

A network analysis of research on African agricultural development

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Abstract

There has been a substantial increase in published research on various aspects of the economies of African countries over the past couple of decades, giving rise to questions such as “who does the research” – is it scholars on and from the continent, or is it scholars from the developed world – as well as “is the research concentrated geographically” and “what is the nature and extent of collaboration between researchers”? Here, social network analysis is used to address the last of these questions in the field of the economics of African agricultural development. The results show an unexpected high degree of collaboration between African and developed country scholars, and the prominent role of international institutions, especially from the CGIAR, in fostering collaboration.

1. Introduction

There is some evidence of constructive collaboration between scholars from different continents and institutions in reporting the results of research on the economics of African agricultural development (Vink, 2021). This runs counter to the experience from other sub-fields of Economics; hence, the purpose of this paper is to explore further the extent and nature of this collaboration against the background of some of the broader trends in the world of scholarly publication and conferences. To this end, four trends in the publication of research outputs should be recognized, namely the volume of publications, co-authorship patterns, geography and gender.

White (2021) has shown that the annual number of journal articles and conference papers produced globally in all fields of science and engineering (i.e. including the social sciences but excluding the humanities) increased from around a million in 2000 to three million in 2018. Over this same period the annual output in the agricultural sciences went from 21 000 to 69 000, in the natural resource and conservation sciences from some 5 000 to 96 000 and in the social sciences from 35 500 to 121 000.

At the same time the number of authors per paper has also been also increasing. McDowell and Melvin (1983), for example, showed that the proportion of multi-authored papers in core economics journals increased from below 5% in 1946 to above 30% in 1972, a trend that was continued through to the 1990s, as shown by Hudson (1996). The proportion virtually quadrupled from 10.9% in 1955-1960 to 40% in 1974-1993, with multiple-authorship more prevalent in the more quantitative journals (a distinction that would be difficult to make today). McDowell and Melvin (1983) argued that if researcher utility increased with more published papers, this trend was both easy to explain and likely to continue in future. Hudson (1996) came to the same conclusion, but also pointed out the disadvantages of co-authorship, a theme

also taken up by Hollis (2001). Finally, Hamermesh (2013) showed that this trend continued into the new millennium, with 80% of articles published in the *American Economic Review*, *Journal of Political Economy*, and *Quarterly Journal of Economics* multi-authored in 2011. Similar analyses have been conducted in sub-fields of economics. Seltzer and Hamermesh (2017), for example, found that economic historians publishing in economic history journals were slightly less likely to collaborate than when publishing in general Economics journals, but that the trend was still toward an increasing number of co-authored papers, and an increasing number of co-authors.

The continued rise in co-authorship is coupled with the increasing importance of building research networks. Teams are becoming more likely than sole authors to produce high impact, widely cited research (Wuchty *et al.*, 2007). However, Ductor *et al.* (2014) show that while being part of better connected co-authorship networks predicts authors' future output, these network associations are more valuable as a signal of credibility than as an actual flow of ideas. Collaboration with prominent researchers may therefore not necessarily increase productivity, but be used as a vehicle to raise the profile of research that is at the margin of being accepted for publication by reputable journals. However, active co-authorship between prominent and non-prominent researchers may create productive synergies when authors formally collaborate with the *right* scientists. Oettl (2012) shows that “helpful” scientists whose names regularly appear in the acknowledgment sections of other papers contribute to the quality of their co-authors' research outputs – an effect which disappears once these helpful scientists pass away. Collaboration can therefore be meaningful contingent on excellent researchers transferring knowledge to less experienced researchers – for this to happen, these researchers must not only be prominent in their fields, but also be the kind of researchers who are open to investing time and resources in the work of less prominent colleagues. Informal collaboration may also be helpful to researchers who are less influential. Less prominent researchers can raise the credibility of their papers by acknowledging “big name” researchers in the comments sections of their papers. Acknowledging prominent researchers is correlated with a larger number of citations, so that associating with a prominent researcher – at least informally – is one possible way of improving research quality (Rose & Georg, 2021).

Furthermore, there has always been a concern about bias in the selection of countries and even areas within countries in the fields of scholarship such as development economics, development studies, and related disciplines. In short, some countries are more frequently researched than others. Porteous (2017), for example, looked at the geographic concentration in Africa of publications in the broad field of Economics and found that 45% of the published research was done in five countries (Ghana, Kenya, Malawi, South Africa and Uganda) that hold only 16% of Africa's population. This proportion was even more pronounced with the “top five” journals (*Quarterly Journal of Economics*, *Econometrica*, *American Economic Review*, *Journal of Political Economy*, *Review of Economic Studies*), where the proportion was as high as 65%.

The literature also shows a concern with the representation of developing country scholars and institutions in these fields of scholarship, starting with Cummings and Hoebink (2016) who show that only 14% of the authors of articles in development studies are located in developing countries, while scholars located in developing countries make up only nine percent of the members of Editorial Boards of the journals in this field. Amaranté *et al.*, (2021) also find that developing country authors are underrepresented to the extent that fewer than 16% of papers were written by developing country authors. They also find that only 11% of the papers were the result of collaboration between scholars from developed and developing countries.

