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TRENDS, GROWTH AND GAPS IN SCHOLARLY COLLABORATION: A 50-YEAR BIBLIOMETRIC AND BIBLIOGRAPHICAL INDEX OF AGRICULTURAL RESEARCH PRODUCTIVITY

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ABSTRACT: *This study presents a bibliometric and bibliographical analysis of 1,148 articles by 43 scientists at the Institute of Agricultural Research and Training (IAR&T), Obafemi Awolowo University, Nigeria, from 1970 to 2020. It examined authorship pattern-collaboration, subjects-year wise distribution, relative growth rate, and research doubling time. Results showed a significant rise in research output, with 67% of publications from 1995-2020, > 2 times the output from 1970-1994 (33%). Prominent subjects include Agricultural Extension (19%), Animal Science (17%), Food Science (14%) and Soil Science (10%). Findings reveal significant authorship collaborations and subject specific growth rates in Animal Science, Food Science, Soil Science and Agricultural Extension with 92, 68, 44, 41 frequency count respectively. Four-author articles dominates with (35%) of total authorship patterns. The study highlighted gaps in fields like Agricultural Engineering and Crop Physiology, emphasizing the need for more interdisciplinary collaboration and targeted resource allocation to underrepresented areas. Findings provide a foundation for future research directions and strategic planning.*

KEYWORDS: Agricultural research productivity, Bibliometric analysis, Authorship collaboration, Relative growth rate, Interdisciplinary research gaps, Research activity.

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INTRODUCTION

Agriculture around the world is seen as a pillars and most vital production sectors of any Nation's economy. The agricultural sector in Nigeria play a pivotal role in the provision of food, contribution to employment creation, poverty and hunger reduction as well as reduction in rural- urban migration. One of such agricultural sector in Nigeria is the Institute of Agricultural Research and Training (I.A. R. & T), Obafemi Awolowo University, Nigeria. I.A. R. & T, a nation multi commodity research institute grew out of the research division in the old western Ministry of Agriculture and was constituted into a University based research Institute of the university of Ife now Obafemi Awolowo University by a Charter on 1st April 1969. IAR&T from inception was positioned and established to generate and validate technically feasible, economically profitable and socio-culturally acceptable technologies, transferring same through extension scientists and productive change agents to enhance industrial farming productivity and agricultural technological developmental growth. The institute is mandated to research in Soil and Water Management Research, Genetic improvement of Maize, Kenaf and Jute and Farming System Research and Extension in the South West Nigeria. These has being the driving force of the institute to engaged foremost agricultural research scientists that are highly skilled, experienced and dedicated technocrats (IAR&T 2019) .

Research activity in the field of agriculture is seen globally as one of the most essential component of the economy. It is considered very important for the development and transformation of the agricultural sector as well as contributing to and generating new knowledge. The Food and Agriculture Organisation of the United Nation (FAO, 2015) viewed research activities in agricultural sector to contributing to improving productivity and quality of crops by their genetic improvement, better plant protection and storage facilities, which in turn bring new products into use to achieve food security and economy development. Also, in Africa research findings have helped in the awarding of scholarly grant and in the formulation of policy that is used in tackling inefficiency in research process in academic and research based institutions (Kasa and Nock 2009; Ani and Onyancha, 2011).

In essence, research exposes research scientists and scholars to current information and enables them to share the research findings with members of the research community. In Nigeria, research scientists in agricultural sectors and other related institutes are required to carry out research and publish their finding in reputable publication outlet within a specific period of time (Haruna et.al 2023). Hence, publication is considered as the channel for disseminating and validating research findings and also crucial for career progression and productivity in research based institutions (Okafor, 2011; Ellegaard, 2018). These factors provide the overriding reasons behind this study to compile a cumulative bibliographical index and bibliometric analysis of the published works to ascertain the publication pattern of technological innovation literature published over the last 50 years.

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Statement of the Problem

Despite the Institute of Agricultural Research and Training's (IAR&T) robust research activities over the past 50 years, there was a lack of comprehensive data on the publication patterns, authorship trends, and research focus areas of its scientists. The absence of a detailed bibliometric and bibliographical analysis limited the institute's ability to assess the growth, areas of strength and research output collaboration. This also hindered efforts to identify underrepresented fields requiring more attention and strategic focus. Additionally, no formal evaluation had been made regarding the relative growth rate and double time in publication output, leaving the institute unable to quantify the progression or acceleration of research activities over time. Without this analysis, it was difficult to assess whether publications output reflected a sustainable growth in research or to identify periods of significant scholarly advancement. This study therefore will address these gaps by compiling a comprehensive bibliographical index of published works and conducting an in-depth bibliometric analysis that guide future research directions, and improve resource allocation within the institute's research mandate, as well as reveals key insights into the relative growth rate and the doubling of publications over the last 25 years, compared to 25 earlier periods.

Research Objectives

(a) To develop a 50-year easy reference bibliographical index of agricultural research scientists' output in the Institute of Agricultural Research and Training

(b) To investigate the subject-wise distribution of research output, highlighting fields with high productivity.

(c) To investigate the year-wise distribution of research output, to assess the growth in research productivity within agricultural disciplines.

