The Nature and Trends of Agricultural Research Development in Africa: An Informetric Study

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Abstract

The study recognizes Agriculture as the mainstay activity of most economies in Africa and analyses research nature and trends in the discipline by using descriptive informetrics and focusing on seven indicators, by using the AGRICOLA and ISI-E databases from 1991 to 2005. We observed that research output in the discipline is much higher in South Africa and Kenya, and research collaboration is greater than non-collaborative research output and collaboration is less among African countries. The most popular research domains were found to exist in environmental science, soil science, plant/crop production and [agricultural] economics. Helpful conclusions and recommendations for an Agricultural policy, capacity and research orientation have been made.

1. Introduction

The African continent occupies about 11 million square miles of the planet's land mass, and is inhabited by approximately 690 million people (see http://www.maryknollafrica.org/Facts.htm). Most (70%) of the African population live in the rural areas where Agriculture is the predominant economic activity that employs 70% of the continents economically active population and accounts for about 25% of the gross domestic product and 60% of the export earning (Kiplang'at, 2004:328 &348; Diouf 2003).Whereas there are many ways of improving agricultural production in Africa, research is considered to play a significant role. A widely held view is that research would solve problems existing in the sector, integrate and interrogate its existing theories and hypothesis', create new knowledge, provide new knowledge and information for decisions informed by empirical evidence and rational thinking, and strengthen capacity building for agricultural research whilst developing the sector. A number of methods are used to determine research capacity that also applies to Agriculture. Among them are the determination of the number of research workers, research institutions, research output (e.g research publication), research policy, research structures and knowledge, and information systems and services. Arunachalam & Umarani (2001:905) observe that the future of a country's agriculture is dependent on research, public policy and the farming community's cooperative action. Related studies have been conducted in Mexico (De Arenas, Sandoval & Arenas 2003), Saskatchewan (Phillips 2001) and India (Arunachalam & Umarani 2001) but none, to the

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best of our knowledge, has been conducted in Africa. The aim of this study is to determine the nature of and trends in Agricultural research development in Africa between 1991 and 2005 through an informetric/bibliometric analysis on the AGRICOLA (on-line) and Thompson Scienctific's Science Citation Index-Expanded databases. The study determines the research indicators relating to geographic region or country of publication, national, institutional and individual levels of collaboration, subject, nature of records and research trends over 15 years (Notes: see above: research indicators). With a view of triangulation, the study also makes comparisons in coverage between AGRICOLA and the Thompson Scientifics' Science Citation Index Expanded database.

2. Method and Procedure

Content analysis conducted using descriptive informetric approaches enabled us to analyze research in Agriculture in Africa between 1991 and 2005 in two databases, namely, AGRICOLA and the Science Citation Index Expanded (SCI-E). AGRICOLA (AGRICultural OnLine Access) is a bibliographic database of citations for agricultural literature created by the National Agricultural Library (NAL) and its co-operators. The records describe publications and resources encompassing all aspects of agriculture and its allied disciplines as reflected in Table 2. The database includes journal articles, book chapters, short reports, and reprints. The SCI-E, on the other hand, is a multidisciplinary index for scientific journal literature. It comprehensively indexes 5,900 major journals across 150 scientific disciplines— 2,100 more journals than print and CD-ROM versions of the *SCI*. The *Index* includes all cited references captured from indexed articles. Additionally, the index provides access to both current information and retrospective data dating back to 1945 and covers approximately 423,000 new cited references per week. Its subject coverage in Agriculture that includes full-length, English-language-based texts is reflected in table 2. Data was extracted from the two databases using a uniform search strategy that combined two keywords. First, the keywords "Agriculture AND Africa" were used to extract data that were specific to agricultural research in Africa as a whole. Then, we conducted a search using the Boolean indicator "NOT":- applying the key word "Agriculture" AND each of the 53 countries (e.g. South Africa) NOT Africa". This process significantly minimized the number of duplicate entries. In the case of AGRICOLA records were stored as text files (i.e. *.txt) which were in turn cleaned of all duplicates and analyzed using BIBEXCEL computer software. Data were then merged and stored in Excel spreadsheets and analyzed using the indicators/output based on institutional and individual collaboration, subject category, nature of records and research trends over 15 years. Similarly, the SCI-E data were downloaded and stored as text files and analyzed using two computer programs (SITKIS v. 1.5 ©2005 and CITESPACE v. 2.0.1 ©2003-2005). SITKIS, developed by Henri Schildt from the Helsinki University of Technology, consists of citation data processing software that can be used to import ISI Web of Science files into a Microsoft Access database, thus enabling ease during modification. SITKIS also exports data from the database into UCINET compatible network graphs and Excel-compatible reports. The purpose of the program is to enable researchers to download and analyze bibliometric records quickly and easily, effectively simplifying what would otherwise be a considerably time-consuming process. Similarly, *CiteSpace* consists of citation data processing computer software that was developed by Chaomei Chen to assist in the preparation of author co-authorship networks, document co-citation networks, journal co-
citation networks, author co-citation networks, and term co-occurrence networks. Microsoft ®Excel 2003 was largely used to process and represent the quantitative data