Two recent papers address this issue with specific reference to Africa. Fourie (2019), for example, analysed publications on African economic history in the top four economic history journals and found that there has been a large increase in writings on Africa, but not by African scholars. Chelwa (2021) supports this finding in his analysis of research in the field of economics generally. Only some 25% of the articles published on Africa had at least one African-based author between 2005 and 2015. It is this latter aspect that we analyse further in this paper with respect to papers in the field of the economics of African agricultural development.

The increasing role of co-authorship networks intersects with our observations on geographic biases in publication. We hypothesise that inexperienced or geographically isolated researchers are more likely to produce influential research if they align with influential international teams. This implies cross-country collaboration, including research alliances between the global South and North. Arguably, to place debates about African agricultural development closer to the centre of the academic and policy discourse, authors on the continent are reliant on building research networks with institutions and academic leaders beyond the continent. On the one hand these alliances could reinforce the voices of researchers from the global North at the heart of debates on the global South; on the other hand, research networks facilitate the dissemination of knowledge that would otherwise have remained localised and that would not be adopted into the international development agenda. Even if these networks were to be pursued, successful collaboration between African and international scholars on African issues presumably depends on working with the *right* scientists (Oettl, 2012), arguably those who are invested in working on agricultural development, rather than scholars who are drawn in for the sake of raising the credibility of their papers (Ductor *et. al.*, 2014).

There are few analyses that address the gender of authors in the economics profession. Hamermesh (2013) analysed authorship in three core journals from 1983 and showed that the proportion of female authors was only 12.6% in 2011, the most recent year in his sample. There is also a considerable literature on the relative numbers of citations of male and female authors (e.g. Hengel and Moon, 2020). They show that female-authored papers attract more citations than male-authored papers in top economics journals and analyse the costs of such discriminatory practices. This pattern is consistent with the hypothesis that only the best quality articles authored by women are accepted by journals, while lower quality articles written by men are more likely to be tolerated. In a subsequent analysis, Hengel (2022) showed that female authors are published less often in core economics journals published in the USA between 1950 and 2015. While there was an increasing trend, the proportion of papers with at least one female author was still below 25% in 2015, while the average share of female authors per paper was only 15%. Hengel (2022) ascribes this to the higher standards to which female authors are held and analyses the damage to women's academic productivity in terms of behavioural changes that follow both experiences with and the anticipation of discrimination. In similar vein, Boschini and Sjögren (2007) analysed "team formation" in co-authored papers between 1991 and 2002 and find no evidence of gender neutrality, i.e., men work with men and discriminate against women, while Cummings and Hoebink (2016) analyse among others the gender of members of journal Editorial Boards from ten journals in the field of Development Studies. On average women made up 30% of the membership in 2015, ranging from only 12% in *Economic Development and Cultural Change* to 50% in the *Journal for International Development*.

Our main focus lies in analysing the importance of co-authorship, specifically the geography of cross-institutional collaboration. To this end, Section 2 of this paper outlines the database

and methods of analysis employed, followed by the results in Section 3, while Section 4 concludes.

2. Data and methods

The database covers eight journals and three conferences that form the core of the reported research on the economics of African agricultural development over the five-year period 2016-2020. In both cases, some demographic/bibliometric information was recorded on each article/paper. These included the names of all authors, the title of the paper, the year of publication, the gender of the authors, the country or region being investigated, the country of domicile¹ of the lead author, the country of origin of all authors, the institutional affiliation of the authors, and the number of pages of each article or paper.

The international journals covered included *Agricultural Economics* (the journal of the IAAE), plus the three highest ranking core Agricultural Economics journals (ranked by their 2019 CiteScores) that regularly published articles in this field, namely the *American Journal of Agricultural Economics*; the *European Review of Agricultural Economics*; and the *Journal of Agricultural Economics* as well as *Food Policy* and *World Development* (WD). The latter were selected because they were the two highest ranking² general journals in the field of development studies in 2019 that published papers in the field of the economics of agricultural development in Africa. In the case of these journals a pragmatic rule of thumb was strictly applied in order to include an article. Articles had to satisfy two criteria, namely whether the institutional home of any of the authors had an agricultural or applied economics focus, and whether the focus of the paper fell into the field of agricultural and applied economics as applied to the economics of African agricultural development.

The African Journal of Agricultural and Resource Economics (AfJARE), and Agrekon, the journal of the Agricultural Economics Association of South Africa were then added to the list. These were selected because they are the only two journals published in Africa with a core focus on Agricultural Economics. Both can also be found on the Scopus database. While Agrekon had a historical focus on commercial farming in South Africa, it has increased its coverage of agricultural economic issues in the rest of the continent. In the 2010 Volume, for example, fully 60% of the articles focussed on South African agriculture. This decreased to 53% in 2016, and 38% in 2020.