(d) To determine the relative growth rate and the doubling time of research publications across the study period

(e) To analyze the authorship pattern and scholarly collaboration of the agricultural research outputs.

(f) To examine the impact of authorship collaboration on the growth of agricultural research outputs, identifying gaps in collaboration and productivity.

Scope of the Study

The study focuses on the bibliometric analysis of research scientists published journal articles in the Institute of Agricultural Research and Training (IAR&T) Ibadan, over the last 50 years, from 1970-2020, from 43 retired and serving research scientists that submitted their works in agricultural and related fields across thirteen (13) subject areas. All the articles are restricted to printed format

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LITERATURE REVIEW

Bibliometric constitutes one of the major thrust areas of research in the field of library and information science. It is an emerging trend as a statistical tool for measuring information bearing materials in order to determine its relevance. It consist of quantitative analysis and statistics to described patterns of publications within a given field or body of literature. Bibliometric as a concept has no single definition because of different views and perspectives of various scholars. For instances, Dotthun and Mukherjee (2017) defined Bibliometric as the set of qualitative methods helpful for describing and measuring academic literature. Marta and Garcia (2022) says a bibliometrical analysis of scientific publication is a sine qua non, an essential part of the research process tool and essential evaluation method. A bibliometric account of a discipline is a reflection of what has been published in specific discipline, author, period of publication and it helps to do a quantitative analysis of such discipline over the years to establish the trends.

Agricultural research has undergone substantial growth over the last fifty years, with scholarly collaboration being a key driver of productivity and impact. Several studies have emphasized evolving trends in agricultural research output and the critical role of co-authorship. Abubakar, (2021); Bornmann and Mutz (2015) conducted an in-depth study into escalation of academic works, and agricultural research productivity, focusing on trends in publication output and authorship collaboration. Their research highlighted a steady increase in the volumes of publications, driven largely by collaborative networks that enhance research growth. Authorship collaboration was identified as a major contributor to this research advancement, underscoring the importance of research networks. The growing prevalence of multi-authored publications has become a defining characteristic of agricultural research. Shanthi and Thanuskodi (2021) noted that co-authorship significantly enhances research visibility and productivity, particularly through collaborations that span institutions and borders. Such collaborations are vital for fostering knowledge exchange and advancing innovation, making them increasingly central to the field of agricultural sciences. In the context of Nigerian institutions, studies by Simisaye, A.O (2019) emphasized the importance of multi-author publications, particularly in agricultural research and related disciplines. Their findings suggested that collaboration leads to higher-impact research, making it essential for addressing complex, multidisciplinary challenges. This trend is mirrored globally, where co-authorship is increasingly recognized as a marker of scholarly productivity and impact.

Bibliometric analysis also offers insights into how research productivity is distributed across different agricultural fields. Okpe et al. (2013) found that certain areas of agricultural research are more developed, often receiving more attention and funding, while others remain underrepresented. These insights are critical for identifying gaps in research that need to be addressed to promote balanced growth across all agricultural disciplines. Bibliometric methods are essential for analyzing agricultural research trends. Dotthun and Mukherjee (2017) defined Bibliometric as the set of qualitative methods helpful for describing and measuring academic literature. Marta and Garcia (2022) says a bibliometrical analysis of scientific publication is a sine qua non, an essential part of the research process tool and essential evaluation method. A bibliometric account of a discipline is a reflection of what has been published in specific discipline, author, period of publication and it helps to do a quantitative analysis of such discipline over the years to establish the trends. Guzeller and Celikeng (2019) highlighted the value of bibliometric indicators in comparing research impact and output, emphasizing their role in identifying key areas of growth over time, says it is an efficient procedure to understand

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how a field of research emerges and develops. D'Angelo, and Reale (2019) argue that bibliometric methods are valuable tools for predicting the growth of scholarly works, particularly when assessing authorship patterns and collaborative efforts across fields. Their study highlights how increased collaboration, often leads to more impactful and visible research outputs. The authors' work underscores the importance of tracking publication growth to understand research dynamics over time. These attributes have made it possible to assess shifts in agricultural research, especially with respect to authorship and publication trends. Therefore, it is possible to measure the evolution of a concrete research area through its scientific production and its productivity over a specific period. Bibliometric analysis also examines the intellectual structure, areas of knowledge, geographical areas, research areas, research themes, methods and maturity level of the topics of a scientific discipline. It is a common sense that a country's capacity to generate sustainable wealth and achieve high levels of well-being is closely linked to its capacity to generate knowledge. Knowledge generation is the foundation of innovation and an essential requirement for increasing production in modern societies.

