

Open Access Digital Repositories of Agricultural Sciences in Africa: a webometric study

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The study examines different characteristics of link analysis and visibility of websites of agricultural digital repositories in Africa. The different link structures and the presence of web through different indicators like Internet access, web pages and link count are also highlighted. This study has used popular search engines Google) to analyse and measure the web presence of African agricultural repositories. An attempt has also been made to find out the correlation among the WIF and WISER indicators of selected agricultural repositories in Africa. The result shows that KARI e-repository- (Kenya Agricultural Research Institute) occupies the first place with 102467.5325 SWIF among 37 agricultural repositories in Africa. Again, it ranks 23rd position with 77 Web Pages and 02 In-link Web Pages and 0.025974026 RWIF. The findings of this study may guide webmasters and library professionals to identify the web presence of repositories and also help them to compare the repository websites of agricultural sciences in Africa by their WIF and WISER Rank.

Keywords: Digital Repositories, Agriculture, Web Impact Factor, WISER Rank, OpenDOAR, ROAR

1 Introduction

Agriculture plays a strategic role in the economic development of developing countries, and act as a backbone of an economy that provides the basic ingredients to mankind (Praburaj 2018). Agriculture provides the main source of food, income, and employment to rural populations of different countries (Monga 2012). The agricultural industry in Africa plays a leading role as a driver of economic transformation as witnessing unprecedented development of the continent. About 23% of the people in Africa depend on agriculture, with 30 to 60% of the total GDP of African continents coming from the agricultural sector and about 30% of the value comes from exports (Robert & Middleton 2018). Therefore, agriculture has become an important aspect in the development of the economic growth of any underdeveloped country. So agricultural knowledge that supports agriculture production, marketing, and post-harvest handling of agricultural products and management of natural resources plays an important role in the process of economic development in Africa. In the 21st century, due to the Open Access movement, all the academic and research organisations are trying to set up repositories to give free full-text access to their research outputs globally. The websites of agricultural digital repositories can be measured through webometric indicators and different web impact factors to show their global presence. The main objective of this study is to analyse and measure the web presence, as well as existence of different links such as self-link, external link of agricultural repository websites of Africa, using different indicators to show the global visibility of such repositories.

2 Agricultural repositories in Africa

Agriculture as a subject and discipline has become an important field of research among academic communities because it is one of the key sectors of an economy which provides the basic needs of people for food as well as larger employment opportunities and also helps to reform the economy of a country. In this point of view, different agricultural research Universities, Institutions, and development organisations of different countries have facilitated opportunities to disseminate their research outputs through the digital repositories based on their websites, so the research scholars can access the scholarly literature through the internet. According to OpenDOAR (A Global Directory of Open Access Repositories) and ROAR (Registry of Open Access Repositories), the total thirty-seven agricultural research organisations disseminate their research output through digital repositories based on their websites. The web presence of these repositories needs to be measured and their web activities evaluated through the help of different webometric indicators and different search engines.

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2.1 Agricultural repository: present status

The Open Access movement has changed the scholarly communication process in the 21st century through the development of institutional repositories in different disciplines all over the world. Different developed countries like the USA, Europe, and UK are the key players in offering agricultural repositories. Developing countries have just started joining this new movement to provide free access to scholarly literature (Roy, Biswas & Mukhopadhyay 2016). Africa emerges as the fourth largest contributor (OpenDOAR 2019; ROAR 2019) only after Europe, North America, and Asia in the agricultural field. In 1991, Dr. Paul Ginsparg has developed arXiv (<https://arxiv.org/>), the first subject repository to provide access to e-prints in disciplines such as Mathematics and Physics. The ROAR (Registry of Open Access Repositories, December 2019) currently reports 4162 repositories of which 167 (4%) are from the 'Agricultural' field. Asia ranks 1st position and contributes 56 repositories, 42 in Europe, 28 from South America, 11 in North America, 20 from Africa, and 2 in Oceania (ROAR, 2019). Another database, OpenDOAR (Directory of Open Access Repositories 2019) has recorded 5179 repositories, of which 186 (3.59%) repositories are from 'Agriculture, Food and Veterinary'. Europe contributes 78 repositories, 46 America, 41 in Asia, 19 repositories from Africa, and 04 repositories from Oceania, which have identified in figure 1 and 2.

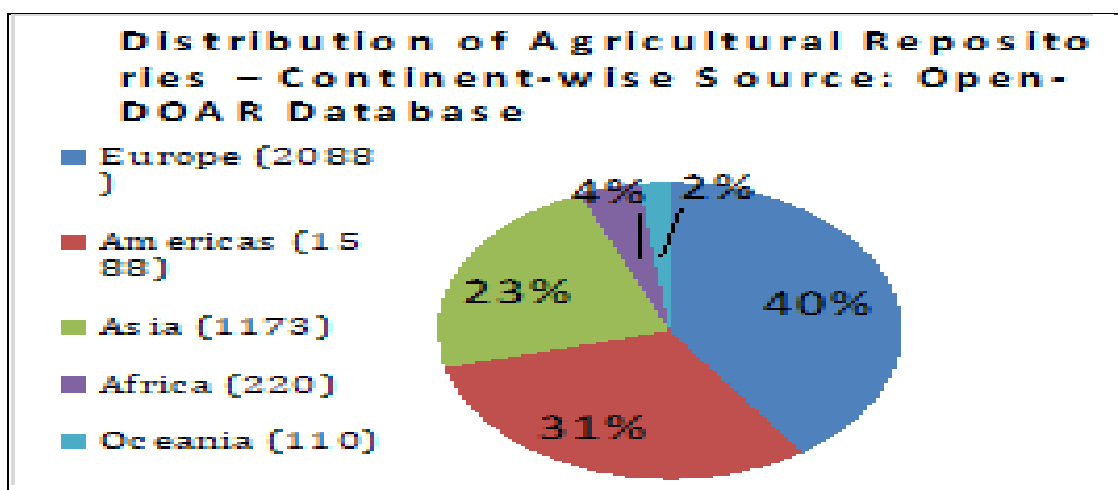


Figure 1: Distribution of agricultural repositories continent-wise (<https://v2.sherpa.ac.uk/opendoar/>)

