner et al., 2020; Sakho-Jimbira & Hathie, 2020). One prominent trend is the integration of sustainable agriculture into educational curricula (Imbuga et al., 2021; Sakho-Jimbira & Hathie, 2020). Researchers have explored how agricultural education can foster an understanding of sustainable practices, equipping students with the skills needed to implement environmentally friendly farming methods (Imbuga et al., 2021; Sakho-Jimbira & Hathie, 2020). For example, some studies have highlighted the importance of incorporating environmental education into agricultural programmes and the role of experiential learning in promoting sustainability (Ardoin et al., 2020). Technology has also become a central theme in AER. The rise of digital tools and precision agriculture technologies has opened new avenues for enhancing learning outcomes. Researchers have examined the effectiveness of these technologies in agricultural education, focusing on their potential to bridge the gap between traditional practices and modern innovations. However, challenges remain, particularly in terms of accessibility and the digital divide in rural areas (Smidt & Jokonya, 2022).

2.4 Research Metrics and Agricultural Education Research

The 1960s are regarded as the decade when research metrics became part of research discourse, but it is only in the 2000s that data such as citation analysis became new ways to determine research impact (Hamermesh, 2018). Citation data was first complied and published by the Institute for Scientific Information (ISI) (Lindner et al., 2020). By the year 2024, multiple providers of research metrics, bibliometrics, and scientometrics that exist including organisations, institutions and universities (Lindner et al., 2020). Since the 1960s, research metrics also expanded beyond citations and now includes h-index, publication count, impact factors among others. Alternative metrics (altmetrics) emerged with the proliferation of the internet and found its role in assessing mentions in social media, citations in policy documents and blogs and download and view counts (Hicks et al., 2015). The growth of online databases such as Scopus and Web of Science among others was followed by the emergence of digital object identifier

numbers (DOIs) and Open Researcher and Contributor Identity (Orchid) (Boudry, 2021). While DOI uniquely provides a persistent research link to a researcher's digital research outputs, the Orchid provide persistent digital identity to distinguish their work from others.

Research metrics are widely used by various stakeholders in the academic, policy, and research ecosystem for diverse purposes. In research institutions such as universities, research metrics are used in benchmarking, faculty promotions, and strategic planning (Bales et al., 2019). Metrics are used to justify claims of the scholarly or societal impact of scholarly publications. Hicks et al. (2015) posits that the use of metrics should be with caution as smaller disciplines such as agriculture education research could be disadvantages. Instead, Hicks et al. (2015) calls for more holistic approaches to assessing the impact of research and researchers rather than blind positivistic metric obsessed approaches.

How these changes have impacted research in agricultural education remains incognito with scarce studies on the subject. Lindner at al. (2020) observed that agricultural education researchers "*… appeared leery of research metrics, perhaps concerned social science metrics would be unfairly compared to our colleagues in the bench sciences …*" (p. 27). The failure to fully exploit the use of research metrics may have led to the low visibility of AER outputs and academics in the discipline. Lindner et al. (2020) concluded their study by recommending that academic supervisors in AER discuss research metrics with their students to enhance the visibility and impact of agriculture education in the broader research community.

2.5 The Rise of "Big Data" and Bibliometrics

In recent times, there has been an exponential increase in research publications, which has come to be known as "Big Data" (Daniel, 2019). Big Data is characterised by the "3Vs": Volume (the massive amount of data), Velocity (the speed at which data is generated and processed), and Variety (Daniel, 2019). Traditional methods of making sense of these data have become limited. This has led to the rise of advanced quantitative methods of data analysis such as bibliometrics. Analysing "Big Data" using these bibliometrics provides valuable insights that drive decision-making, innovation, and problem-solving across various fields, including education. This study uses bibliometrics as one of the tools that is used to make sense of large volumes of AER outputs.

The term bibliometrics was coined by Alan Pritchard in 1969, who defined it as the application of mathematical and statistical methods research outputs (Hicks et al., 2015). The late 20th century saw rapid advancements in bibliometrics, driven by digital databases and computational tools (Hicks et al., 2015). The integration of network analysis, visualisation techniques, and indicators like the h-index expanded its application in evaluating researchers, institutions, and academic trends. The emergence of robust databases such as Scopus and Web of Science supported the widespread use of bibliometrics. Today, bibliometrics play a vital role in research evaluation, funding decisions, and understanding the dynamics of knowledge production across disciplines (Phoobane et al., 2022). Besides a study by Twetwa-Dube and Oki (2023), who used bibliometrics in their study on technology adoption in African Agriculture practices, there is a scarcity

of studies that have employed bibliometrics in agriculture research in Africa. Through this bibliometric study, the study sought to provide valuable insights into the landscape of AER by responding to the research questions. By analysing publication patterns, citation networks, and research collaborations, this study identifies key trends, influential researchers, and emerging areas of interest in agriculture education research from 2004 to 2024.