Knowledge generation**,** research in agricultural and technological output over the years has generated considerable scholarly articles published in the area of agriculture and its related disciplines. The research activities engaged by scientists in agricultural institution have resulted to quite a substantive numbers of published articles which cumulative compilations in forms of a bibliographical index and bibliometrical analysis are necessary to be able to advance research in agriculture and related discipline by providing sequential arraignment of published articles and making visible the bibliographical details of the statements of responsibilities, source and location of the publication and pagination and other important bibliographical variables for easy location , usage and documentation of publications. The analysis of this cumulative bibliographical index of scientists' literature help to evaluate research productivity and doubling time of research output overtime. Okonedo (2015) explored research and publication productivity in Nigerian universities and found that institutions that prioritize research dissemination tend to experience faster growth in publication output. His study showed that strong institutional support and a focus on research visibility lead to increased scholarly contributions, which mirrors the pattern of growth seen at research institutions. Okonedo's research further supports the notion that strategic institutional efforts are critical to fostering research productivity. Donthu et al. (2021) also emphasized the value of bibliometric analysis in tracking research output, how research output evolves and identifying key areas of strength and weakness' over time. Their work on how to conduct bibliometric analysis highlights the increasing trend of collaboration, the importance of evaluating relative growth rates and publication doubling as indicators of institutional research capacity.

Katerere et al. (2009) identified substantial gaps, lack of capacity-building efforts and underrepresentation in some agricultural related fields and highlighted the need for targeted interventions to support research in underrepresented areas. The gaps and disparities in research output across different fields indicate a need for greater support for emerging areas of agricultural science. Donthu et al. (2021) pointed out, that fields with slower growth often lack institutional backing and collaboration opportunities, which impedes their development. Identifying and addressing these gaps is crucial for promoting balanced growth in agricultural research.

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RELEVANCE TO THE INSTITUTE OF AGRICULTURAL RESEARCH AND TRAINING (IAR&T)

This study is particularly relevant to research scientists at the Institute of Agricultural Research and Training (IAR&T), as it provides easy reference comprehensive compendium and analysis of trends, growth, and gaps in agricultural research productivity over the last fifty years. Given IAR&T's pivotal role in advancing agricultural research in Nigeria, understanding these trends is vital for identifying underrepresented fields and enhancing collaboration. The study's insights will be crucial for guiding future research strategies, fostering collaboration, and addressing gaps in research output to ensure balanced growth across agricultural disciplines.

RESEARCH METHODOLOGY

This study adopted bibliometric research method which consists of the technique of gathering data by extraction and word count analysis of the bibliographic features in the published journal articles of research scientists in the Institute of Agricultural Research and Training (IAR&T) Ibadan. Published articles were elicited both in print and soft copy over the last 50 years, from 1970-2020. A total number of 1,148 articles elicited from 43 retired and current research scientists that submitted their works in agricultural and related fields across thirteen (13) subject areas were analyzed. Reprographies of source documents of the articles were done. This is followed, by the extraction of the bibliographic details of authors or statement of responsibilities, titles of publications, year of publication, pagination etc. of all articles published from 1970 to 2020 were recorded for analysis. All the bibliographic details of 1,148 journal articles were extracted to achieve a detailed compendium of published literature and systematically organized in alphabetical and chronological sequence for easy identification, accessibility and usage and a computerized database is then created for in-depth study and analysis of the pattern of authorship, pattern of publications and the year wise distribution of articles. The year wise distribution of published articles productivity, relative growth rate and double time in research was determine dividing the scope of study 1970-2020 into two categories. While bibliography compiled was subjected to face validity.

Compilation of Bibliographical Research Index

As part of this study, a comprehensive index was compiled of all research works produced by the research scientists of the Institute of Agricultural Research and Training (IAR&T) from 1970 to 2020 in thirteen (13) research fields. This index serves as a vital reference tool to enhance the accessibility and visibility of scholarly works within the institute. The index includes 1,148 articles submitted by 43 scientists across thirteen different subject areas. The research works are organized chronologically and by subject, making it easy for researchers, academics, and policymakers to locate specific studies. The index records each work's bibliographic details, including the title, author(s), publication year, pagination, and subject category. The compilation process involved extracting data from printed and soft copy formats of the articles, followed by categorization into a database. The goal was to create a user-friendly tool for tracking the intellectual output of the institute over the past 50 years. A detailed version of the index is presented in the appendix, categorized for quick reference by subject and year.

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DISCUSSION OF FINDINGS

Subject-Wise Distribution of Research Outputs

Figure 1 Shows the frequency of published articles by the research scientists in the Institute of Agricultural Research and Training with dominance research area in Agricultural Extension which accounted for 215 (19%) of the total publication. This prominence indicates the institute places a strong emphasis on agricultural extension particularly with priority in engaging the farm families and farming community. The high output in this field underscore IAR&T's commitment to improving agricultural practices through publication of scholarly research output. This is followed by Animal Science with 190 (17%) indicates a substantial focus on livestock research, reflecting the importance of Animal husbandry in Nigeria's agricultural economy. Food science and Soil sciences were notably represented with 161(14%) and 113 (10%) of the publications respectively. The considerable metric on Food Science is an indication of attention given to food production, which align with global trends prioritizing food security and sustainability. Similarly, the substantial number of publications in Soil Sciences points to the institute's recognition of soil health as fundamental to sustainable agricultural. Highlight of the results has therefore shown that quite a quantum of research was dedicated to Soil Science to developed strategies that enhance soil and crop productivity which are critical for long-term agricultural success. However, certain subjects such as Agricultural Economic, Plant Pathology, Seed Technology, Plant Nematology and Crop Physiology with less metrics 1% to 5% of the total subject distribution. Crop Physiology which provides insights into the processes that underpin plant growth and development has the lowest representation at just 1% this indicated a lower research interest and published works, the infinitesimal number is adduced to the recent emergence of this field in the institute. Study suggest a need for increased research efforts in these fields. Agricultural Extension, Animal Science and Food Science should be well supported with compressive resources to sustain and further advance research in these areas. A potential gap was identified in Crop Physiology, Agricultural Engineering, and Agricultural Economic. Study suggest that research scientists should prioritized future research initiatives in these subjects especially given their foundational importance to broader agricultural challenges. By addressing these gaps, the institute can enhance its overall research output and make more significant contributions to these agricultural fields. Strengthening research efforts in these underrepresented fields will stimulate and compliment further research thereby achieve a more balance research output in the institute Figure 1 showed the research scientists fields and subject distribution output.