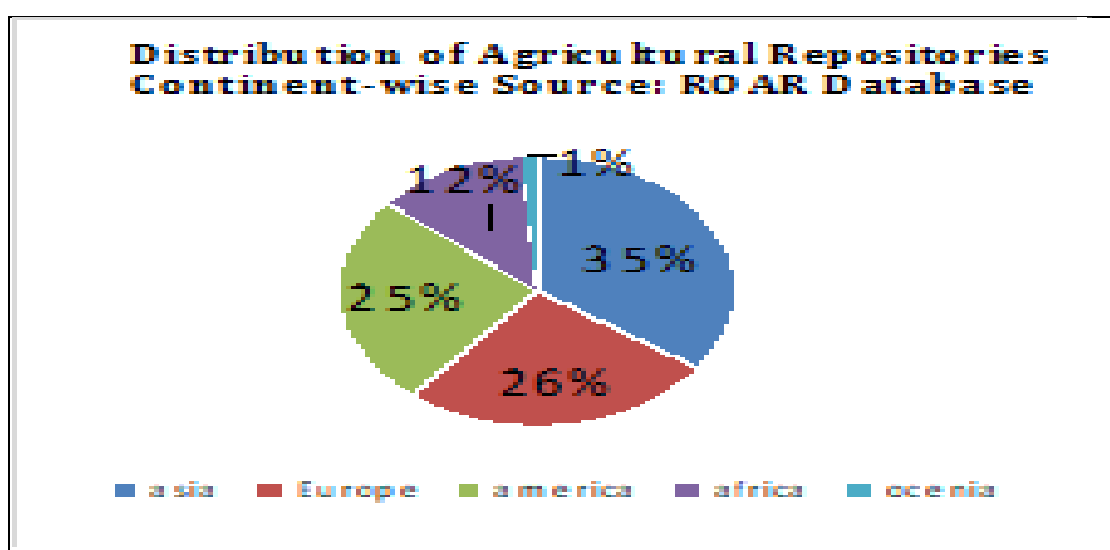


Figure 2: Distribution of agricultural repositories continent-wise (<https://roar.eprint.org>)

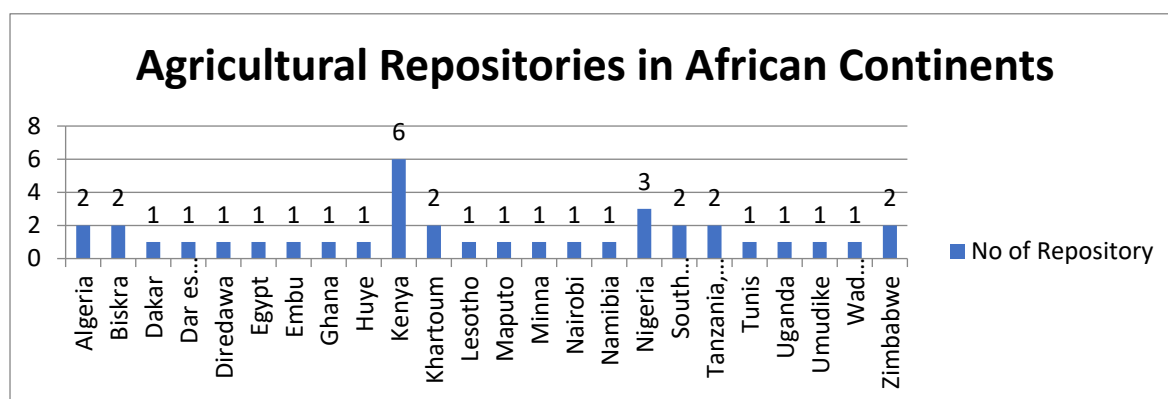


Figure 3 Agricultural repositories in African Continents country-wise (Africa)

3 Scope and limitations

This analytical study is limited to all open access repositories of agricultural science in African countries registered in OpenDOAR (21 OARS) and ROAR (18 OARS) databases within December 2019. For this study, a total of 37 unique repositories have been finally selected from ROAR and OpenDOAR, after eliminating all common repositories. In OpenDOAR and ROAR, the 'agriculture' as a key subject covers different fields such as agriculture, food, veterinary science, plant culture, forestry, animal culture, aquaculture, fisheries, angling and hunting sports.

4 Purpose and objectives of the study

The purpose of this study is to examine different characteristics of link analysis and visibility of websites of agricultural digital repositories in Africa. The specific objectives are to:

- analyse the selected OA agricultural repositories in Africa extracted from OpenDOAR and ROAR repository on the basis of their websites' activity;
- trace and classify the domain of the selected open accesses agricultural repositories and find out various types of links, explore the web presence and calculate various web impact factors of websites of the selected agricultural repositories;
- use WISER (**W**eb **I**ndicators for **S**cience, **T**echnology and **I**nnovation **R**esearch) ranking method to assess the Web presence of the open access agricultural repositories on the web; and
- compute the correlation between the ranking of WISER value and In-link WIF.