3. Methodology

3.1 Research Design

This study employs a mixed-methods approach, integrating quantitative bibliometric analysis with qualitative data to provide a comprehensive understanding of the research landscape. The quantitative component utilised bibliometric techniques to systematically map out publication patterns, citation networks, and emerging trends in the field. This data were extracted from the Scopus database and was analised using VOSviewer for network analysis, which identifies influential researchers, key institutions, and thematic clusters. The qualitative component is derived from an in-depth examination of the authors' backgrounds, institutional affiliations, and research interests, sourced from academic profiles and publication metadata. This approach allowed for a nuanced understanding of the motivations and thematic orientations that drive scholarly work in the field. By combining empirical data with detailed institutional and author-centric analysis, the study provides a multi-dimensional perspective of the academic landscape, offering both statistical trends and contextual insights that enrich the interpretation of bibliometric findings.

The Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) was used as the methodology for this study as previously applied by other academics (Phoobane et al., 2022). PRISMA involves four stages: identification, screening, eligibility and inclusion. The four stages are described in detail in Table 1.

Table 1: Stages of PRISMA

Stage	What the stage entails
Identification	Identifying and retrieving relevant studies from various sources, like databases, journals, and conferences.
Screening	Removal of duplicates and assessment of each study based on its title and abstract. Those that do not meet the inclusion criteria are then removed.
Eligibility	During this stage studies are assessed on relevance, quality, and alignment with the bibliometric objectives.
Inclusion	Eligible studies are included in the systematic review. Data are extracted into a comma separated excel file and analysed, using VOSviewer, to respond to the research questions.

3.2 Data Collection

Data were extracted from the Scopus database. The following search string was run on the Scopus database:

TITLE-ABS-KEY ((agricultur* AND education OR teach* OR learn*or AND pedagog* OR assessment OR facilitation OR school OR tvet OR tertiary OR university OR student* OR college OR "school vegetable garden" OR adrogogy))).

The global search conducted on the 10th of July 2024 yielded 12 116 publications. The search was refined by using country/territory aspect to select only publications from African affiliated institutions and collaborations with other academics outside Africa. This resulted in 1 340 publications from African institutions and their collaborations. These were manually screened firstly to remove duplicates, which results in 1 315 after removing 25 duplicates. The remaining 1 315 outputs were further scrutinised for eligibility, that they had to be publications related to research on education, teaching and learning of Agriculture including extension. Besides closely looking at the title and keywords, this stage involved reading the abstracts and removing those outputs that did not meet the eligibility criteria. The use of Scopus database as the only source of research outputs is a limitation in this study. Nevertheless, Scopus is one of the largest databases and it covers a larger number of journals than its closest rivals like Web of Science (Singh et al., 2021).

3.3 Data Analysis

The final dataset had 265 research outputs which were then exported for VOSviewer analysis. The VOSviewer analysis included author key words analysis, Co-author collaboration**,** author citation analysis among others. Scopus database also provides analysis on publication trends, funding data, publication by affiliations and information on the distribution of the research outputs by document types.

4. Results and Discussions

4.1 Trends and Patterns in Agricultural Education Research in Africa from 2004 to 2024

In response to the first research questions, the trends and patterns in AER are presented and discussed under annual trends in publication outputs and the distribution of the types of documents published between 2004 and 2024.

4.1.1 *Annual trends in publication outputs between 2004 and 2024*

Analysing annual publication trends in bibliometrics provides indicators on whether the research outputs are increasing or declining, identifying peaks and permits benchmarking against related fields. Figure 1 shows the annual publications trends in agricultural education in African between 2004 and 2024.

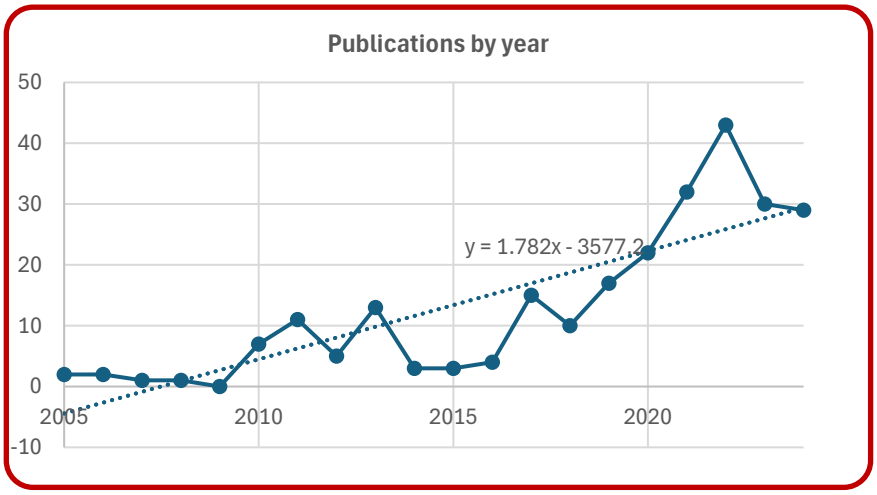

Figure 1: Annual publication trends on agricultural education in Africa between 2004 to 2024