The database on conferences included all the contributed papers from the Fourth Conference of the African Association of Agricultural Economists in Addis Ababa (2016), the Fifth Conference in Abuja in 2019, as well as IAAE 2018 in Vancouver.

The database contains 604 journal articles and 622 conference papers. We pool the data over time but conduct separate analysis by journal type and conference.

¹ In the sense of domicile at the time of publication. Thus, if, say, a Ghanaian was doing her PhD in Germany, the country of domicile was Germany, not Ghana. As will become evident, many authors are affiliated with multilateral institutions. Their country of domicile was taken as the location of the head office of the institution in question. Thus, while IFPRI, for example, has offices in Africa, all of its staff were assumed to be from Washington, DC. By implication, this creates a conservative bias in the analysis of country of origin.

²These ranked seventh (*World Development*) and eighth (*Food Policy*) on the Scimago Journal and Country Rank website (<https://www.scimagojr.com/journalrank.php?category=3303&area=3300&type=j&year=2016>). The three highest ranked development studies journals published very few articles in this field. The *World Bank Research Observer* had no articles, the *Journal of Development Economics* one article, and *Economic Development and Cultural Change* had two article in this field in 2019.

The first step in analysing the data was to look at some descriptive statistics on co-authorship, gender and geography. The results are reported in the following section. The second step was to conduct a network analysis to ascertain the main patterns of collaboration between authors in the production of these research results.

We use social network analysis between institutions to deepen understanding of the strategies of scholars of African agriculture, such as whether and to what extent authors in African institutions leverage connections to developed country institutions (and to what type of institutions) or whether and to what extent scholars from beyond the continent leverage authors in African countries. We therefore create bi-directional networks, where lead authors from African institutions collaborate with other institutions; however, other lead authors can also include African researchers as co-authors. The network is created by arranging the home institutions of authors into connected clusters using the ForceAtlas2 algorithm in Gephi (Jacomy et al, 2014). Graph theory was applied to visualise co-authorship networks. Frequent collaboration between institutional pairs places them closer to each other in the network. We use the modularity measure to distinguish particular “clusters” of institutions that interact more regularly with each other as opposed to collaborating across groups of institutions (Newman, 2006). “Bubbles” of the same colour show that the component institutions belong to the same “club”. Additionally, the graphs indicate the centrality of particular institutions. Central institutions have authors that are likely to collaborate with authors from many other institutions; furthermore, an institution is considered to be a more central node if its authors tend to collaborate with other institutions that also collaborate widely. We scale the size of the bubbles by their eigenvector centrality, which quantifies the centrality of each institution in the network (Rose & Georg, 2021; Bonacich, 1987). Graphically, institutions that have the highest frequency of high-quality connections are located at the centre of a cluster, and the most central cluster is placed at the centre of the network. The size of the bubbles in our graph correspond to institutions’ centrality in the network, while the number of collaborations across institutional pairs is shown by curved lines: the thickness of the lines is proportional to the number of interactions across institutions and is more informative than their length.

Our unit of observation is at the level of institutional affiliation rather than individual authors. This includes universities, research institutes, think tanks and multilateral organisations. To reduce the complexity of networks, we place some limitations on the data. Where fewer than 15 collaborations were recorded by a particular institution, we categorize them into larger geographic regions (Europe, Southern Africa, East Africa, North Africa, Eastern USA, Western USA and Mid USA). After this simplification, we exclude observations with fewer than 5 collaborations.

3. Results

3.1 The descriptive analysis

Vink (2021) analysed aspects such as the number of authors, their gender, the institution where they work and the countries where their research has been conducted for a set of journal articles and conference papers that address the economics of agricultural development in Africa for the period 2016-2020. These are issues that have been raised in the general economics literature, in the agricultural economics literature, and in the literature on agricultural development. The database for that study is described in section 3 below.

3.1.1 Co-authorship

In the case of the number of co-authors for papers on the economics of African agricultural development, Vink (2021) found that the average number of authors was 3,16 for journal articles and 3,08 for conference papers, and further that only 11% of the journal articles were single authored, with 75% having between 2 and four authors. Conference papers had a higher proportion of single authors (17%), and a lower proportion of papers with between two and four authors (68%).

3.1.2 Gender

In contrast, Vink (2021) showed that the proportion of female authors in the field of the economics of agricultural development in Africa was higher during the 2016-2020 period. Women constituted 24% of all single or lead authors, and 23% of all authors (i.e., including co-authors) in the main journals analysed. The proportions were lower for authors of conference papers – 18% for single and lead authors and 21% for all authors. These proportions are low, and cause for concern.

3.1.3 Geography

Vink (2021) shows that around one-fifth of the journal articles that report on empirical research on the economics of agricultural development in Africa in a single country focus on Ethiopia, which has less than 9% of Africa's population and produces less than 7% of the agricultural output. Apart from South Africa, the other top four countries that are most frequently researched are in East Africa. These five countries contribute (63,4%) of the total, similar to the proportion reported by Porteous (2017). Nevertheless, 33 countries are included in the research reported in journals. They make up some 85% of Africa's population and 82% of the farm output, and so are representative of the continent.