5 Review of literature

5.1 Webometrics is the quantitative study of the web and in this field several researchers have already conducted Webometric analysis of different fields. This review has been conducted under four broad headings viz. *Webometrics development, Web Content Analysis, Web Link Analysis, Web Technology Analysis and Web Impact Factor*. Bjorneborn and Ingwersen (2001) pointed out the framework for evaluating quality and content-based search engine coverage and performance. Web Impact Factors (Web-IF) measurement issues are also examined and outlined that transversal linkages may be an underappreciated beneficial effect of imperfect behavior, resulting in shorter pathways on the Web that could enhance the probability of encountering quality content in the intermediate web pages along the link path.

Bjorneborn and Ingwersen (2004) defined webometrics as generic sub-field of cybermetrics based on Informetric studies and the bibliometric approach belongs to Library and Information Science. Thelwall et al. (2008) studied Life Sciences research groups in Europe to assess the web connectivity using a commercial search engine which harnessed hyperlink data and used LexiURL for link analysis. It is supposed to be the first study which "applied" webometrics study for an external contract. Jalal, Biswas and Mukhopadhyay (2009) analysed websites of 13 Indian Institutes of Technology (IITs) and Indian Institutes of Management (IIMs) to determine the extent of the development of webometrics from bibliometrics. They reviewed the application, areas of webometrics research, the methodology adopted for data collection, techniques and tools of web analysis and the problems encountered in web research.

5.2 Web content analysis is one of the parameters of webometric analysis and many authors (Thelwall 2003, 2004; Thanuskodi 2012) have applied this technique in different fields to select the core journals. Thelwall (2003) introduced two web link count metrics such as in-links and out-links which is complemented to the Web Impact Factor. The in-links act as

an average degree of online informal scholarly communication and information used by the academics and out-links act as a degree of web interconnection in a given university. Thanuskodi (2012) analysed the content of web page of libraries of institutes of national importance in India and applied the bibliometric methods to evaluate the contents, the link structures and other research areas in webometrics, and suggested that the webometric techniques are still at an experimental stage.

Webometrics is a term that refers to the study of all network-based communication through the use of informetric or other quantitative measurements. Citations analysis treats hyperlinks to and from other websites as "bibliographical citations" in conventional analysis. Rousseau (1997) first discovered power-law occurrences on the Web and established the phrase. Thelwall (2001) applied the external Web Impact Factor of universities in Britain to know the relationship between academic hyperlinks and research activity. Ortega and Aguillo (2007) compared the link relationships of 23 Finnish, 11 Danish and 28 Swedish academic web domains with the European one in the Nordic academic web. The results showed that the Danish network had less visibility than other Nordic countries. Jalal, Biswas, and Mukhopadhyay (2010a) analysed the Web Impact Factors to investigate the effectiveness and relevance of Indian universities websites globally.

They developed a micro link topology for Indian universities, using WebCrawler i.e., SocSciBot and showed that all the NITs were closely related to each other, whereas nodes of State and Central universities were not linked significantly. To know the visibility and connectivity of 173 State universities in India, Shukla and Poluru (2012) analysed the websites of these universities using the WISER ranking method. Data were collected through Yahoo Site Explorer and Google Scholar. Sujithai, Maria and Jeyshankar (2013) analysed and compared the web pages of Indian Institute of Technology websites through a commercial search engine. The reliability of data was checked with Histogram and Scatter Plot which were analysed with SPSS software. The result revealed that External link of web pages were greater than other link pages. Using the Google search engine, Majhi and Das (2020) investigated several web impact factors of IDRs website in Southern Asia. They also ranked digital repositories of Southern Asia utilising different web Impact Factors and assessed the link network visualisation. Ghosh and Roy (2021a, 2021b & 2021c) analysed websites of different agricultural repositories in Asia, Europe, and the Oceania continents, based on Web Impact Factor and WISER value to determine their presence, as well as their visibility on the web.

Vaughan (2004b) in his study applied a set of measurements for evaluating the three different commercial search engines i.e., Google, AltaVista and Teoma to test their performance in the web. Vaughan and Zhang (2007) examined the websites of commercial, educational, governmental and organisational domains of U.S., China, Singapore, and Taiwan through random sampling by custom-built computer programs. And the result revealed that the sites of US domains got higher positions than other countries. Bar-Ilan (2008) evaluated the performance of search engine through a set of measures that provide guideline for testing search engines. Thelwall (2008b) compared the API of Google, Live Search, and Yahoo to find out the consistency and inconsistency of these three selected search engines and suggested that the quantitative findings from the three search engines are usually similar. However, there are some unanticipated inconsistencies in the number of different URLs, sites, and domains returned within the search results that consumers should be aware of. For 'hit count estimations' author suggested Google, and Yahoo! for Webometric uses.

Ingwersen (1998) analysed seven small and medium-scale national and four large web domains and six institutional websites for investigating the feasibility and reliability of calculating impact factors of these websites. The findings showed that Web-IFs for national and sector domains may be calculated with high confidence, while institutional Web-IFs might be handled with care. Smith (1999b) explained the WIF of web pages of Australasian universities for comparing the relative attractiveness of web spaces of Australasian universities and electronic journals (Author/LRW). Walia and Kaur (2008) investigated selected Indian library associations' websites to realise the presence of Indian library associations over the web. Babu, Jayshankar and Rao (2009) analysed the web impact factor of 34 state agricultural universities in India, based on three indicators related to domain systems of the websites, number of web pages and link pages, and different Impact Factor. Jalal, Biswas and Mukhopadhyay (2010b) examined the web presence and Web Impact Factor of selected Asian countries using different search engines like AltaVista, Google, Yahoo and MSN and the result revealed that China, Japan and India occupied the highest rank in compared to other Asian countries.