According to this Scopus dataset the general trend was an increment in publications with a trendline of y = 1.782 x -3577.2. The graph shows a significant increase especially between 2016 to 2022. The general increase in research outputs has been credited to the "Big Data" phenomenon which has increased in its impact on most sectors of human society from the mid-2000s (Bronson & Sengers, 2022). There are several prominent peaks, for example in the years 2013, 2017 and 2021. Although there has been a steady increase in research outputs on agricultural education and extension, we opine that even at 43 outputs per year for all African institutions, this still indicates very low research outputs. In a bibliometrics study focused on disease prediction in Africa, Phoobane et al. (2022) noted a steeper increase of research outputs.

4.1.2 *Documents by type*

Analysing research outputs by document type is important in bibliometrics study as it sheds light on the impact of the publications, among other revelations. Figure 2 below summarises the research outputs which are spread according to publication types.

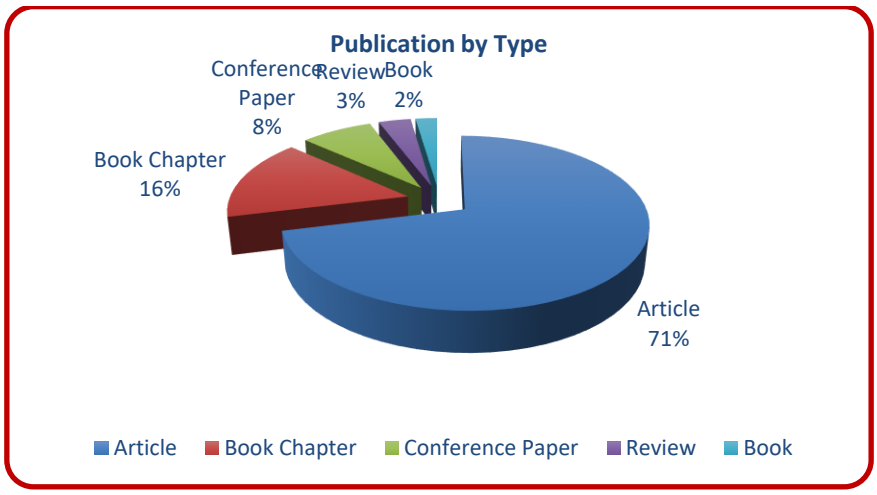

Figure 2: Documents by type

Most of the publications (70.6%) were published as academic articles. This may indicate that generally, the impact of the publications can be considered high because academic articles have more impact and influence on discourse than other forms of publications such as books. Few outputs (7.5%) were published as conference papers. This may be of concern because it may hint at reduced participations in Agricultural related conferences by African academics, yet conferences provide platforms for debates, important discourses, networking and collaborations.

4.2 Authors Profile: Institutions, and Countries Contributing to Agricultural Science Research in Africa

In response to the second research question, the results on author profile, institutions and countries contributing to agricultural education and research in Africa were presented and discussed under sub-themes such as author citations, documents produced according to affiliations, publications by authors and publications by countries.

4.2.1 *Most cited academics on agricultural education in Africa*

Citation analysis enables academics (and other stakeholders) to understand the reach and influence of academic outputs and benchmark their work against fellow researchers (Phoobane et al., 2022). This study utilised VOSviewer to generate the visualisation map in Figure 3. Out of a total of 886 authors, 198 met the criteria of having one publication and at least eight citations. The most cited authors (represented by the large nodes in the centre) were identified as Ifeanyize F.O, Njura H.I, Isiwu E.C., Nwankwo C.U, Lynam J, and Kidane K. The strings around the nodes indicate fellow authors who were citing their works. The most cited Ifeanyieze, F.O. represented by the large purple note in the middle, had the most citations. Ifeanyieze has researched on various themes in the field of agricultural education including sustainability issues and career prospects of agricultural students. Authors on the periphery of this visualisation map have fewer citations than those at the centre as indicated by the smaller sizes of their nodes.