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Figure 1: Subject-Wise Distribution of Research Output

The Year-Wise Distribution of Research Output at IAR&T (1970-2020)

Figure 2 revealed a distinct growth pattern of the year-wise distribution of publications at the Institute of Agricultural Research and Training (IAR&T) over the five decades under review. The study's findings, based on the analysis of 1,148 articles published by IAR&T scientists, show that there has been a significant increase in research output between 1970 and 2020. The total number of publications grew steadily from 384 (33%) during the first 25 years (1970-1994) to 764 (67%) in the subsequent 25 years (1995-2020). This growth highlights an impressive doubling of research publications in the latter half of the study period, signaling a marked increase in scholarly productivity. During the period between 1970 and 1994, IAR&T research output was relatively modest, with fewer resources, collaborations, and platforms for publication compared to more recent times. This lower rate of publication can be attributed to various factors, such as the limited availability of research grants, challenges in accessing cutting-edge technologies, and constraints in dissemination platforms for African researchers during that era. As Okonedo (2015) highlighted in his study on the research and publication productivity of Nigerian universities, many institutions in sub-Saharan Africa during this period struggled to maintain a consistent output of research publications due to these limitations. His findings are reflective of the challenges that IAR&T also faced during the early years, contributing to the modest publication rate at the time. From 1995 to 2020, however, there was a noticeable shift in the research landscape at IAR&T, characterized by a significant increase in publication output. This period witnessed the publication of 764 articles, accounting for 67% of the total output over the 50-year span. The doubling of research publications during this period can be attributed to several factors, including improved access to research funding, enhanced institutional support, and stronger international collaborations (IAR&T 50 Years Compendium). This surge in output reflects the global trend of prioritizing agricultural research, as noted by Donthu et al. (2021) in their work on bibliometric analysis. They argued that institutions that implement strategic support for research and prioritize collaboration often

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see substantial growth in scholarly output. This trend is clearly observed in the case of IAR&T, where such factors contributed to the increase in publication rates (Donthu et al., 2021). Moreover, the second half of the period under study (1995-2020) coincided with a global shift towards prioritizing agricultural sustainability and food security, which likely influenced the type and volume of research being conducted at IAR&T.

As the world increasingly recognized the importance of agricultural innovation in ensuring food security, institutions like IAR&T found themselves at the forefront of research efforts. This trend aligns with the findings of Guzeller and Celiker (2019), who, in their bibliometric analysis of research output, demonstrated that institutions focused on globally significant fields tend to experience rapid growth in their research productivity. The upward trend in IAR&T's research output mirrors this global movement, as more emphasis was placed on critical agricultural topics such as food security, sustainable farming, and agricultural extension (Guzeller and Celiker, 2019).

The results also indicated in Figure 1, that within the 50-year span, research output in key fields like Animal Science, Food Science, Soil Science and Agricultural Extension experienced the most significant growth, especially during the latter period. These fields were identified as priorities, both globally and within the institute, which translated into higher publication rates. The findings of Abramo, D'Angelo, and Reale (2019) provided further context to this phenomenon. Their study on the impact of collaboration in research outputs concluded that fields with high levels of collaboration tend to produce more publications and have a greater impact. The authors observed that institutions that foster interdisciplinary and collaborative research often see an acceleration in scholarly output, which aligns with IAR&T's experience during the 1995-2020 period (Abramo et al., 2019).Despite the overall growth, certain subject areas such as Crop Physiology, Agricultural Economics, and Agricultural Engineering remained underrepresented throughout the study period, with a small percentage of publications attributed to these fields. This suggests that while the overall output doubled, there is still a need for more balanced research in less dominant fields. Okpe, Simisaye, and Otuza (2013), in their work on research output patterns in Nigerian universities, noted similar trends, observed that certain disciplines often lag behind in terms of publication rates due to inadequate collaborative and institutional focus. Their findings suggest that targeted efforts may be required to stimulate research in underrepresented fields at IAR&T (Okpe et al., 2013).