Thanuskodi (2011) in his study analysed and compared the WIF of private engineering colleges in Tamil Nadu using the AltaVista search engine due to its coverage in comparison to other commercial search engines and found that general information about homepage features is more in PEC, EEC, SCT and lease in RMKEC and SJCE. Islam and Alam (2011) conducted a study about the 44 private universities in Bangladesh to find out the impact of websites and their web impact factor based on the webometrics indicator. The result showed that the universities did not have much of an impact factor on the web and were not known internationally due to insufficient number of link pages. Walia and Gupta (2012) analysed web impact factors and the quantity of information available in the form of rich files on national library websites. The study discovered that the websites of the United States, Australia and the United Kingdom were more visible and had more

materials than the websites of India, Namibia, and South Africa. Majhi and Das (2019) used the Web Impact Factor analysis to evaluate the websites of India's High Courts in order to determine their web presence.

6 Methodology

To conduct the study, data were collected from the websites of selected agricultural digital repositories registered in ROAR and OpenDOAR using Google search engine. A total of 37 unique repositories were finally selected from 39 repositories in Africa and the collected data were analysed and interpreted keeping in mind the objective of the study. The methodology has two parts – i) webometric study which includes identifying the Web Impact factors, WISER rank analysis and ii) evaluating the correlation between the ranking of WISER value and In-link WIF.

6.1 Data collection through searching

For the present study, data were collected using Google's advanced queries to collect the approximate number of pages from the websites of 37 selected agricultural repositories of Africa during 15-24 December 2019 by using a suitable search engine, i.e., Google (www.google.com) that counts the number of pages in websites and number of pages linking to the websites. The following search statements were used to collect data for each of the 37 repository websites as:

- **site: url**-this will extract the total number of web pages to the websites under the url.
- **link: url**- this will retrieve the total number of web pages linking to the websites
- **link:url AND site:url**-it will provide a complete report of a number of web pages under the websites that provide links from the same websites i.e., Self-Link pages.
- **link:url NOT site: URL** - it will provide a complete report of a number of links incoming from other websites i.e In-Link / Backlink pages.
- **link:url AND NOT site: URL**- it will provide a complete report of a number of web pages not under the websites which provide links from the other websites i.e., External-Link pages. Based on the command syntax of Google, the above five retrieval arguments were applied to collect data of each Open Access Institutional Agricultural Digital Repositories in Africa.

Table 1 Search syntax used

Search Command	Results
site: URL	Retrieve total number of web pages
link: URL	Retrieve the number of web pages with a hyperlink with the specified URL/website or domain name
link: URL AND site: URL	Retrieve total number of self-links i.e. Retrieve the number of web pages under a URL (links from the same website).
link: URL NOT site: URL	Retrieve total number of links incoming from other websites i.e. Inlink/backlink pages
link: URL AND NOT site: URL	Retrieve the number of web pages not under a URL/website or domain name, i.e. External-link pages
site: abc filetype:pdf/ppt/doc	Report total number of pdf/ppt/doc files

Web search engines are commonly used in Webometric studies such as Yahoo (<https://www.yahoo.com>), Google (<https://www.google.com>), Hotbot (<https://www.hotbot.com>), Exalead (<https://www.exalead.com>) and Bing (<https://www.bing.com>). Advanced query syntax of different search engines helps to access web data and to obtain hyperlink counts.

For this study, the five special command syntaxes as per Table 1, were used for accessing the number of web pages, number of hyperlink web pages, number of self-link pages, number of external-link pages, and number of in-link pages from Google search engine.

6.2 Calculation of web impact factors

Most of the webometric study is based on the web impact factors (WIFs) of either simple WIF (WIFs) or revised WIF (WIFs). The calculation of WIF is as follows:

1. Simple WIF = $\frac{\text{Total number of links / hyperlinks (external-link and self-link web pages) (LWP)}}{\text{Total number of web pages (NWP)}}$
(SWIF)
2. Self-link WIF = $\frac{\text{Total number self-link web pages}}{\text{Total number of web pages (NWP)}}$
(SLWIF)
3. External-link WIF = $\frac{\text{Total number of external-link web pages}}{\text{Total number of web pages (NWP)}}$
(ELWIF)
4. InLink / Revised WIF = $\frac{\text{Total number of in-link web pages}}{\text{Total number of web pages (NWP)}}$
(ILWIF / RWIF)

Where A=Total number of web pages of a given site; B=Total number of external back links to a given site; C=Total number of self-link of a given site; D=total number of links to a given site.

6.3 Calculation of WISER INDEX VALUE

The activities of agricultural digital repositories are multi-dimensional and are reflected through their web presence. Almind and Ingwersen (1997) first used the term Web indicator. The WISER Ranking value is calculated through the combination of these four indicators viz. *the number of in-links or external links, the number of web pages, the number of rich files in a web domain and the number of publications in Google scholar database* based on the following formula where each one has a different weight:

$$\text{Webometrics Rank (position)} = 4*\text{RankV} + 2*\text{RankS} + 1*\text{RankR} + 1*\text{RankSc};$$

Where, **V**=Visibility; **S**= Size; **R**= Rich Files and **Sc**= Google Scholar.