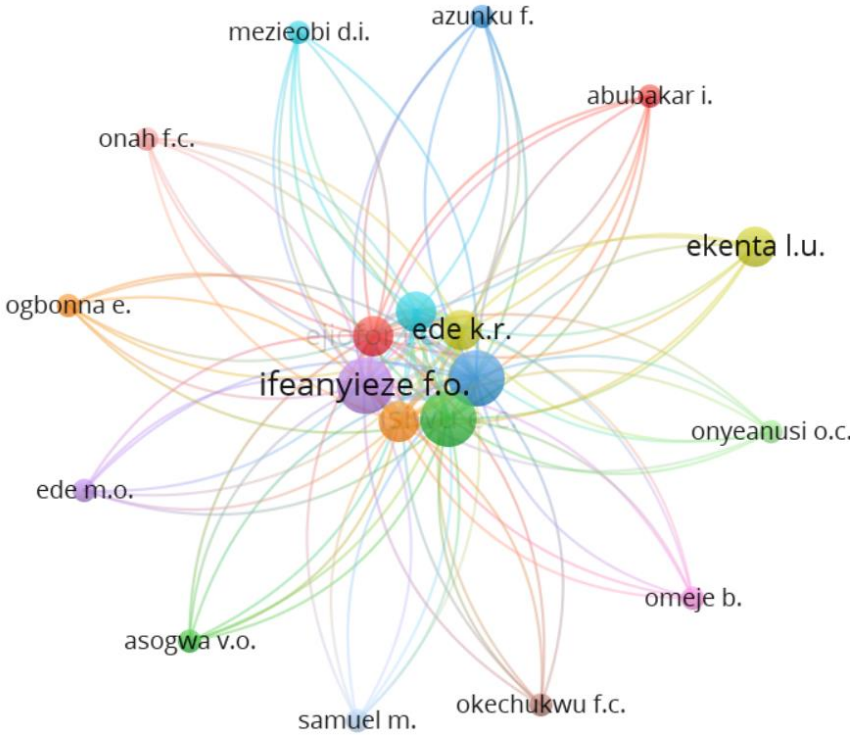

Figure 3: Most cited authors

4.2.2 *Documents by African affiliations*

This study also sought to find the distribution of agricultural education related research outputs according to affiliations. Figure 4 illustrates the top 10 affiliations with the most outputs.

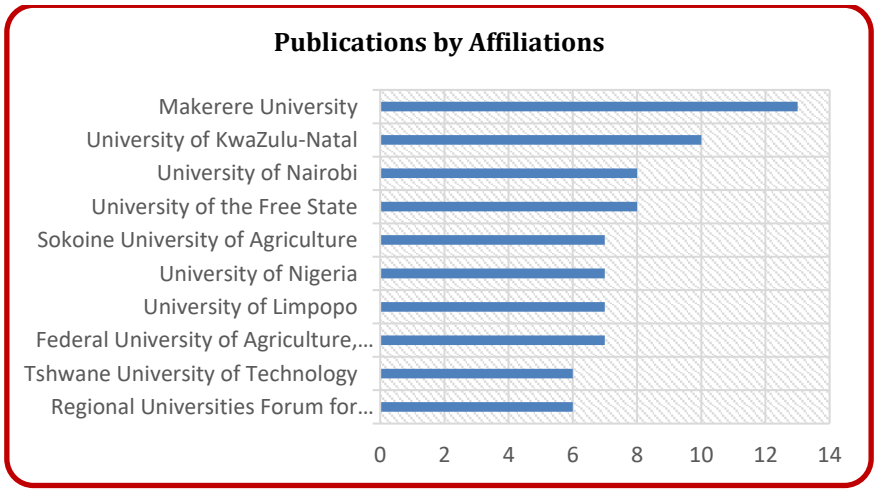

Figure 4: Publications by affiliations

Uganda's Makerere University tops the list with 13 outputs published between 2004 to 2024. South Africa's University of KwaZulu-Natal occupies second position with 10 publications during the years under consideration. Among these top 10 institutions, four are South African, revealing the dominance of South African institutions on the continent. Three of the institutions, UKZN, University

of the Free State and the University of Limpopo, are predominately in agriculture-based provinces. The Regional Universities Forum for Capacity building in Agriculture (RUFORUM) is a consortium of about 40 African institutions established in 2004. Such levels of collaboration among African institutions could be key in unlocking the potential of the continent in research and application of technology in agriculture across the continent. The dominance of South African institutions could be attributed to the country's high Gross National Product (GDP). Furthermore, South African Department of Higher Education and Technology (DHET) has a model that provides incentives to academics for publishing research outputs (Masinde & Coetzee, 2021).

4.2.3 *Publications by countries*

Analysing research outputs by country allow as for comparison and describing the disparities on the continent. Figure 5 shows the lead 12 countries in terms of publication outputs.