Ghana and Nigeria appear in the list of the five most frequently researched countries when conference papers are analysed. Over 70% of the research is done in seven countries where 40% of Africa's population lives and where half of its farm output is produced.

3.2 Collaboration

Table 1 shows the region of origin of the authors of all the journals, the non-Africa journals and all of the conference papers. Half of the authors (52,2%) who publish in the journals published outside of the African continent live and work outside of the continent, while this is only true for 16,1% of the conference papers. In contrast, about a fifth of the journal articles and conference papers have an African lead author and some non-African co-authors, while there are even fewer papers with a lead author from outside of the continent with some African co-authors. There is some evidence, therefore, of active collaboration between scholars who live and work in Africa and those who are elsewhere, and an absence of dominance of non-African scholars.

Table 1: Place of origin of lead author plus co-authors¹, 2016-2020

	Non-African only		Non-African + some African		African only		African + non-some African		Total
	Number	%	Number	%	Number	%	Number	%	
All journals	237	39,2	57	9,4	174	28,8	136	22,5	604
Non-African journals	204	52,2	51	13,0	44	11,3	92	23,5	391
All conferences	100	16,1	40	6,4	344	55,3	138	22,2	622
Total	337	27,5	97	7,9	518	42,3	274	22,3	1226

Note: ¹Co-authors are taken as a group

In this regard, Figure 1 presents the first network, focussing exclusively on conference participation. The figure reveals wide geographic representation in debates around African agriculture, even if the data is dominated by two conferences hosted in Africa. The International Food Policy Research Institute (IFPRI) is located at the centre of the network, and also has the highest eigenvector centrality (as indicated by the size of the bubble). Other international organisations “orbit” closely around this centre, including authors from the Food and Agricultural Organisation (FAO) and the International Institute on Tropical Agriculture (IITA). International organisations are therefore influential players in researching Africa agriculture. However, these institutions are an important link to the academic domain. The “IFPRI club” marked in green includes universities in Germany, Cornell, Eastern and Western USA universities and University of Pretoria in South Africa. While this club seems to be US and Euro-centric, it is characterised by cross-sectoral collaboration. The “IITA club” marked in purple is slightly more far reaching – it includes other organisations such as the International Maize and Wheat Improvement Centre (CIMMYT) and the World Bank, US universities (particularly Purdue and Michigan State University), but also extends to universities such as Ibadan, the University of Cape Town and the Jomo Kenyatta University. African institutions are mainly located away from the centre of the network. For instance, South African Think Tanks (marked in brown) link closely to Lilongwe and UKZN, and are most closely related to South African universities in other clubs (Pretoria and Stellenbosch in green). An East African constellation (marked in blue) emerges, with think tanks in the region at the centre. Nairobi, other East African universities, International Centre of Insect Physiology and Ecology (icipe), the International Centre for Tropical Agriculture (CIAT) and Wageningen University also form part of this sub-network. Again, think tanks and international organisations are important role-players in this geographic region. Overall, our results reveal that there is strong geographic clustering with major international organisation working with academics from the global North. Academics from the global South tend to work within their geographic confines, but nevertheless collaborate with regional think tanks and selected international organisations with stronger regional relevance.

Figure 2 shifts the focus to co-authorship networks in journals published in Africa – namely AfJARE and Agrekon. Relative to conferences, participation from all regions in the world is limited. Nevertheless, international organisations are strongly represented. Clusters of institutions are more distinct from each other, and no single cluster dominates the centre of the network. Furthermore, no single set of institutions dominates in eigenvector centrality – as represented by the size of the bubbles. This network is therefore characterised by a number of separate “sub-networks” in which the players have relatively equal influence. The blue cluster is dominated by universities from South Africa, who collaborate with the Agricultural Research Council in that country and southern USA universities. This cluster is highly interconnected, with few links to other institutions and is constituted by the large number of papers published in Agrekon, which has a strong South African focus. The purple cluster is centred around IFPRI

and the FAO, with collaborations mainly with German and US Universities. As with conferences, these two international institutions are less likely to collaborate with African researchers. On the other hand, an East African bloc (in green) again emerges, which has strong ties to CIMMYT, the IITA and Wageningen University. It is unsurprising that this pattern is similar to what we observed for conferences – both samples are dominated by events and publications co-ordinated on the African continent. The results emphasise strong regional segmentation in co-authorship, and that collaboration with non-academic institutions is important for universities. Nevertheless, the identity of the international partner is contingent on the region. While USA universities tend to collaborate with all groups, IFPRI and the FAO tend to favour working with Northern countries; some region-specific organisations are central to the publication output of Eastern and Southern African countries.