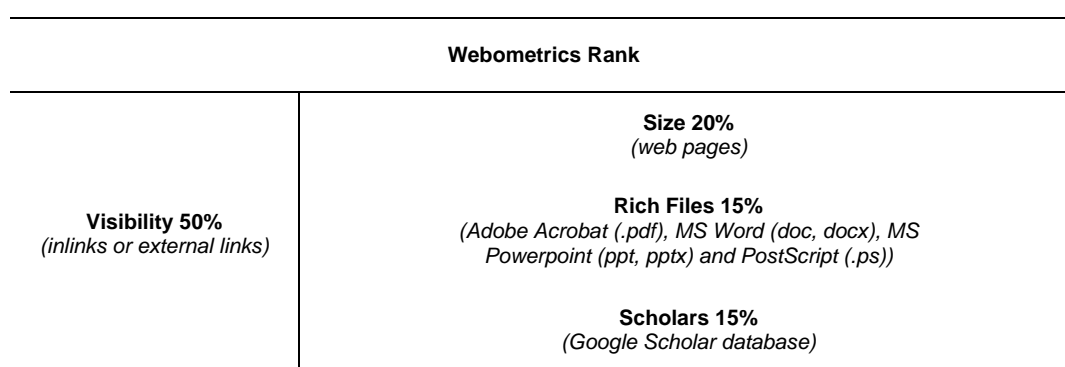


Figure 4: WISER ranking (<http://www.webometrics.info/en/Methodology>)

Aguillo, et al. (2008) has proposed the formula for WISER ranking as: WISER ranking = log (Visibility 50%) + log (Size 20%) + log (Rich files 15%) + log (Scholars 15%) as presented in Figure 4.

7 Data analysis and interpretation

WIF for each Agricultural digital repository has been calculated on the basis of formula given in Figure 4. These are WIF (simple) a ratio of the number of total link pages and number of web pages; WIF (Self link)-a ratio of number of total self-link pages and number of web pages; WIF (External link)-a ratio of number of total external link pages and number of web pages; WIF (Revised link)-a ratio of number of total in-link pages and number of web pages which reflex of the degree of impact of the domain spaces on the Web. A matrix may represent the calculation of WIF of different web spaces in different levels shown in tables 2 to 5.

Table 2: Simple Link Web Impact Factor

Repository name	NWP (A)	LP (B)	SIMPLE LINK IF (B/A)	RANK
KARI e-repository-Kenya Agricultural Research Institute	77	7890000	102467.5325	1
IR of the University of Limpopo (ULSpace)	4810	453000000	94178.79418	2
Repository of the Agricultural Research Corporation (ARC) - Sudan	74	2280000	30810.81081	3
Mahider- CGIAR - International Livestock Research Institute	19	29300	1542.105263	4
HIT Scholar-Harare Institute of Technology Library, Zimbabwe	1890	2180000	1153.439153	5
Repository of the Egyptian Agricultural Research Centre, Egypt	9890	9630000	973.710819	6
Bindura University of Science Education IR	5590	4550000	813.9534884	7
DSpace at My University: Alzaiem Alazhari University Repository	1260	241000	191.2698413	8
University of Nigeria Nsukka IR	876	41000	46.80365297	9
Egerton University IR	17600	776000	44.09090909	10
UPSpace- IR of the University of Pretoria	159000	1420000	8.93081761	11
OceanDocs: Institute National des Sciences et Technologies de la Mer	708	4260	6.016949153	12
University of Cape Coast IR	789000	2100000	2.661596958	13
RUFORUM Institutional Repository	29200	77400	2.650684932	14
University of Biskra Theses Repository	17000	32500	1.911764706	15
Federal University of Technology, Minna IR	2940	5190	1.765306122	16
Federal University Oye Ekiti Repository	5850	10100	1.726495726	17
Ahmadu Bello University Inst. Digital Rep.	19600	32000	1.632653061	18
UNAM Scholarly Repository-of the University of Namibia	115000	149000	1.295652174	19
JKUAT Digital Repository- Jomo Kenyatta Univ of Agri. And Tech	53500	63900	1.194392523	20
IDEP DOCUMENT SERVER of African Inst. for Economic Development and Planning	8540	7490	0.87704918	21
DSpace Universite de Biskra: Home	85000	55000	0.647058824	22
AgriSearch Repository (Dept of Agricultural Research, Lesotho)	7	3	0.428571429	23
Bouira University Digital Space	41800	14200	0.339712919	24
Haramaya University IR	41000	13800	0.336585366	25
dspace@UABT-IR OF Universite Abou Bekr Belkaid Tlemcen	123000	26900	0.218699187	26
Rongo University Repository	2450	508	0.207346939	27
EUC Repository Home	18000	3710	0.206111111	28
Khartoum space-Repository of The University of Khartoum	274000	45000	0.164233577	29

University of Nairobi Digital Repository	1361000	213000	0.156502572	30
University of Dar es Salaam Research Repository	234000	25200	0.107692308	31
Sokoine University of Agriculture Inst. Rep.	165000	17000	0.103030303	32
Nelson Mandela African Inst. of Sci. and Tech. Repository	3550	10	0.002816901	33
University of Fort Hare IR	0	0	0	34
DSpace at MOUUAU-IR of Michael Okpara University of Agriculture	0	0	0	35
IAPRA: Irish African Partnership Research Archive	0	0	0	36
National University of Rwanda Repository	0	0	0	37

Note: NWP=No. of Web Page, SWLP=Simple Link Web Page, SWIF=Simple Link Web Impact Factor, IR=Institutional Repositories

Table 2 illustrates the rank distribution of agricultural digital repositories in Africa according to their Simple Web Impact Factor (SWIF). By dividing the number of link pages by the number of web pages, the SLWIF for each repository has been calculated. The KARI e-repository occupies first place with 102467.5325% SWIF. The second and third places go to the Institutional Repository of the University of Limpopo (ULSpace), and the Repository of the Agricultural Research Corporation (ARC) – Sudan. The University of Nairobi Digital Repository (13,61000), the University of Cape Coast Institutional Repository (789000), Khartoum Space (274000), and the University of Dar es Salaam Research Repository (234000) have more web pages than the three agricultural repositories mentioned above, but they ranked 26th, 14th, 30th, and 32nd, respectively, based on their simple link web impact factor.