3. Results

This section reports on the distribution of documents by year of publication, the distribution of documents by document type and the subject category of documents, by region/country of publication, by author's country of affiliation, by sources, by language, and by collaboration.

3.1. Distribution of documents by year of publication

A total of 2368 documents and 1254 papers were extracted from AGRICOLA and the SCI-E respectively. Six hundred and twenty seven (627) records found in the AGRICOLA database were excluded from the analysis according to the year of publication because their dates of publication, which were in the formats such as "between 1996 and 1998" and "1996 or 1997<1992-1995>" were unclear. Where there were two copyright dates of publication, only the most recent date was considered for analysis. This analysis yielded 1741 AGRICOLA records, whilst the SCI-E generated 1254 records (see Table 1). Table 1 show that there has been an incremental growth in the number of records indexed in the SCI and a negative growth in the case of AGRICOLA.

The number of records fell from 157 in 1991 to 13 in 2005 in AGRICOLA's case, whilst SCI-E's papers rose from 36 to 149 during the same period. Nevertheless, columns six and seven show that, cumulatively, the total number of records increased to the current 2368 for AGRICOLA, and 1254 for SCI-E.

Table 1: Distribution of documents by year of publication

Year of publication	Documents		% increase/decrease		Cumulative		% increase	
	AGRICOLA	SCI-E	AGRICOLA	SCI-E	AGRICOLA	SCI-E	AGRICOLA	SCI-E
2005	13	149	-61.76	16.78	1741	1254	0.75	11.88
2004	34	124	-34.62	0.81	1728	1105	2.01	11.22
2003	52	123	-37.35	8.94	1694	981	3.17	12.54
2002	83	112	-43.15	9.82	1642	858	5.32	13.05
2001	146	101	25.86	0.99	1559	746	10.33	13.54
2000	116	100	-5.69	19.00	1413	645	8.94	15.50
1999	123	81	-3.91	7.41	1297	545	10.48	14.86
1998	128	75	5.79	9.33	1174	464	12.24	16.16
1997	121	68	5.22	1.47	1046	389	13.08	17.48
1996	115	67	-11.54	1.49	925	321	14.20	20.87
1995	130	66	28.71	19.70	810	254	19.12	25.98
1994	101	53	-22.31	5.66	680	188	17.44	28.19
1993	130	50	-32.29	2.00	579	135	28.95	37.04
1992	192	49	-25.29	26.53	449	85	74.71	57.65
1991	257	36	-		257	36	-	
TOTAL	1741	1254	-		-		-	

3.2. Distribution of documents by document type

Agricultural information on Africa and her 53 countries was published in several different document types, amounting to 14 different categories. Ranked first were journal articles, which had 1175 and 1180 postings, followed by books (986), book chapters (151) and book reviews (56). Others, in descending order, were serials (47), editorials (9), meeting abstracts (5), audio-visual materials (4), manuscript collections (2), notes (2), machine-readable data files (2), maps (1), biographical items (1), and news items (1). Worth noting is the large representation of books and book chapters.