We now focus our attention on specialist international agricultural economics journals with high impact factors. Figure 3 depicts a very different network in comparison to what we have observed thus far. It is clear from the broader geographic representation that authors at international institutions prefer these journals than African journals. Even though they work on issues pertaining to Africa, they target a broader, international audience and aim to publish in journals with higher impact. The networks are also visibly different to those for African journals. Firstly, while a number of clusters can be distinguished, they are less distinct from each other, and there is significant collaboration *across* the groups, as represented by the many connecting lines between the nodes. Secondly, while international organisations continue to be represented, universities dominate this network. There are clear selection effects, as academic collaborations – especially from USA universities are better represented in journals with high citations than at conferences and in African publications. The first orange cluster has a number of “large players” from American institutions with high eigenvector centrality. This network is dominated by Cornell University, but with close links to the World Bank, Michigan State University, US think tanks, Western and Southern US Universities. A number of African universities (Egerton and Sokoine) are included at the margins of this sub-network. However, this network is unambiguously dominated by USA universities, with leading institutions choosing high impact journals and being more selective about who they collaborate with compared to when they publish in African journals. A second cluster is more geographically diverse and has IFPRI at its centre (marked in purple). FAO is again grouped with IFPRI. However, while IFPRI and FAO were more narrowly linked to Northern researchers at conferences and in African publications, they have a different profile in high ranking journals. They collaborate with East African, German, Belgian and eastern US universities. South African universities are unlikely to have direct links with IFPRI and FAO, but are also located in this broader sub-network. This sub-network is geographically diverse, and illustrates the facilitating role that IFPRI plays in drawing in researchers into debates in leading publications. A third dominant network, marked in green, centres around CIMMYT. As was previously the case, this sub-network has a strong regional dimension, with collaboration linked to East African think tanks, Wageningen, CIAT and ICIPE, but additionally West African institutions, Purdue University, Canadian institutes and Norwegian University of Life Sciences are aligned with this group. While this sub-network is regionally concentrated, it again emphasises the role of central institutions to put forward debates mainly regarding East Africa, but also includes West Africa.

Finally, Figure 4 maps collaboration in articles published in high impact journals with a broader development focus, but that cannot be classified as specialist agricultural economics publications (World Development and Food Policy). African institutions are sparsely represented in this group, limited mainly to East Africa. As with other international journals,

the network is more densely connected across clusters than was the case for African publications. While we again observe a (purple) cluster dominated by USA universities (Michigan State, Cornell, Mid-US universities), their networks are somewhat larger and more open than was the case for specialist journals. This sub-network now includes Wageningen and the World Bank, but African researchers continue to be excluded from this group. The US research network is therefore more open in non-specialist than in specialist high impact journals, but is nevertheless inclusive mainly of institutions in the global North. IFPRI is again at the centre of a (blue) sub-network. The patterns of collaboration are less clear, with co-authors ranging from the University of Pretoria in South Africa, Leuven in Belgium and other US universities. This network is much smaller in generalist than in specialist journals. East African institutions are again located in a distinct (green) cluster. In this instance, they are most closely connected to Canadian and European institutions, as well as the FAO and IITA.