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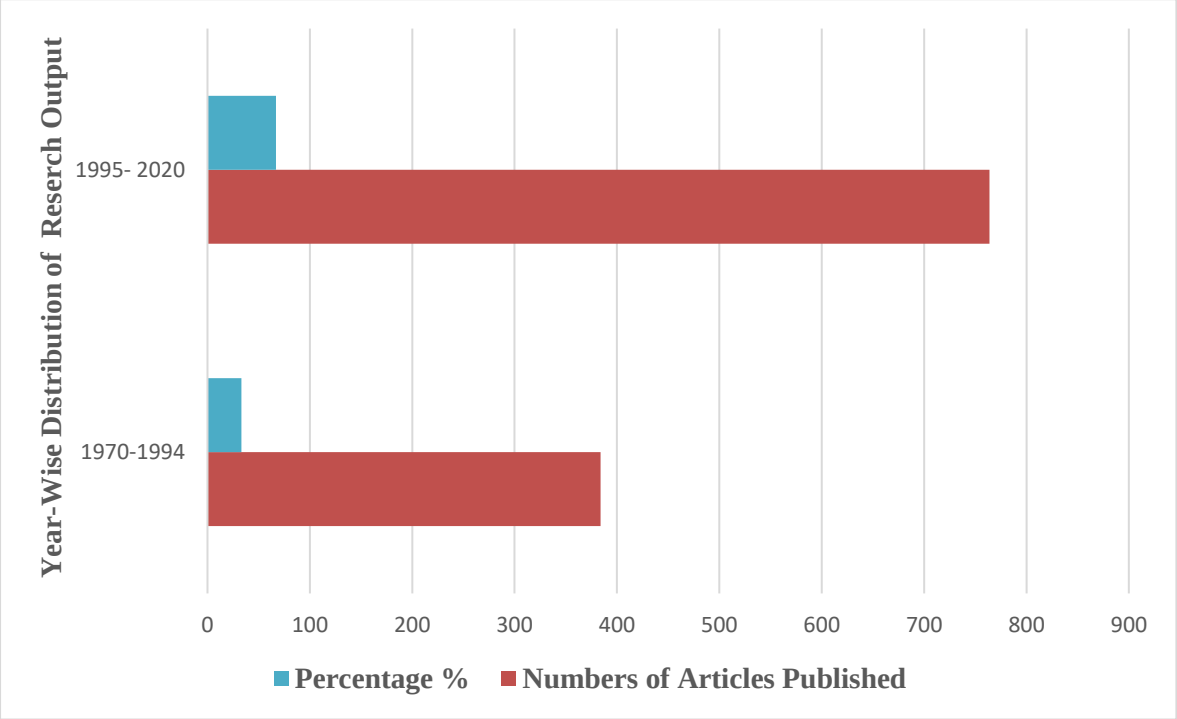

Figure 2: The Year-Wise Distribution of Research Output at IAR&T (1970-2020)

Relative Growth Rate and Double Time in IAR&T Research Output (1970-2020)

As shown in figure 3, the research output of the Institute of Agricultural Research and Training (IAR&T) has demonstrated remarkable growth over the past 50 years. One of the most significant findings from this study is the relative growth rate and double time of published articles. Between 1970 and 1994, the institute's research scientists produced a total of 384 articles, accounting for 33% of the total research output during the study period. However, from 1995 to 2020, the number of published articles surged to 764, representing 67% of the total. This demonstrates a substantial increase in publication productivity over time, effectively doubling the output in the latter 25 years compared to the earlier period. The concept of relative growth rate indicates the speed at which the research output increased over time. In the case of IAR&T, the doubling of publications in the latter half of the study period reflects a consistent and significant acceleration in research activities. This rapid increase suggests that the institute has enhanced its capacity to disseminate research findings and foster collaborative efforts among its scientists. Factors such as improved access to research funding, institutional support, and advancements in agricultural research technology likely contributed to this notable rise in output. The doubling of output signifies an evolving and expanding research environment at the institute, characterized by increased publication activities and enhanced collaboration among researchers. The double time in publication output at IAR&T occurred between the two timeframes under review (1970-1994 and 1995-2020). The fields of Agricultural Extension, Animal Science, Food Science and Plant Nematology saw the highest, relative growth rate and doubling time from 50-160, 48-142, 52-129 and 10-28 respectively. Findings also showed high levels of research output in the fields of Soil Science, Entomology and Plant Breeding. The highlights of this result indicated that IAR&T focused on critical areas in extension services, animal production, agricultural sustainability and food addition value. Guzeller and Celiker (2019) findings aligned with the significant growth seen at IAR&T, where