3.3. Distribution of documents by subject category

The grouping of documents by subject category was useful for establishing the size, scope, nature of subject coverage by the database on Agricultural research, and the various disciplines that are utilizing agricultural information. A similar approach has been adopted by Arunachalam & Umarani (2001). It's important to note that the SCI-E categorizes its records according to broader disciplines (subject categories) than AGRICOLA. The dominant subject areas/categories include Environmental sciences (274), Economics (254), Plant production (234), Soil cultivation (209), Agriculture, Multidisciplinary (179), Soil Fertility (170), Agronomy (143) and Agriculture [general] (119). Others are Soil science (116), Water resources (116) and Farm organization and management (114). We have observed that Animal production does not feature among the top categories.

Table 2: Distribution of documents by Subject Category

AGRICOLA			*SCIENCE CITATION INDEX*	
No.	*Subject Category*	*Records*	*Subject Category*	*Records*
1	Economics	254	Environmental Sciences	274
2	Plant production	234	Ecology	181
3	Soil cultivation	209	Agriculture, Multidisciplinary	179
4	Soil fertility and fertilizers	170	Agronomy	143
5	Agriculture(General)	119	Agriculture, Soil Science	116
6	Farm organization and management	114	Water Resources	116
7	Research	111	Economics	88
8	Pests of plants	96	Plant Sciences	79
9	Plant breeding	58	Agricultural Economics & Policy	78
10	Soil chemistry and physics	56	Geosciences, Multidisciplinary	76
11	Distribution and marketing	52	Meteorology & Atmospheric Sciences	64
12	Land economics	50	Nutrition & Dietetics	49
13	Rural development	44	Entomology	44
14	Soil erosion and reclamation	42	Public, Environmental & Occupational Health	42
15	Plant physiology and biochemistry	41	Food Science & Technology	37
16	Plant nutrition	40	Multidisciplinary Sciences	36
17	Economics of agricultural	37	Forestry	34
18	Weeds	35	Biodiversity Conservation	33
19	Drainage and irrigation	34	Engineering, Environmental	32
20	Soil biology	34	Tropical Medicine	28
21	Development aid: Aims, Policies, Etc	33	Zoology	28
22	Food composition	30	Veterinary Sciences	27
23	Plant diseases	30	Geography, Physical	24
24	Animal production	29	Parasitology	22
25	Natural resources	29	Marine & Freshwater Biology	19
26	Rural sociology	27	Agriculture, Dairy & Animal Science	18
27	Water resources and management	22	Biotechnology & Applied Microbiology	16
28	Economics and administration	18	Energy & Fuels	14
29	Food science	16	Engineering, Civil	13
30	Education and training	15	Horticulture	13
31	Farm equipment	15	Ornithology	12
32	General agriculture and rural	15	Limnology	11
33	Animal nutrition	13	Agricultural Engineering	9
34	Extension and advisory work	12	Chemistry, Analytical	9
35	Food processing	12	Chemistry, Applied	9
36	Meteorology and climatology	11	Toxicology	9
37	Pests of animals	11	Biology	8
38	Human nutrition, General	10	Evolutionary Biology	8
39	Social sciences and humanities	10	Anthropology	7
40	History	9	Oceanography	7
41	Protection of stored plant	9	Paleontology	7
42	Agricultural production costs	8	Remote Sensing	7
43	Microbiology of food processing	8	Engineering, Chemical	6
44	Pesticides, General	8	Imaging Science & Photographic Technology	6
45	Animal genetics	7	Pathology	6
46	Documentation	7	Computer Science, Interdisciplinary Applications	5
47	General agricultural economics	7	Mycology	5
48	Land resources	7	Biochemistry & Molecular Biology	4
49	Pollution, General	7	Computer Science, Software Engineering	4

3.4. *Distribution of documents by geographic region*

The distribution of documents by geographic region or country reflects the countries as subjects of research, i.e. the geographic areas of research focus. This analysis sought to answer the question of which area(s) was/were most researched in Africa. Table 3 indicates that as far as country output is concerned, South Africa was first and posted 153 (6.46%) records in AGRICOLA, and 147 (11.72%) in the SCI. Other regions/countries that ranked highly in both databases, included Kenya, Nigeria, Angola, Ethiopia, Sub-Saharan Africa, Southern Africa, Zimbabwe and Tanzania.