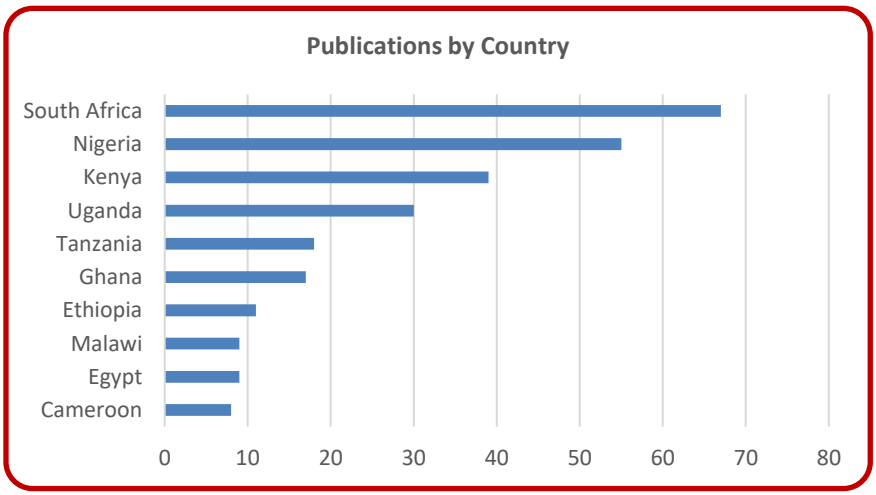

Figure 5: Publications by countries

South Africa, with 67 publications, heads the list in terms of publications followed by Nigeria and Kenya with 55 and 38 publications respectively. With the two biggest economies in Africa, it is not surprising to have South Africa and Nigeria, leading in this aspect as research outputs have been linked to GDP. South Africa's DHET has been reported to incentivise researchers and their institutions and this may explain its relatively high productivity in research. Furthermore, the high GDP, most associated with better quality life, may suggest that the country's institutions benefit from scholars from other countries. The disparity in publication outputs is wide with the top five countries contributing about 80% of all publications. Many countries, for example, Lesotho and Chad, among others did not contribute any publication outputs. Research capacity in Africa has been cited as highly limited. Research could be enhanced by developing policy that creates sustainable research environments including funding models that are realistic in focusing on research that responds to local needs.

4.2.4 *Most prolific authors*

Analysis of publication by authors can shed light on who could be the most influential authors and browsing through what the most prolific academics are publishing about may also hint at areas of research that are mostly being focused on. Table 2 summarises outputs by authors focusing on the top 12 published authors.

Table 2: Most prolific authors

Author	Citations
Sephokgole, R.D.	5
Makgato, M.	4
Allahyari, M.S.	3
Ekwamu, A.	3
Fényes, T.I.	3
Govender, N.	3
Hulela, K.	3
Ifeanyieze, F.O.	3
Isiwu, E.C.	3
Kidane, T.T.	3
Kraybill, D.	3
Leresche, K.M.	3

Leading the list with five and four publications over the 10-year period, are Sephokgole and Makgato, two academics at South Africa's Tshwane University of Technology. Most of their research focuses on teacher practices at South African technical and vocational education and training (TVET) colleges. These two have co-published on three of these research outputs. The rest of the list consists of academics that have three publications each for the period between 2004 to 2024. These numbers are lower than the number of publications by most prolific authors in other studies (Phoobane et al., 2022). In a bibliometrics study that investigated "research trends and evolution in Radiogenomics", Wang et al. (2024) noted that the most prolific academic had 35 publications in the period of 2005 to 2023. In the same study, all the top 10 most prolific researchers had at least 20 publications. In another study that explored African publications in biomedicine (Kiwelu et al., 2023), the most prolific academics at had more than 20 publications while the rest of the top 10 academics had at least 10 publications. Research metrics should be used with caution especially when comparing different disciplines. However, even considering the said fact, the low number of research products in AER in Africa could be an indication of deeper challenges such as lack of adequate funding models and poor policy planning and implementations.

4.3 Collaboration Patterns among Countries and Academics in AET Research in Africa

Collaboration in a research discipline like agriculture education is very critical for various reasons, among them: it brings together a diversity of perspectives and expertise, increases research productivity, strengthening policy impact, and builds research networks and relationships among academics. Previous studies have concluded that African academics often collaborate with European and North American researchers as it increases the visibility of their research outputs and enhance access to funding. In response to the third research question, we presented this subsection under the following sub-themes: Collaboration among authors and co-Author collaborations across Countries/Regions.

4.3.1 *Co-author collaborations on agriculture education*

To unpack collaboration network in AER, the study analysed collaboration by authors and collaboration patterns by country. The VOSviewer visualisation map in Figure 6 shows the co-author collaboration patterns.