Table 3: Self-Link Web Impact Factor

Repository Name	NWP (A)	SLP (C)	SELF L-IF C/A	RANK
Repository of the Egyptian Agricultural Research Centre, Egypt	9890	4490	0.453993933	1
Agri Search Repository	7	3	0.428571429	2
Federal University of Technology, Minna IR	2940	930	0.316326531	3
IDEP Document Server of African Inst. For Economic Development and Planning	8540	2570	0.300936768	4
IR of the University of Limpopo (ULSpace)	4810	1360	0.282744283	5
Mahider- CGIAR - International Livestock Research Institute	2520	656	0.26031746	6
Repository of the Agricultural Research Corporation (ARC) - Sudan	74	17	0.22972973	7
UPSpace- Institutional Repository of the University of Pretoria	159000	31900	0.200628931	8
Bindura University of Science Education Institutional Repository	5590	1090	0.194991055	9
OceanDocs: Institut National des Sciences et Technologies de la Mer	708	133	0.187853107	10
University of Nigeria Nsukka Institutional Repository	876	147	0.167808219	11
Haramaya University Institutional Repository	41000	5880	0.143414634	12
NM-AIST Repository- Nelson Mandela African Inst. of Sci. and Tech.	3550	357	0.10056338	13
Egerton University Institutional Repository	17600	1530	0.086931818	14
Federal University Oye Ekiti Repository	5850	507	0.086666667	15
Rongo University Repository	2450	176	0.071836735	16

JKUAT Digital Repository- Jomo Kenyatta Univ of Agri. & Tech	53500	3610	0.067476636	17
EUC Repository	18000	1130	0.062777778	18
RUFORUM Institutional Repository	29200	1700	0.058219178	19
DSpace at My University: Alzaiem Alazhari University Repository	1260	67	0.053174603	20
KARI e-repository-Kenya Agricultural Research Institute	77	4	0.051948052	21
Ahmadu Bello University IDR	19600	805	0.041071429	22
Khartoumspace-Repository of The University of Khartoum	274000	10700	0.039051095	23
Bouira University Digital Space	41800	1510	0.036124402	24
University of Biskra Theses Repository	17000	592	0.034823529	25
University of Nairobi Digital Repository	1361000	35500	0.026083762	26
dspace@UABT-IR OF Université Abou Bekr Belkaid Tlemcen	123000	2820	0.022926829	27
Sokoine University of Agriculture IR	165000	3420	0.020727273	28
University of Dar es Salaam Research Repository	234000	4530	0.019358974	29
DSpace Universite de Biskra: Home	85000	1430	0.016823529	30
UNAM Scholarly Repository-of the University of Namibia	115000	1880	0.016347826	31
HIT Scholar-Harare Institute of Technology Library, Zimbabwe	1890	19	0.01005291	32
University of Cape Coast Institutional Repository	789000	385	0.000487959	33
DSpace at MOUAU	0	0	0	34
IAPRA: Irish African Partnership Research Archive	0	0	0	35
National University of Rwanda Repository	0	0	0	36
University of Fort Hare Institutional Repository	0	0	0	37

Note: NWP=No. of Web Page, SWLP=Self Link Web Page, SWIF=Self Link Web Impact Factor

The ranking of Agricultural Repositories in Africa is based on their Self Link Web Impact Factor as showed in Table 3. Repository of the Egyptian Agricultural Research Centre, Egypt occupies the first place with 4490 Self Link Pages and 9890 web pages with 0.453993933 % SWIF. AgriSearch Repository (Dept of Agricultural Research, Lesotho) and Institutional Repository of Federal University of Technology, Minna ranked 2nd and 3rd place with SWIF of 0.428571429 and 0.316326531 respectively. The University of Nairobi Digital Repository (1361000), University of Cape Coast Institutional Repository (789000), Khartoumspace (274000), University of Dar es Salaam Research Repository (234000), Sokoine University of Agriculture Institutional Repository (165000) have a greater number of web pages compared to all other repositories. These repositories ranked 26th, 33th, 23rd, 29th, 28th position respectively due to their insufficient number of Link Pages compared to their number of web pages.

Table 4: External Link Web Impact Factor

Repository Name	NWP (C)	ELP (D)	ELIF D/C	RANK
AgriSearch Repository (Dept of Agricultural Research, Lesotho)	7	3	0.4285714	1
Rep. of the Agricultural Research Corporation (ARC),Sudan	74	26	0.3513514	2
IDEP Document Server of African Inst. For Economic Development and Planning	8540	2520	0.295082	3
Federal University of Technology, Minna Inst. Repository	2940	816	0.277551	4
IR of the University of Limpopo (ULSpace)	4810	1250	0.2598753	5
Mahider- CGIAR International Livestock Research Institute	2520	553	0.2194444	6
UPSpace- the IR of the University of Pretoria	159000	30800	0.1937107	7
OceanDocs: Inst.National des Sciences et Tech. de la Mer	708	118	0.1666667	8
Haramaya University Institutional Repository	41000	5810	0.1417073	9
Bindura University of Science Education Institutional Repo.	5590	768	0.1373882	10
University of Nigeria Nsukka Institutional Repository	876	116	0.1324201	11
Nelson Mandela African Inst. of Sci. and Tech.Repository	3550	383	0.1078873	12
Egerton University Institutional Repository	17600	1420	0.0806818	13
Rongo University Repository	2450	189	0.0771429	14
JKUAT Digital Rep.- Jomo Kenyatta Univ of Agri.and Tech	53500	3780	0.0706542	15
Federal University Oye Ekiti Repository	5850	370	0.0632479	16
EUC Repository - Embu University College Repository	18000	1010	0.0561111	17
RUFORUM Institutional Repository	29200	1620	0.0554795	18
KARI e-repository (Kenya Agricultural Research Institute)	77	4	0.0519481	19
Khartoumspace-University of Khartoum	274000	10800	0.0394161	20
University of Biskra Theses Repository	17000	626	0.0368235	21
Ahmadu Bello University Institutional Digital Repository	19600	673	0.0343367	22
University of Nairobi Digital Repository	1361000	35500	0.0260838	23
Bouira University Digital Space	41800	1060	0.0253589	24
Sokoine University of Agriculture Institutional Repository	165000	3930	0.0238182	25
HITScholar-Harare Institute of Technology Repository	1890	42	0.0222222	26
dspace@UABT-University of Tlemcen	123000	2530	0.0205691	27
University of Dar es Salaam Research Repository	234000	4520	0.0193162	28
UNAM Scholarly Repository	115000	1820	0.0158261	29
DSpace:University of Biskra	85000	1310	0.0154118	30
Rep. of the Egyptian Agricultural Research Centre, Egypt	9890	86	0.0086957	31
DSpace at My University: Alzaiem Alazhari Univ.Repository	1260	8	0.0063492	32