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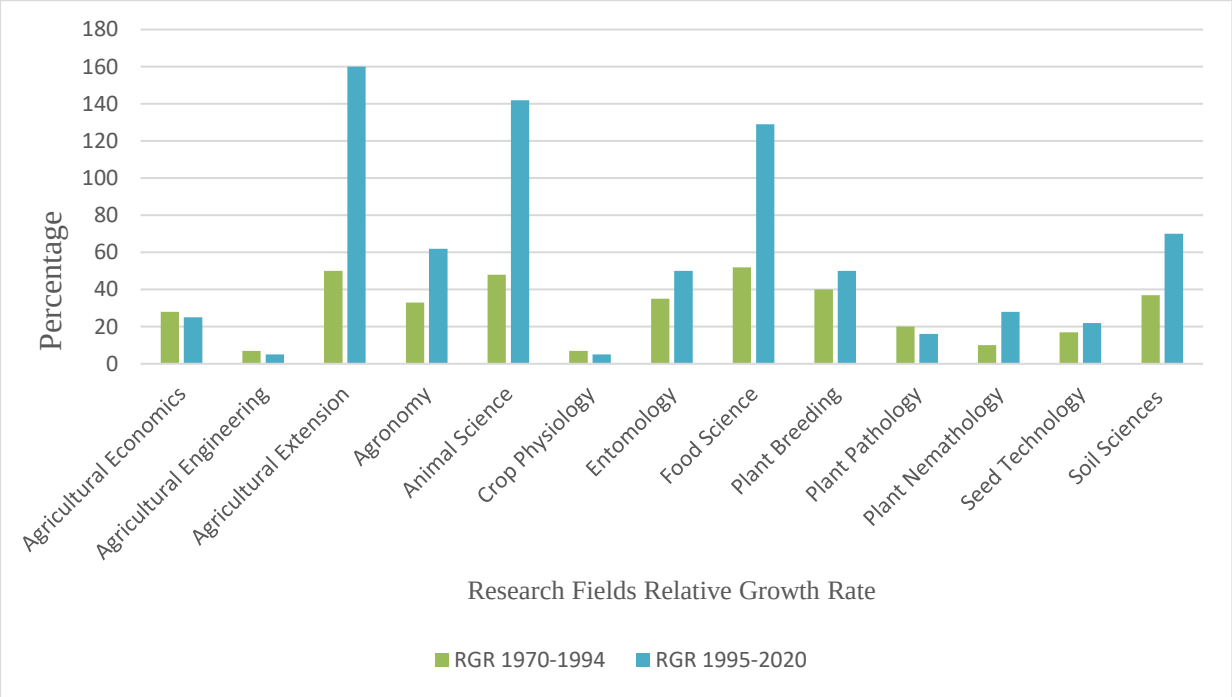
the publication rate has more than doubled in recent decades. Their study assessed the evolution of research fields with relative growth rates noticeable in related research fields. As reflected in this study, the growing publication trend in this study, indicates an expanding research environment, particularly the doubling of research output from the first to the second half of the study period, reflects the institute's increasing focus on agricultural innovation and collaboration. The findings provide valuable insights into how research productivity at IAR&T has evolved over time, underscoring the need for continued institutional support and resource allocation to sustain and further enhance research efforts, most especially in areas with less growth and reduced rate of publications.



Legend: GR= Relative Growth Rate

Figure 3: Relative Growth Rate and Double Time in IAR&T Research Output (1970-2020)

Authorship Pattern and Scholarly Collaboration

Figures 4 and 5, offer significant insights into the patterns of authorship and collaboration across the 13 subject areas under investigation. A clear trend emerges, revealing a pronounced emphasis on collaborative research efforts, especially in fields such as Animal Science, Food Science, and Soil Science.

Patterns of Authorship

The authorship pattern in this study reveals a strong inclination towards collaboration. Articles authored by four individuals dominate the research output, accounting for 35% of the total, which is indicative of a preference for moderate-sized research teams. This result is corroborated by Oyeniyi and Olaifa, (2012) whose collaborative degree revealed a 77.5% predominant joint authorship to 28.5% of single authorship. This pattern likely stems from the interdisciplinary nature of agricultural research, where multiple perspectives and expertise are

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required to address complex challenges. Fields like Food Science, Animal Science, and Soil Science often involve laboratory work, field research, and data analysis, necessitating a diverse set of skills that can only be achieved through collaboration. Notably, while four-author articles are the most common, the study also highlights a significant number of three-author (22%) and single-author papers (20%). This shows that while collaboration is central, individual scholarly efforts remain relevant in certain subject areas, where research can be more specialized or less dependent on multidisciplinary input. The preference for multiple authorship as discovered in this study contradicted the position of Simisaye (2019) whose work showed that majority of the research productivity has single authorship. It is therefore inferred, that single-author publications may reflect the work of experienced researchers or investigations that do not require extensive collaboration. However, the low percentage of articles with five or more authors (only 4%) suggests that large-scale collaborations are less frequent, possibly due to the logistical complexities involved in managing larger teams or the specific nature of the research projects.

Fig 4: Authorship Pattern (AP)

Figure 4 provide an overview of the authorship collaboration in the published articles of the Institutes' agricultural research scientists with a significant collaboration of four (4) authors articles having 400 (35%) high degree of research collaboration followed by 3 authors 229 (22%), single author 223 (20%) and the lease collaboration is in 5 authors 94 (4%) out of 1,148 total authorship patterns.

Authorship Collaboration by Subject

When looking at collaboration by subject, it is evident that certain fields encourage higher degrees of collaboration than others. Animal Science, with 92 instances of multi-author articles, leads the way, followed by Food Science (68), Soil Science (44), and Agricultural Extension (41). These fields are highly interdisciplinary and require input from various domains, such as biology, chemistry, environmental science, and agricultural economics, to produce meaningful

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results. The relatively high degree of collaboration in these fields underscores the importance of teamwork in advancing agricultural research. For example, in Animal Science, which involves studies in veterinary science, livestock management, and nutrition, the diversity of expertise required makes collaboration essential. The same applies to Food Science, where research often spans food safety, preservation, and production, involving input from chemists, food engineers, and nutritionists. In contrast, fields such as Agricultural Engineering show minimal collaboration, with only one recorded instance of multi-author work. This suggests that research in this field may either be more specialized, requiring individual efforts, or that it has not yet gained significant traction as a collaborative discipline within the institute. Given the critical role of Agricultural Engineering in developing mechanization and improving agricultural techniques, this field could benefit from increased collaboration to address broader challenges and innovations in agricultural practices.