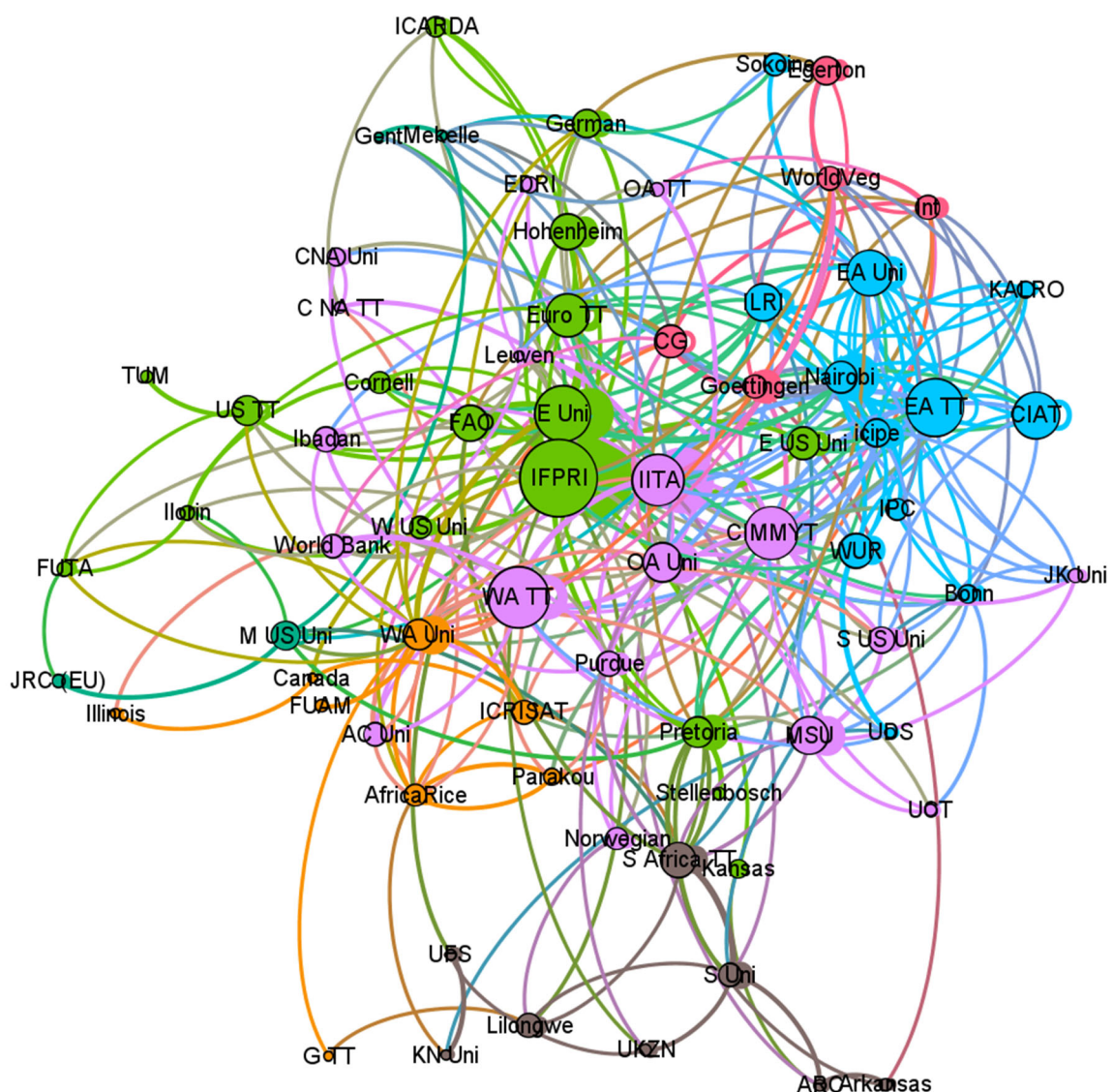


Figure 1 Institutional co-authorship network at conferences.

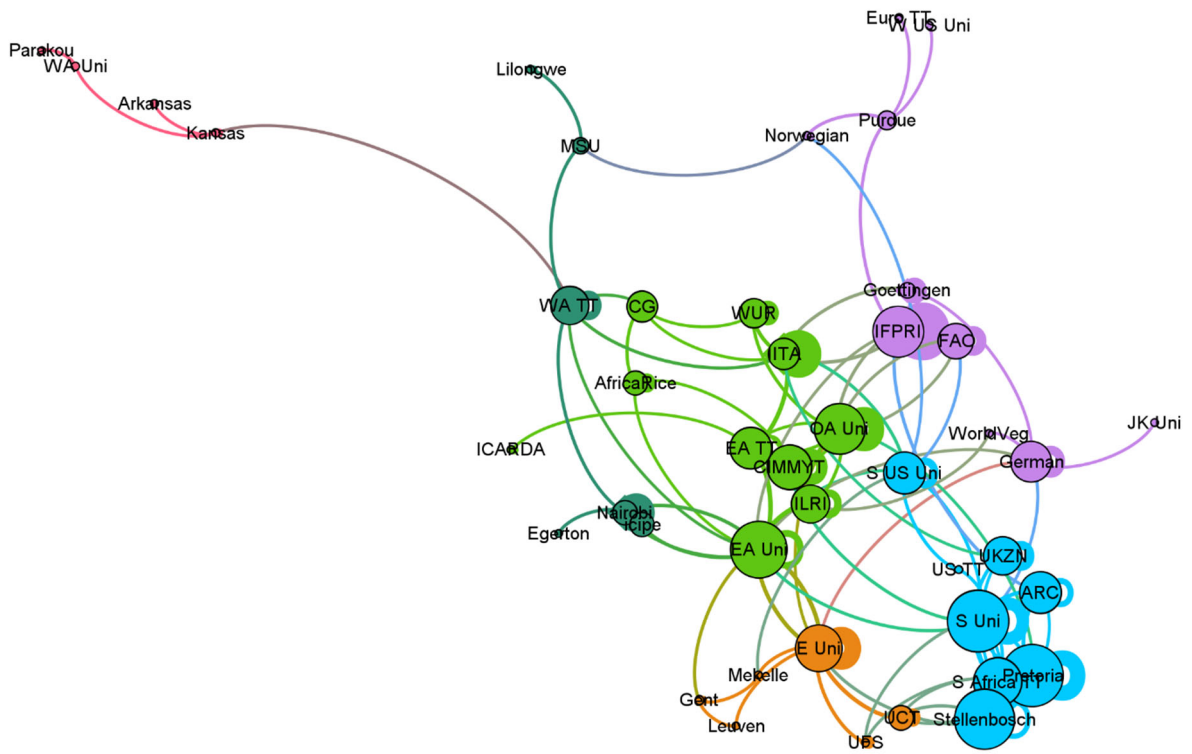


Figure 2 Institutional co-authorship network in journals based in Africa (Agrekon and AFJARE)