University of Cape Coast Institutional Repository	789000	383	0.0004854	33
DSpace at MOUAU	0	0	0	34
IAPRA: Irish African Partnership Research Archive	0	0	0	35
National University of Rwanda Repository	0	0	0	36

Note: NWP=No. of Web Page, EWLP=External Link Web Page, EWIF=External Link Web Impact Factor

Table 4 reveals the rank distribution of African Open Access Agricultural Digital Repositories based on their External Link Web Impact Factor (ELWIF). AgriSearch Repository (Dept of Agricultural Research, Lesotho) occupies the first place with 07 web pages, 03 link pages and its ELWIF is 0.428571429. Repository of the Agricultural Research Corporation of Sudan and IDEP Document Server of African Inst. for Economic Development and Planning have ranked 2nd and 3rd position with the EWIF as 0.351351351 and 0.295081967 respectively. AgriSearch Repository (Dept of Agricultural Research, Lesotho) is in the 2nd position with the SELWIF as 0.428571429.

Table 5 Revised-Link Web Factor

Repository Name	NWP (C)	IN-LP (D)	RLIF D/C	RANK
AgriSearch Repository (Dept of Agricultural Research, Lesotho) (Dept of Agricultural Research, Lesotho)	7	3	0.4285714	1
Repository of the Egyptian Agricultural Research Centre, Egypt	9890	3350	0.338726	2
IR of the University of Limpopo (ULSpace)	4810	1240	0.2577963	3
IDEP Document Server of African Inst. For Economic Development and Planning	8540	2160	0.2529274	4
Ahmadu Bello University Institutional Digital Repository	19600	3950	0.2015306	5
Mahider- CGIAR - International Livestock Research Institute	2520	505	0.2003968	6
UPSpace- the IR of the University of Pretoria	159000	29200	0.1836478	7
Bindura University of Science Education IR	5590	737	0.1318426	8
University of Nigeria Nsukka IR	876	111	0.1267123	9
OceanDocs: Institut National des Sciences et Tech. de la Mer	708	80	0.1129944	10
Haramaya University IR	41000	4110	0.1002439	11
Nelson Mandela African Inst. of Sci. and Technology Repository	3550	331	0.0932394	12
Federal University of Technology, Minna Inst. Repository	2940	238	0.0809524	13
Repo. of the Agricultural Research Corporation (ARC) - Sudan	74	5	0.0675676	14
Egerton University IR	17600	1060	0.0602273	15
Rongo University Repository	2450	146	0.0595918	16
Federal University Oye Ekiti Repository	5850	332	0.0567521	17
JKUAT Digital Repo.- Jomo Kenyatta Univ of Agri.and Tech	53500	2820	0.0527103	18
EUC Repository - Embu University College Repository	18000	844	0.0468889	19
University of Biskra Theses Repository	17000	539	0.0317059	20
RUFORUM Institutional Repository	29200	846	0.0289726	21
Khartoumspace-University of Khartoum	274000	7610	0.0277737	22

KARI e-repository (Kenya Agricultural Research Institute)	77	2	0.025974	23
University of Nairobi Digital Repository	1361000	32100	0.0235856	24
dspace@UABT-University of Tlemcen	123000	2370	0.0192683	25
Sokoine University of Agriculture IR	165000	2890	0.0175152	26
UNAM Scholarly Repository	115000	1400	0.0121739	27
HITScholar-Harare Institute of Technology Repository	1890	23	0.0121693	28
DSpace:University of Biskra	85000	930	0.0109412	29
University of Dar es Salaam Research Repository	234000	1940	0.0082906	30
Bouira University Digital Space	41800	260	0.0062201	31
DSpace at My University: Alzaiem Alazhari Univ. Repository	1260	3	0.002381	32
University of Cape Coast IR	789000	277	0.0003511	33
University of Fort Hare Institutional Repository	0	0	0	34
DSpace at MOUAU	0	0	0	35
IAPRA: Irish African Partnership Research Archive	0	0	0	36
National University of Rwanda Repository	0	0	0	37

Note: NWP=No. of Web Page, IWLP=In-Link Web Page, RWIF=Revised Link Web Impact Factor, IR=Institutional Repository

Table 5 exhibits the rank distribution of the 37 African Open Access Agricultural Digital Repositories according to their revised web impact factor (RWIF). It has been calculated by putting the following formula i.e., Revised Web Impact Factor=E/A Where E=Internal Link Web Page and A=Number of Web Page. AgriSearch Repository (Dept of Agricultural Research, Lesotho) ranks first position with 07 web pages and 03 in-link web pages and 0.428571429 % RWIF; followed by Repository of the Egyptian Agricultural Research Centre, Egypt with 9890 web pages and 3350 In-link web pages and 0.338726%. Institutional Repository of the University of Limpopo (ULSpace) occupies 3rd position with 0.257796258%. The University of Nairobi Digital Repository and UPSpace Repository again have the maximum number of In-link Pages (i.e. 32100 & 29200) ranked 24th and 7th, position due to their less impact factor compared to all other repositories.