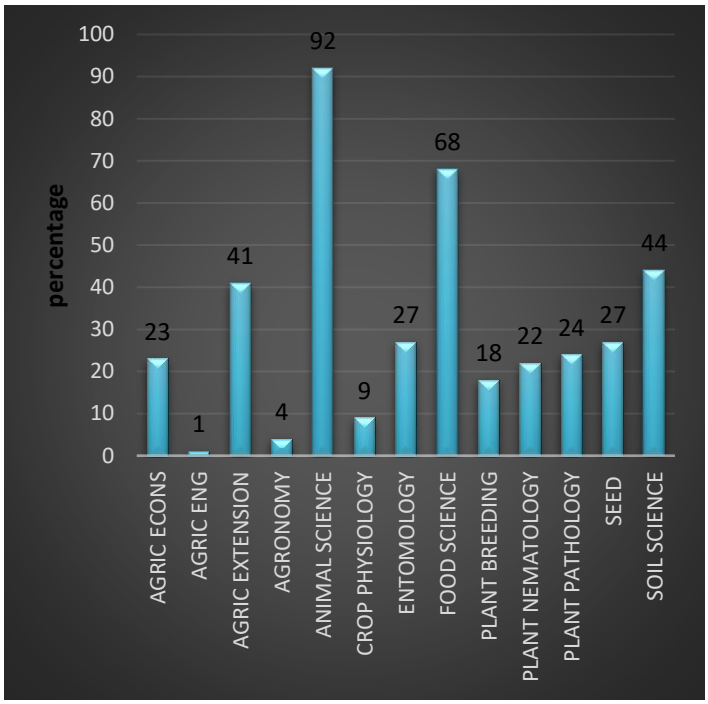

Fig 5: Authorship Collaboration in Specific Subject (ACSS)

Figure 5 revealed the authorship pattern by subject with high degree of research collaboration in Animal Science 92 frequency count, Food Science 68, Soil Science 44, Agricultural Extension 41, Entomology and Seed Technology 27 respectively.

Authorship Collaboration and Growth in Research Output

The patterns of authorship and collaboration can be directly linked to the significant growth in research output at the Institute of Agricultural Research and Training (IAR&T) over the past 50 years. As seen in the year-wise distribution of published literature in Figure 2, the institute experienced a marked increase in the number of publications between 1995 and 2020, doubling the output from the earlier period of 1970 to 1994. This growth as revealed in figure 3 can be attributed, in part, to the enhanced collaboration seen in key subject areas such as Animal Science, Food Science, and Agricultural Extension. The surge in collaborative research directly

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correlates with the relative growth rate and the doubling of publications within this period. The increase in authorship collaboration has not only fostered a more productive research environment but has also contributed to the rapid expansion of the institute's scholarly output. This is evident in the doubling of publications during the latter 25 years of the study period, with 67% of the total output being produced between 1995 and 2020. The fields with the highest degrees of collaboration Animal Science, Food Science, Soil Science and Agricultural Extension were also the fields that contributed most significantly to this growth, reinforcing the idea that interdisciplinary and team-based research efforts are key drivers of increased productivity. Andalon, et.al (2024) corroborated this in their research, titled 'The rise of teamwork and career prospects in academic science' which examined how increasing team size in academia influence scholarly output, productivity and career trajectories, findings revealed that high metrics recorded in the scholarly works are the hallmarks of teamwork practices among researchers and that divers set of expertise and collaborative approaches are essential for a robust research output, as collaborative efforts expand, so does the relative growth rate of research output.

The study shows that the collaborative nature of research in these key fields has contributed to a higher number of publications, as well as an increase in the quality and visibility of the research produced. This pattern of collaboration not only accelerates the output but also enhances the overall impact of the research, leading to more significant contributions to the agricultural sector. This phenomenon is supported by bibliometric studies that suggested fields with higher levels of collaboration tend to generate more impactful and widely cited research. Afolabi and Oladokun (2021) research paper "Authorship patterns and collaborative research in agricultural sciences: A case study of Nigerian research institutions" corroborated the dominance of multiple authorship over single authorship in research scientists' publications across agriculture and related. Their empirical research on the authorship trends among agricultural researchers in Nigeria revealed that multi-authored works overwhelmingly surpassed single-authored publications. This study revealed, that collaboration among agricultural researchers is becoming the norm rather than the exception, with disciplines such as animal science, food science, and soil science showing particularly high instances of co-authorship. With multi-authored works dominating over single-authored publications, this study has proved that the increasing complexity of agricultural problems required the expertise of multiple scientists in the sharing of resources and knowledge. Study therefore inferred, that multi-authored research tends to receive more citations and have a wider impact, as collaborative work often brings diverse perspectives and higher-quality research outputs. The strong patterns of authorship collaboration observed in this study, particularly in key fields like Animal Science, Food Science, and Soil Science, have played a pivotal role in enhancing the relative growth rate and doubling of the publication output at IAR&T. These collaborative efforts are crucial to the institute's ongoing ability to produce cutting-edge research and to maintain its position as a leader in agricultural innovation. While, increasing collaboration in underrepresented fields, such as Agricultural Engineering and Crop Physiology, could further accelerate research productivity and contribute to a more balanced output across all subject areas.