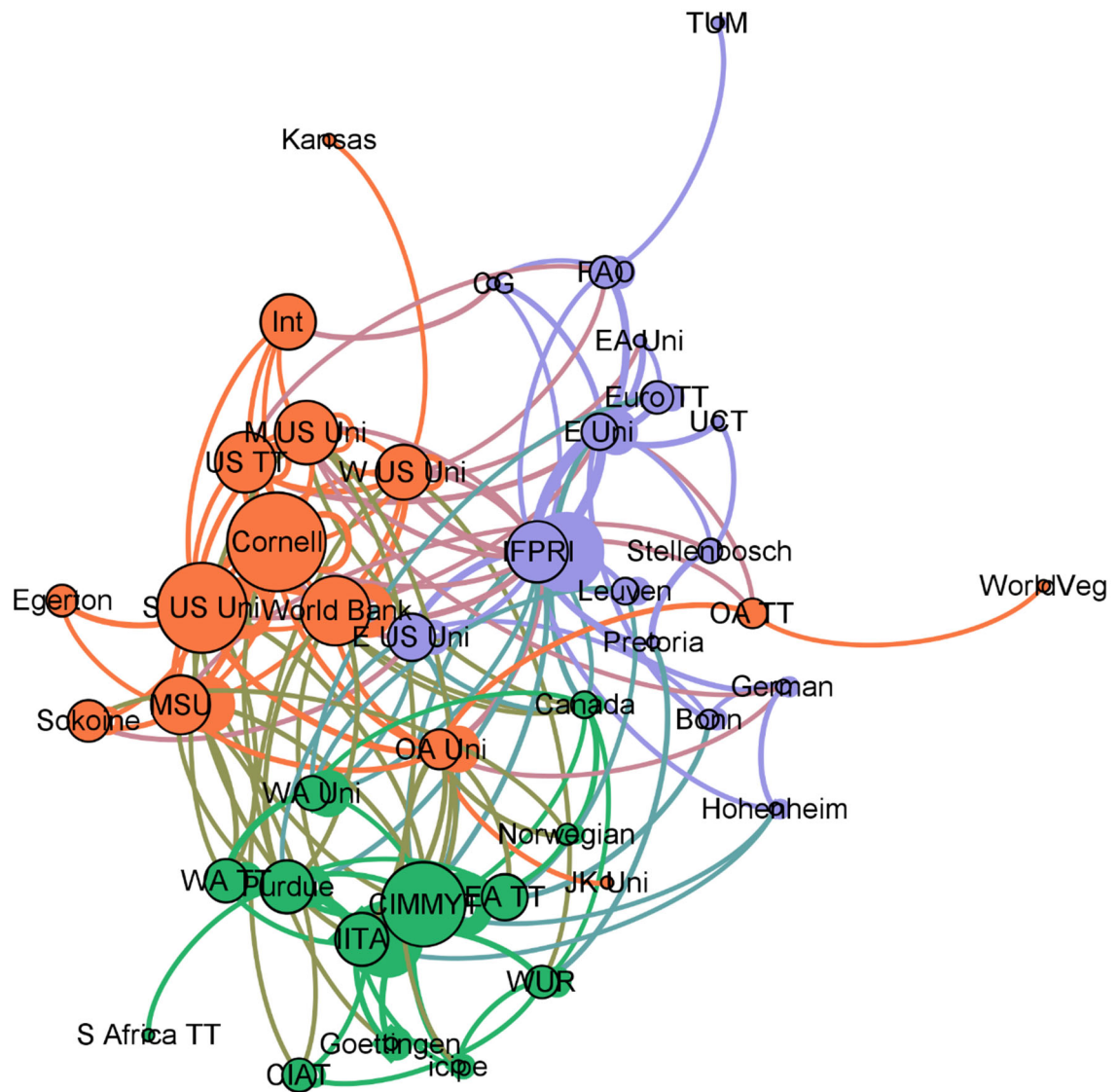


Figure 3 Institutional co-authorship network in leading journals with an Agricultural focus (AE, AJAE, ERAE, JAE)