Table 3: Distribution of documents by Geographic region/territory

AGRICOLA **(N = 2368)**					*SCIENCE CITATION INDEX* **(N = 1254)**				
No.	*Rank*	*Geographic area*	*Records*	*%*	*No.*	*Rank*	*Geographic area*	*Records*	*%*
1	1	Africa	194	8.19	1	1	Africa	216	17.22
2	2	South Africa	153	6.46	2	2	Nigeria	184	14.67
3	3	Kenya	125	5.28	3	3	South Africa	147	11.72
4	4	Angola	113	4.77	4	4	West-Africa	125	9.97
5	5	Ethiopia	103	4.35	5	5	Kenya	122	9.73
6	6	Zimbabwe	98	4.14	6	6	Sub-Saharan Africa	120	9.57
7	7	Nigeria	92	3.89	7	7	Southern Africa	78	6.22
8	8	Tanzania	90	3.80	8	7	Egypt	78	6.22
9	9	Senegal	62	2.62	9	8	Tanzania	76	6.06
10	10	Ghana	58	2.45	10	9	Zimbabwe	73	5.82
11	11	Africa, Sub-Saharan	57	2.41	11	10	Niger	70	5.58
12	12	Uganda	46	1.94	12	11	Ethiopia	65	5.18
13	13	Niger	41	1.73	13	12	Cameroon	56	4.47
14	14	Sudan	39	1.65	14	13	Ghana	44	3.51
15	15	Cameroon	36	1.52	15	14	Uganda	43	3.43
16	16	Burkina Faso	33	1.39	16	15	East Africa	38	3.03
17	17	West Africa	31	1.31	17	16	Sudan	34	2.71
18	18	Malawi	30	1.27	18	17	Morocco	33	2.63
20	19	Benin	21	0.89	20	17	Burkina Faso	33	2.63
21	20	Mali	20	0.84	21	17	Central Africa	33	2.63
22	20	Tropics	20	0.84	22	18	Senegal	31	2.47
24	21	Algeria	18	0.76	24	18	Malawi	31	2.47
25	22	Southern Africa	17	0.72	25	19	Zambia	29	2.31
26	23	Botswana	16	0.68	26	20	Madagascar	28	2.23
27	24	Burundi	15	0.63	27	21	Cote D'ivoire	24	1.91
28	24	Mozambique	15	0.63	28	22	Botswana	21	1.67
29	25	Guinea	14	0.59	29	23	Benin	20	1.59
30	26	Zambia	13	0.55	30	24	Mali	20	1.59
31	27	Swaziland	12	0.51	31	24	Togo	12	0.96
32	27	Zaire	12	0.51	32	24	Gambia	12	0.96
33	28	Central Africa	11	0.46	33	24	Eastern Africa	12	0.96
34	28	Tunisia	11	0.46	34	25	Congo	11	0.88
35	29	Africa south of Sahara	10	0.42	35	26	Gabon	7	0.56
36	29	Togo	10	0.42	36	26	Lesotho	7	0.56

3.5. *Distribution of documents by country of publication/author's country of affiliation*

The distribution of documents by country of publication and the author's country of affiliation was based on the analysis of 1006 AGRICOLA and 1254 SCI records. Focus was placed on the country in which the document was published and the author's country of affiliation (i.e. where the author resides or works). Whereas the former provided information on where research in agriculture regarding Africa is published, the latter analysis provided information on the country conducting research on agriculture in Africa (i.e. the country from which the document originated). In other words, the former can be treated as the publisher (publishing country), whilst the latter refers to the country as the author/producer of the record. Leading in both cases (i.e. publisher and author/producer) is the USA, which published 222 records and authored 297

papers. The second ranked country-publisher is France, which posted 100 records, followed by England (85, 8.45%), Egypt (77, 7.65%), South Africa (66, 6.56%), Italy (45, 4.47%), and Ethiopia (41, 4.08%). Besides the USA, the most productive country-authors' were England (160, 12.80%), South Africa (132, 10.50%), Nigeria (109, 8.70%), Kenya (73, 5.80%), Netherlands (68, 5.40%), Germany (65, 5.20%), France (61, 4.90%), Australia (55, 4.40%) and Egypt (48, 3.80%). We observed was that most African countries that appeared as authors do not appear as major publishers, suggesting that documents associated with them are not necessarily published within the country.