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IMPLICATIONS FOR RESEARCH AND PRACTICE

This study has several implications for both research and practice. For research, the findings underline the significance of authorship collaboration as a means to boost productivity and impact, suggesting that institutions should encourage team-based approaches across underrepresented areas. Practically, the insights provide a roadmap for allocating resources to strengthen growth in fields with lower output and developing targeted support for interdisciplinary and international collaborations. These steps will help advance agricultural innovation and ensure balanced progress across all fields of agricultural research.

CONCLUSION

The findings of this study offer a detailed bibliometric analysis of the research output and authorship patterns at the Institute of Agricultural Research and Training (IAR&T) over a 50-year period (1970-2020). The analysis reveals a substantial increase in research productivity, particularly between 1995 and 2020, during which the number of publications doubled compared to the earlier period (1970-1994). This impressive growth is largely attributed to enhanced research collaboration, increased access to funding, and a supportive institutional environment. Fields such as Animal Science, Food Science, Soil Science, and Agricultural Extension demonstrated the highest levels of collaboration, which contributed significantly to the overall increase in research output. These subject areas, characterized by multi-disciplinary research teams, benefited from diverse expertise that enriched the scope and impact of the research. The predominance of four-author articles, as well as a strong presence of three-author and single-author papers, reflects a collaborative research environment that has fostered a high level of scholarly output at IAR&T. However, the study also highlighted underrepresentation in specific fields, such as Agricultural Engineering and Crop Physiology. These disciplines exhibited lower levels of collaboration and fewer publications, indicating a gap in research focus. While the institute has made significant strides in productivity, these gaps suggested that there are opportunities for strategic improvements, particularly in promoting interdisciplinary research in these underrepresented areas. In light of these findings, several key recommendations are made to further enhance research productivity at IAR&T.

RECOMMENDATION

Promoting Interdisciplinary Collaboration: A painstaking research efforts most especially on the underrepresented fields is critical to ensuring balanced growth across all disciplines. Agricultural Engineering and Crop Physiology, which have lower levels of collaboration and output, should be prioritized. IAR&T can encourage cross-disciplinary research teams by providing targeted funding for projects that integrate expertise from diverse fields. Additionally, fostering strategic partnerships with both local and international research institutions can help stimulate activity in these fields.

Strengthening Institutional Support for Collaborative Research: The success of high-output fields, such as Animal Science and Food Science, demonstrates the value of a strong collaborative culture. To sustain and build upon the success of high-output in fields such Animal Science and Food Science, Soil Science and Agricultural Extension IAR&T should

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offer dedicated grants for multi-disciplinary research projects, create collaborative research spaces, and promote workshops or conferences that facilitate partnerships among researchers from different departments. Increased resource allocation for high-output fields is essential for maintaining the momentum in publication productivity. These fields that have shown substantial research activities should be supported with up-to-date resources, including access to the latest journals, databases, and research tools. Ensuring that these fields remain well-resourced will help sustain their leadership in research output. Mentorship programs for junior researchers are recommended to cultivate the next generation of research leaders. Senior researchers, particularly those with established records of publication and collaboration, should mentor junior scientists to help them navigate the publication process, build research networks, and engage in collaborative projects. This will ensure a continued pipeline of high-quality research and publication productivity.

Encouraging International Collaborations: is vital for elevating the research profile of IAR&T on the global stage. International partnerships can bring diverse perspectives, advanced methodologies, and access to cutting-edge research tools, which are crucial for addressing global agricultural challenges. By fostering these collaborations, IAR&T can enhance its visibility and impact in the global research community.

Lastly, supporting research in emerging fields such as Crop Physiology is essential for future growth. Although these fields currently exhibit lower research output, they hold significant potential for innovation. By providing targeted funding and fostering research opportunities in these emerging areas, the institute can ensure a more balanced and comprehensive research output.

In conclusion, IAR&T has made remarkable progress in enhancing its research productivity through increased collaboration and strategic institutional support. However, to sustain this growth and address the gaps in underrepresented fields, it is imperative to foster interdisciplinary research, provide enhanced support for collaboration, and ensure that all fields receive adequate resources. By implementing these recommendations, IAR&T will continue to play a pivotal role in advancing agricultural science and contributing to innovation in Nigeria and beyond.

FUTURE RESEARCH ON THE STUDY

Future research could build on this bibliometric analysis by exploring how collaborative efforts, especially those involving international partnerships, might further enhance productivity in high-impact areas like Animal Science and Soil Science. Additionally, evaluating the influence of digital access and open-access publishing on research output could provide insights into how modern publishing trends may shape future scholarly productivity in agricultural research.

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APPENDIX

Scientists publication new 2 bibliographical Index.docx

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