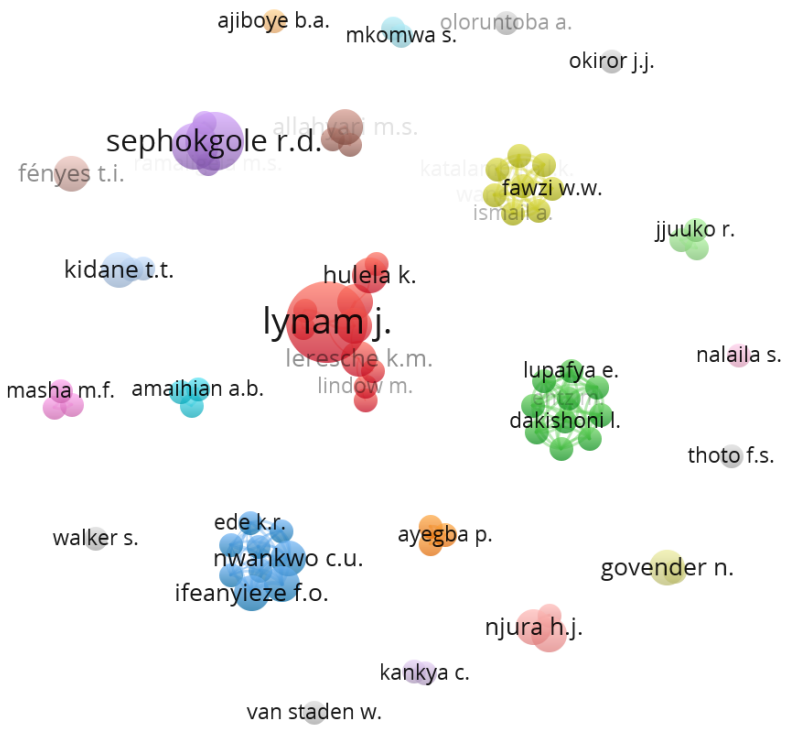

Figure 6: Co-author collaboration map

Of the 886 authors, 77 authors the set criteria requiring an author to have published at least two research outputs. From the above visualisation map, five significant collaboration maps can be identified. The red node dominated by Lynam J., the green one that includes Lupatya E. and Dakishoni I, the blue one that includes Ifeanyieze and others, the purple node dominated by Sephokgole R.D. and the yellow one that has Fawzi with the most co-author products. Apart from these larger collaboration networks, the rest are small networks with two or three authors involved. The map suggests weak collaboration networks among academics researching on agriculture education in

Africa. Previously, Phoobane et al. (2022) had observed similarly weak collaboration networks among African academics. The co-author visualisation map does not provide information on whether the collaboration is among African authors only or if it is between African and other research from outside Africa.

4.3.2 *Co-author collaborations across countries/regions*

Co-author collaboration by country refers to the analysis of scholarly publications co-authored by researchers from different countries. It examines the extent, patterns, and impact of international research partnerships, providing insights into how nations collaborate on scientific work. Figure 7 shows the co-author collaboration visualisation map by country.

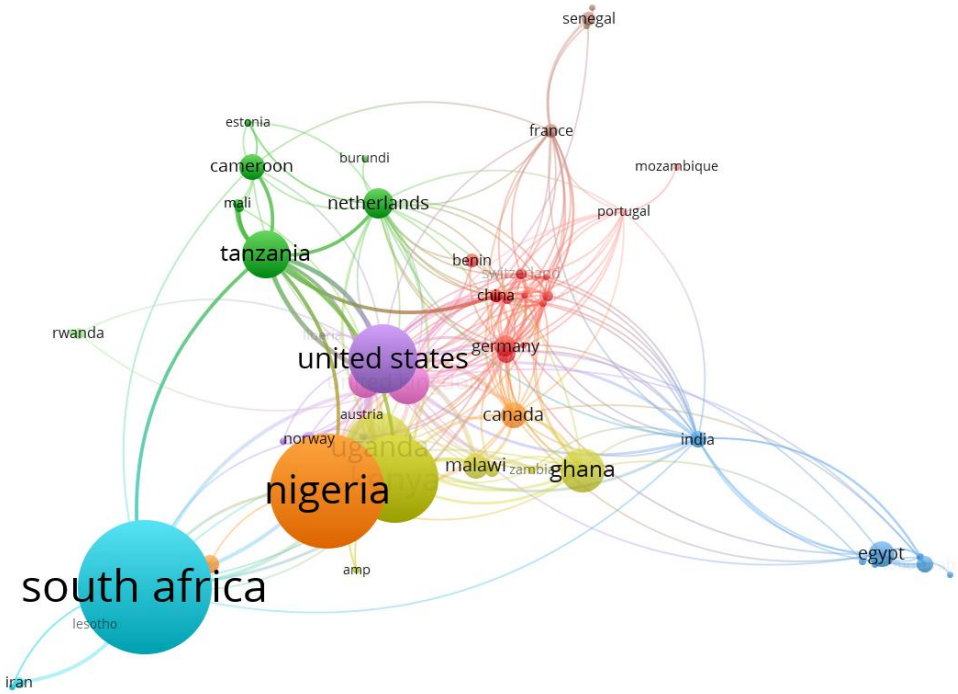

Figure 7: Co-author collaborations across countries/regions map

The criteria used was that a country had to have at least one co-authored publication; as a result, there were 72 countries. South Africa forms the largest collaboration hub as indicated by the biggest blue node on the map. Other research nodes of note are the one dominated by Nigeria as well as those that include the United States (purple) and one that includes Tanzania (green). Other smaller research collaboration hubs are with German, Canadian and Chinese researchers. The map confirms findings by Phoobane et al. (2022), that academics researching on agricultural education in Africa collaborate with among themselves as well as with other academics from outside Africa especially from the United States. These results differed from those found by the same study in that the United Kingdom does not appear as a major research partner in research on agricultural education.