3.6. Sources publishing Agricultural research on Africa

A total of 151 AGRICOLA and 442 SCI sources published agricultural research on Africa and her countries. The top ranking 39 sources that produced 4 or more records (in each database) are presented in Table 6. The top 10 most productive sources include Agriculture, ecosystems and environment (197, 42), Experimental agriculture (143, 15), Tropical Agriculture (115, 9), Journal of Sustainable Agriculture (69, 41), Outlook on Agriculture (81, 20), Journal of the Science of Food and Agriculture (79, 1), Agricultural Economics (32, 40), Agricultural Systems (20, 32), Food Policy (24, 19) and Agriculture and Human Values (37, 0)

Table 4: Sources publishing agricultural research on Africa, 1991-2005

No.	Source	AGRICOLA	SCI
1	Agriculture, ecosystems and environment	197	42
2	Experimental agriculture	143	15
3	Tropical agriculture	115	9
4	Journal of sustainable agriculture	69	41
5	Outlook on agriculture	81	20
6	Journal of the science of food and agriculture.	79	1
7	Agricultural economics	32	40
8	Agricultural systems	20	32
9	Food policy	24	19
10	Agriculture and human values	37	-
11	Applied soil ecology	36	1
12	Physics And Chemistry of The Earth	-	27
13	Biological agriculture and horticulture	22	3
14	Nutrient cycling in agro ecosystems	10	15
15	Horticultural products review FHORT	23	-
16	Communications in soil science and plant analysis	12	9
17	Land Degradation and development	-	19
18	Journal of Arid Environments	-	16
19	Applied engineering in agriculture	15	-
20	American journal of agricultural Economics	6	8
21	Biodiversity and Conservation	-	14
22	Agricultural Water Management	-	13
23	Ambio	-	13
24	Geoderma	-	13
25	Soil & Tillage Research	-	13
26	Climatic Change	-	12
27	South African Journal Of Science	-	12
28	Biological Conservation	-	11
29	Economic Botany	-	11
30	Environmental geology	4	7
31	Plant and Soil	-	11
32	Ecological Economics	-	10
33	Crop protection	4	4
34	Science	4	4
35	American journal of alternative agriculture	7	-
36	Ecology, economy & environment	7	-
37	Journal of hydrology	4	3
38	Journal of stored products research	4	3
39	Proceedings of the Natl Acad of Sci of the U.S.A	4	3

3.7. Language of publication

English language was the dominant language of publication of the agricultural research on Africa. It can be noted that AGRICOLA indexes documents in a variety of languages than the SCI-E that largely prefers English-based papers. The distribution of the documents by the language of publication is provided in Table 5

No.	LANGUAGE	AGRICOLA		SCI	
		No. of records	Percentage	No. of records	Percentage
1	English	2161	91.26	1225	97.69
2	French	138	5.83	19	1.52
3	German	15	0.63	9	0.72
4	French/English	17	0.72		
5	Spanish	6	0.25		
6	English/Afrikaans	4	0.17		
7	Russian	4	0.17		
8	Arabic	4	0.17		
9	Portuguese	3	0.13	1	0.08
10	Italian	3	0.13		
11	French/Arabic	2	0.08		
12	English/Arabic	2	0.08		
13	English/Spanish	2	0.08		
14	Afrikaans	2	0.08		
15	Ukranian	1	0.04		
16	Hungarian	1	0.04		
17	German/English	1	0.04		
18	English/Swahili	1	0.04		
19	Dutch	1	0.04		
	TOTAL	**2368**	**100.00**	**1254**	**100.00**