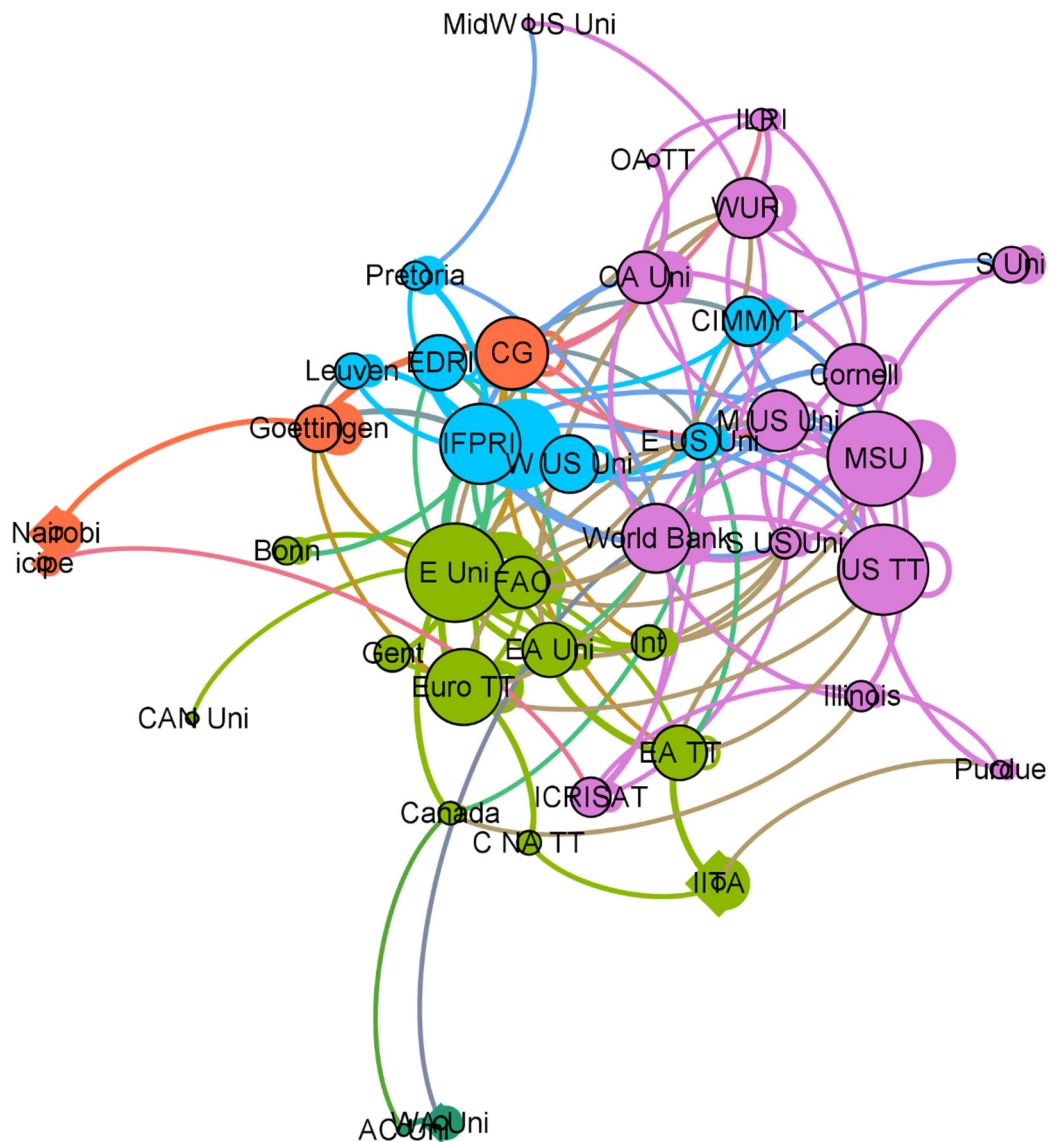


Figure 4 Institutional co-authorship network in leading journals with a broader development focus (Food Policy, World Development)

4. Conclusions and lessons learned

IFPRI is important in all types of networks. At conferences and in African journals they are more influential and more Northern centric. But, in high impact journals, they are more inclusive of a few (East) African research institutions, but far less influential. They therefore play a role to facilitate collaboration with the South in specialist journals, but do not dominate to the same extent as US academic institutions.

Authors of conference papers are far more connected across geographies than journal authors are. This relates strongly to the fact that US universities collaborate across many geographies on conference papers and in African journals but are more exclusive when it comes to published papers. Their selectivity is most prominent in specialist high impact agricultural economics journals. While they work on African issues, their objective is still to reach a broader audience,

and to produce high impact research with mainly American colleagues. While this pattern can also be traced in non-specialist high impact journals, the American network is a bit more open in these generalist journals. We generally observe both a greater extent of participation and exclusivity of American universities as the academic stakes grow from conference papers to publishing in African journals, to generalist journals to specialist agricultural economics journals.

African universities are not central to any networks, but their connection to non-academic think tanks and international organisations are important collaboration nodes in all sub-networks. While there are limited regional patterns, East Africa forms a distinct cluster in all networks: and they align closely with a few international organisations (such as CIMMYT, Wageningen, CIAT and ICIPE). They represent a separate branch of research. Again, partnership between academia and international organisations is a key feature of collaboration.

African journals are distinct, with strong regional separation of sub-networks, but with equality within those networks. There is a distinct “Agrekon” cluster in South Africa. However, the lower geographic representation and stronger segmentation emphasises that research on Africa is not generally disseminated in African journals.

Overall we note that as the academic stakes grow from conference participation to publishing in African journals to publishing in generalist high impact journals to publishing in specialist high impact journals, the central influence of international organisations declines, while the influence of American universities increases. International organisations play a facilitating role to draw in (especially East) African researchers, but this does not compensate for dominance of US universities at the highest levels of Agricultural Economics publishing.

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