4.4 Funding Organization of AET Research in Africa

Research that is independent and that responses to local needs requires sustainable funding models (Suri & Udry, 2022). Research Funding has long been reported as a challenging issue in African research in general (Rosegrant et al., 2023). Arvanitis et al. (2022) report that oftentimes, external funding in African research raises questions about whether the funding agencies have got the best interest for Africa and how much influence they may impose on setting research. On the other hand, research funding information may not be readily available. Table 3 summarises the how different organisations funded the present research outputs.

Table 3: Organisations funding research outputs

Abbreviation	Full name of organisation	Outputs funded
World Bank	World Bank Group	5
CIARC	Consortium of international Agriculture Research Centres	4
USAID	United States Agency for International Development	4
DIDUK	Department for International Development, UK Government	3
ESRC	Economic and Social Research Council	3
IFAD	International Fund for Agricultural Development	3
NRF	National Research Foundation	3
UKRI	UK Research and Innovation	3
CREA	Consortium pour la recherche économique en Afrique	2
ASCTMSI	Department of Science and Technology, Ministry of Science and Technology, India	2
DAA	Deutscher Akademischer Austauschdienst	2
EC	European Commission	2

There were 72 organisations that were registered for the 265 research outputs in this dataset. Only seven of these were registered as African organisations with the rest being European, North America or Asian. The absence of adequate funding models in Africa has been previously discussed (Rosegrant et al., 2023). The legacy of colonial times is still prevalent with organisations from formerly "mother colonies" seeming to fill funding gaps in African research. However, some academics have expresses scepticism on the funding of African researcher by external organisations. Oftentimes these sceptical academics question whether the external funders have African interests and question how much clout they have in setting research agendas in Africa. On the other hand, neutral observers may easily appreciate that these external funders are filling an important gap which African governments have failed to fill. African governments and institutions need to develop and implement policies that support sustainable funding models for research in agricultural education.

4.5 Main Research Domains within Agricultural Science Education in Africa

Author Keywords

Author Keywords are a highly important aspect of bibliometrics analysis for several reasons. The analysis of such keywords in a bibliometrics analysis can assist in mapping knowledge domains and relationships and highlighting research gaps and opportunities among other aspects. Figure 8 shows a visualisation map of author keywords.