Table 5: Distribution of records by language of publication

3.8. Research Collaboration

AGRICOLA produced a total of 2269 (95.8) records that provided information on author names while the SCI provided author names in 1253 (99.9) records. The distribution of the records according to the number of authors for each record is as shown in Fig 1. In the case of AGRICOLA, one-author records were 934 followed by two-author records which numbered 596, three-author records (394), and four-author records (166). Institutional collaboration is presented in Table 6 which provides the leading collaborating institutions that produced 3 or more papers in the SCI. The high pattern of co-authorship was witnessed between the UNIV IBADAN, Nigeria and INT INST TROP AGR, Nigeria (8), INT INST TROP AGR and INT LIVESTOCK RES INST – Ethiopia, Kenya, Niger, and Nigeria – (6), TEXAS TECH UNIV, USA and UNIV GUELPH, Canada (6). Others include CSIR, South Africa and UNIV PORT ELIZABETH, South Africa (4), FENG CHIA UNIV, Taiwan and UNIV KANSAS (4), HARVARD UNIV, England and UNIV WISCONSIN, USA (4), and HARVARD UNIV and UNIV WISCONSIN (4), etc.The Food and Agriculture Organization, based in different countries (e.g. Austria, Burkina Faso, Italy, Togo, and Zimbabwe) contributed a large number of papers in conjunction with other institutions such as UNIV OXFORD (6), RUG (5), ITG IMT (3), TROP INST (3), and ITG (2). Visualizing the SCI co-authored papers produced 25 collaborative networks as shown in Fig 3. The size of the nodes and fonts indicates the size of contributions made by each author in the network. The largest network consists of 7 authors while the smallest network is made up of two authors. Major co-authorship contributions involved COWLING RM and RICHARDSON DM (6), IKOTUN T and FOKUNANG CN (5), FOKUNANG CN and DIXON AGO (5), NAPALA A and HENDRICKX G (5), IKOTUN T and DIXON AGO (5), KOLAWOLE GO and TIAN G (5), just to name a few.

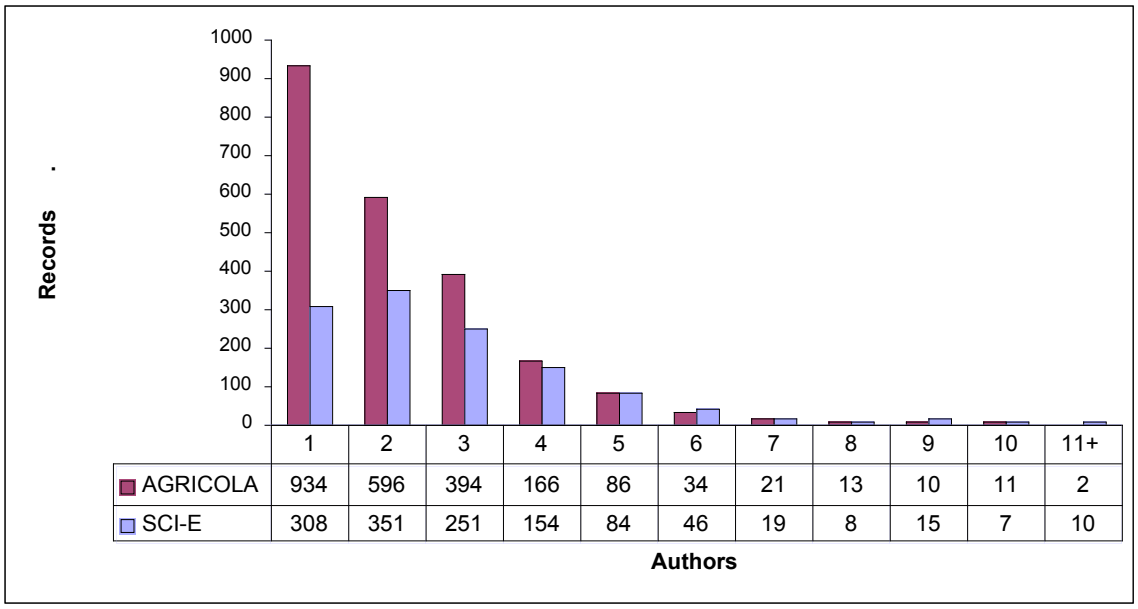

Fig 1: Distribution of records by number of authors for each record.

Institute A	Institute B	Records
UNIV IBADAN	INT INST TROP AGR	8
INT INST TROP AGR	INT LIVESTOCK RES INST	6
TEXAS TECH UNIV	UNIV GUELPH	6
CSIR	UNIV PORT ELIZABETH	4
FENG CHIA UNIV	UNIV KANSAS	4
HARVARD UNIV	UNIV WISCONSIN	4
KANSAS STATE UNIV	UNIV KANSAS	4
KASTENS INC FARMS	UNIV KANSAS	4
KATHOLIEKE UNIV LEUVEN	RMCA	4
RIVERS STATE UNIV SCI & TECHNOL	WORLD AGROFORESTRY CTR ICRAF	4
TUFTS UNIV	UNIV GEORGIA	4
UNIV CAPE TOWN	UNIV PORT ELIZABETH	4
UNIV KANSAS	FENG CHIA UNIV	4
UNIV PORT ELIZABETH	CSIR	4
UNIV PORT ELIZABETH	NEW S WALES NATL PARKS & WILDLIFE SERV	4
UNIV PRETORIA	US ECON RES SERV	4
BATTELLE MEM INST	USAMRIID	3
BROUWER ENVIRONM & AGR CONSULTANCY	FREE UNIV AMSTERDAM	3
CROPS RES INST	NOVA SCOTIA AGR COLL	3
CTR HOSP UNIV IBN EL JAZZAR KAIROUAN	INST PASTEUR TUNIS	3
GRAZ UNIV	RUSSIAN ACAD SCI	3
ICRAF	WAGENINGEN UNIV AGR	3
ILLINOIS DEPT AGR	USAMRIID	3
ILLINOIS DEPT PUBL HLTH	USAMRIID	3
KENYA AGR RES INST	WAGENINGEN UNIV AGR	3
METROPOLITAN WATER RECLAMAT DIST GREATER CHICAGO	UNIV IBADAN	3
MICHIGAN STATE UNIV	UNIV GUELPH	3
MICHIGAN STATE UNIV	UNIV TENNESSEE	3
NATL BOT INST	UNIV CAPE TOWN	3
NEW MEXICO STATE UNIV	WAGENINGEN UNIV AGR	3
ORSTOM	SECTEUR GRANDES ENDEMIES	3
ORSTOM	UNIV CAD	3
POTCHEFSTROOM UNIV CHRISTIAN HIGHER EDUC	UNIV GUELPH	3
PURDUE UNIV	WAGENINGEN UNIV AGR	3
RUSSIAN ACAD SCI	UFZ	3
UNIV DAR ES SALAAM	UNIV NAIROBI	3
UNIV NAIROBI	AGR UNIV WAGENINGEN	3
UNIV WISCONSIN	UNIV WATERLOO	3