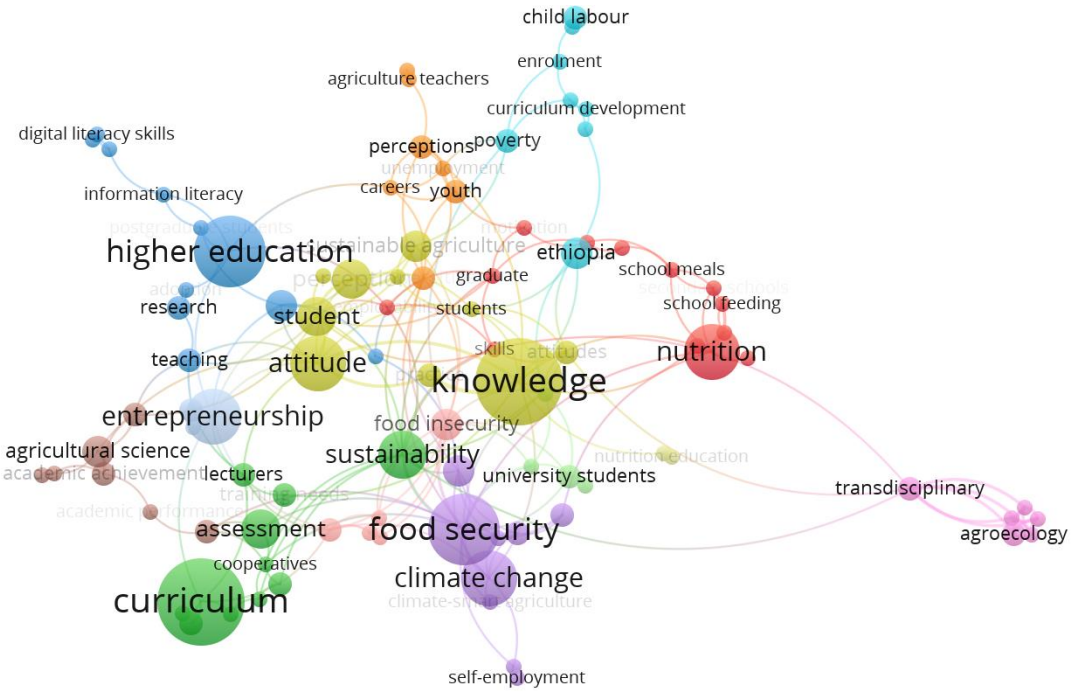

Figure 8: Author keywords

For this keyword analysis, a total of 839 keywords were analysed and 56 met the criteria of having appeared three times. The appearance of words such as knowledge, pedagogy curriculum and higher education was not surprising given the nature of this bibliometrics study as it focused on agricultural education and related issues. Nodes such as secondary school confirm that research on agricultural education and extension may not be limited to tertiary institutions but could be delving research study that focus on the teaching and learning of agriculture as a curriculum subject in secondary schools. The node on sustainable agriculture albeit small, may indicate that African academics could be dedicating their focus on the important aspects of sustainable agricultural practices. The appearance of "agroecology" and "transdisciplinary" as keywords may give hints on approaches African academics may be taking in research towards sustainability and combating climate change. The large blue node on food security may not come as surprise as academics could be conducting research that aims to address the persistent issues of food shortages, famine, hunger and below optimal nutrition in some parts of the continent. Despite the general emphasis on the application of technology in agriculture from other academics from other parts of the globe (Zarafshani et al., 2020), there appears to be limited research on the subject in Africa. The words that provide some evidence of agricultural education technology are "digital literacy skills" and "information literacy" and these are

represented by very small nodes. African institutions may need to conduct more research directed at how technology may be used in enhancing AER and agricultural practices in general.

4.6 Gaps in the Current Research on Agricultural Science Education in Africa, and How Future Research Can Address these Gaps

Despite a rise in research outputs between 2004 and 2024, the overall volume of research remains low compared to other disciplines (Phoobane et al., 2022). This suggests a significant gap in the breadth and depth of research being conducted, which future studies could address by exploring under-researched areas such as the impact of agricultural education on rural development and modern agricultural techniques. Furthermore, the analysis shows that research is heavily concentrated in a few countries, notably South Africa, Egypt, and Kenya, leaving many African nations without substantial research contributions. Future research should aim to include these underrepresented regions to provide a more comprehensive understanding of the continent's agricultural education needs and opportunities. This could involve developing targeted funding programs and research initiatives that encourage participation from these countries.

Additionally, while there is significant collaboration with international researchers, particularly from the United States, there is a noted weakness in intra-African collaboration. Future research could focus on strengthening networks within the continent to foster regional expertise and share locally relevant findings more effectively. This approach would help in building a resilient and interconnected research community in Africa that can tackle the unique challenges of agricultural education on the continent. Lastly, the predominance of external funding underscores the vulnerability of African AER to fluctuations in international support. Future studies should explore sustainable funding models that rely more on local and regional sources. This shift would not only secure more stable funding for AER but also ensure that the research agendas are aligned with the continent's priorities and needs.

5. Limitations of the Study

The dataset used in this study was extracted from Scopus. Although Scopus is one of the largest databases in indexing (Lindner et al., 2020; Singh et al., 2021), using it as the sole source of data may exclude some relevant research outputs that were not published under Scopus. Future research may merge datasets from Scopus and other databases such as Web of Science to create a more inclusive dataset for analysis. The second limitation is that the data was extracted in July 2024 yet Scopus as a database keeps on being updated overtime.

6. Conclusions

This study highlights key insights into AER in Africa from 2004 to 2024, revealing important trends and gaps. While annual research outputs have shown gradual growth, the field remains underrepresented compared to other disciplines. A few countries, such as South Africa, Egypt, and Kenya, dominate research contributions, with several African nations showing no outputs. External funding organisations significantly drive research activity, while inter-African

collaboration remains weak. Thematic analysis of author keywords indicates that research aligns with critical areas such as curriculum development, food security, sustainability, and climate change, addressing pressing continental priorities. To address the challenges identified, the study recommends policies that promote sustainable, locally driven funding models. African governments, regional organisations, and private sectors must prioritise investments in AER to reduce reliance on external funding. Policies should also support inter-African collaborations by creating research hubs, funding cross-border projects, and incentivising partnerships within the continent. This study has limitations, including reliance on the Scopus database, which may exclude relevant works indexed in other databases like Web of Science or local African repositories. Future research should incorporate multiple databases to provide a more comprehensive analysis of AER. Additionally, increasing local investment in key areas such as curriculum development, food security, and climate change is crucial. This focus not only meets immediate educational needs but also supports sustainable agricultural practices. Furthermore, exploring qualitative aspects of research, such as the societal impact of publications, could yield deeper insights. Future research directions include examining the role of regional institutions in facilitating collaboration, analysing the impact of digital tools on research networking, and investigating the integration of agricultural education into broader education systems. These efforts strengthen research capacity and promote sustainable AER in Africa.

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