Table 6: Institutional co-authorships

4. Discussions and Conclusions

We observed, first, that the distribution of documents by year of publication over the duration of 15 years, whilst exhibiting a cumulative growth of records in 1999, does also show largely negative growth, as is the case with AGRICOLA in 2005, reflected in table 1. This negative growth in turn suggests that either research output is indexed in databases other than AGRICOLA or ISI, or, those published are indexed in non subject gateway databases (e.g those on the web), or indexed in national/regional databases. There could of course be a general decline in the amount of Agricultural research output and support in Africa. Unfortunately, besides the South African based SABINET databases, recognizable databases in other parts of Africa are not known and this in turn affects the visibility of Africa's research. The limited growth between 2002 and 2005 could also be attributed to an indexing time lag factor [the period between the publication of a paper in the public domain and the date it is captured in abstracting and indexing journals] (see Daidato 1994:157). Second, most indexing and abstracting databases largely index journal articles. AGRICOLA, however, makes use of a unique approach involving the inclusive indexing of a variety of document types, particularly books. Among the 14 document types identified, articles (SCI and AGRICOLA) and books (only AGRICOLA) are dominant. We observe that there is a positive, albeit complex, attempt at incorporating inclusive indexing, which involves the inclusion of books and book chapters as reflected in the AGRICOLA database, that should augur well in diffusing criticism on the over reliability of journal articles for measuring research output. The small number of documents captured from the other 12 document types is not unusual. Third, a subject category that was created and arranged by the frequency of occurrence of records in the particular subject area as illustrated in Table 2 indicate that although a total of 98 subject areas were identified, when some of these domains were grouped into broader concepts or logically within a larger subject field,the dominant subject categories emerging were soil science; plant[crop]production; environmental science;[Agricultural]economics; general Agriculture; farm administration and management; research and animal production. One of the initial research assumptions was that crop/plant production and animal production would be dominant in the research domain. Regrettably, research in animal production is insignificant. This perhaps shows that less research is conducted in animal production, even though we believe that it is one of the largest agricultural sectors in Africa unlike in India as attested by Arunachalam & Umarani (2001:896) where plant production and its subfields occupy a leading position. Fourth, a comparative analysis of the distribution of research output by geographic region or country reveals that agricultural research in Africa is insignificant. But this could also mean that research output is not indexed in popular databases. Although there are other speculative reasons why Agricultural research would be higher in some countries in Africa(such as South Africa and Kenya), stronger research output is observed in less popular agricultural areas such as Angola, Ethiopia and Nigeria suggesting growing interest in increasing agricultural production in the formerly marginalized but potential agricultural areas. Fifth, a list of journals that publish Agricultural research on Africa in Table 4 captured some 39 sources out of an identified 595. It illustrated that most journals indexed by AGRICOLA are also indexed by ISI. However the number of indexed records from the same source is fairly varied (e.g SCI indexes less records). This could be attributed to the large variety of document types indexed by AGRICOLA. Sixth, as is widely known, Africa consists of 53 independent countries whose major non African languages, according to individual histories, are 21 (35.5%) English speaking [Anglophone], 24(40.6%) French speaking [Francophone], 5(8.4%) Portuguese speaking [Lucophone], 7 [11.8%] Arabic speaking and 2 [3.4%] Spanish speaking (Ocholla 2000:34). In some countries, however, one or more of the above languages is or are spoken as official and national languages alongside popular African local languages, and ultimately research output is published in these non-African languages. The dominant language of publication with regard to agricultural publications on Africa is English, although publication does occur in other languages as well. English was leading in both databases. 91.26% of AGRICOLA records and 97.69% of SCI papers were published in English, whilst French and German were ranked second and third as illustrated in Table 5. Other languages used in agricultural publications on Africa are Spanish, Afrikaans, Russian, Arabic, Portuguese, Italian, Ukranian, Hungarian, Swahili and Dutch. In some instances, documents were published in two languages, thus catering for a larger audience. This may also have been necessitated by collaboration amongst researchers from different countries, hence requiring the incorporation of multiple languages. Seventh, this study also focused on collaborative research output. There are several benefits of research collaboration as outlined by Katz & Martin (1997). Among them according to the two authors are: the fact that it enables researchers to share skills and techniques and is one

way of transferring knowledge (especially tacit knowledge); through clashing views it may bring about the cross-fertilization of ideas, which may in turn generate new insights or perspectives that individuals, working on their own, would not have grasped; collaboration provides intellectual companionship (i.e. within a practising community); collaboration plugs the researcher into a wider contact network in the scientific community; and it enhances the potential visibility of the work. Thus, collaboration helps speed up problem solving, stimulates creativity and enables inter-disciplinary boundary crossing which in turn enriches knowledge development and transfer. Co-authored records totaled 1335 in the case of AGRICOLA thus producing a collaboration degree (calculated as percentage proportion of co-authored records to single-authored records) of 58.84 and a collaboration coefficient (the ratio of the number of collaborative records to the total number of records published in a domain [Rao & Raghavan (2003)]) of 0.564 or [56.4]. The SCI produced 308 one-author records, 351 two-author records, 251 three-author records and 154 four author-records. The collaboration degree for the SCI was 75.42, with the collaboration coefficient slightly lower, i.e. 0.7536 (75.36). Generally, universities recorded the highest pattern of collaboration, either among themselves or between universities and non-academic institutions (e.g. agricultural research institutions/centers). We noted that research collaboration amongst African based researchers and individuals is very minimal. Finally, we recommend that the research agenda in Africa focuses on how to: support, balance and increase Agricultural research; increase research partnership or collaboration in general and among African countries in particular; create and support national indexing databases that would strongly reflect national or regional research output; and audit and map research outputs outside the public domain caused by non existent indexing services. Further, AGRICOLA and SCI based results be compared with national database indexing records (e.g SABINET based databases such as Current and Completed Research[C&CR] and the Union of Completed Thesis and Dissertations [UCTD]) in order to show how national agricultural research trends (reflected in SABINET for South Africa) can be utilized alongside internationally popular databases such as SCI.

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