8 Calculation of WISER Rank

According to the WISER (Web Indicator for Science, Technology and Innovation Research) ranking method, the four indicators namely Size (S), Visibility (V), Rich Files (R) and Scholar (Sc) are used and have been given different weights to each indicator to calculate the rank of repositories. This ranking method is used to know the visibility and connectivity of the open access agricultural repositories on the web. The WISER Rank is calculated by using the following formula: WISER Rank = log (Visibility 50%) + log (Size 20% +log (Rich Files 15%) + log (Scholar 15%) recommended by the World Webometrics Group (<http://www.webometrics.info/en/Methodology>). The WISER Rank of selected repositories is presented in Table 6.

Table 6 Ranking of Repositories based WISER INDICATOR

SL No	List of Repositories	Rich Files							Total	GS	WISER INDEX VALUE	RANK
		NWP										
		IN-LP			No of Pdf	No of PPT	No of Doc	No of Ps				
1	University of Nairobi Digital Repository	1361000	32100	213000	106000	8	84	0	106092	12300	22.84403	1
2	UPSpace- the IR of the University of Pretoria	159000	29200	1420000	32000000	10100	54400	7980	32072480	2170	22.66499	2
3	Khartoum space-Rep. of The Univ. of Khartoum	274000	7610	45000	16200	1	1	0	16202	467	18.58999	3
4	University of Cape Coast IR	789000	277	2100000	290000	124	1620	187	291931	73	18.51946	4
5	dspace@UABT- University of Tlemcen	123000	2370	26900	24600	1	59	0	24660	2290	18.26061	5
6	Repository of the Egyptian Agricultural Research Centre, Egypt	9890	3350	9630000	14700000	2090	21800	7390	14731280	71	17.48916	6
7	IR of the University of Limpopo (ULSpace)	4810	1240	4.5E+08	22600000	1960	29600	4680	22636240	117	16.83492	7
8	UNAM Scholarly Repository	115000	1400	149000	50800	6	134	54	50994	49	16.61946	8
9	University of Dar es Salaam Research Repository	234000	1940	25200	9860	4	76	0	9940	35	16.5219	9
10	Sokoine University of Agriculture IR	165000	2890	17000	2700	0	4	0	2704	131	16.39937	10
11	DSpace: Univ. of Biskra	85000	930	55000	20700	1	20	1	20722	153	16.28267	11
12	JKUAT Digital Repository- Jomo Kenyatta Univ of Agri.and Tech	53500	2820	63900	7980	1	110	0	8091	96	15.75146	12
13	University of Biskra Theses Repository	17000	539	32500	43600	3	76	2	43681	533	15.51372	13
14	Ahmadu Bello University Institutional DR	19600	3950	32000	7990	0	9	0	7999	148	15.20863	14
15	Bouira University Digital Space	41800	260	14200	6430	0	2	0	6432	484	15.10473	15
16	RUFORUM IR	29200	846	77400	2350	3	1060	0	3413	458	15.00636	16
17	Egerton University IR	17600	1060	776000	45900	2	173	23	46098	22	14.47666	17
18	Haramaya University IR	41000	4110	13800	4830	0	47	0	4877	3	13.95892	18

19	IDEP Document Server Of African Institute For Economic Development And Planning	8540	2160	7490	2110	2	22	0	2134	109	13.51821	19
20	Bindura University of Science Education IR	5590	737	4550000	164000	4	907	54	164965	9	13.48815	20
21	EUC Repository - Embu University College Repo.	18000	844	3710	2030	0	0	0	2030	14	12.84473	21
22	HITScholar-Harare Institute of Technology Repository	1890	23	2180000	8100000	8	1710	19700	8121418	0	12.60242	22
23	Federal University of Technology, Minna IR	2940	238	5190	572	0	4	0	576	1850	12.29509	23
24	Federal University Oye Ekiti Repository	5850	332	10100	201	1	2	0	204	715	12.17361	24
25	Mahider-CGIAR - International Livestock Research Institute	2520	505	19700	572	0	1	0	573	191	11.49951	25
26	Nelson Mandela African Inst. of Sci. and Technology Repository	3550	331	10	1610	0	2	5	1617	35	11.32728	26
27	University of Nigeria Nsukka IR	876	111	41000	14200	8	215	49	14472	159	11.24647	27
28	OceanDocs: Institut National des Sciences et Technologies de la Mer	708	80	4260	6670	6	49	1	6726	105	10.40633	28
29	KARI e-repository (Kenya Agricultural Research Inst.	77	2	7890000	542000	124	3580	2220	547924	674	9.59563	29
30	Rep. of the Agricultural Research Corporation (ARC) - Sudan	74	5	2280000	10400000	563	19100	3440	10423103	NA	9.23357	30
31	Rongo University Repository	2450	146	508	214	0	1	0	215	7	9.07443	31
32	DSpace at My University: Alzaiem Alazhari University Repository	1260	3	241000	32600	6	141	44	32791	NA	8.97176	32
33	Agri Search Repository	7	3	3	3	0	54400	7980	62383	2170	7.25306	33
34	University of Fort Hare IR	NA	NA	NA	1180000	598	9760	292	1190650	90	6.3822	34

35	National University of Rwanda Repository	NA	NA	NA	197000	8	242	47	197297	5	4.34628	35
36	IAPRA: Irish African Partnership Research Archive	NA	NA	NA	8	0	0	0	8	2	-0.44369	36
37	DSpace at MOUAU	NA	NA	NA	1	0	0	0	1	NA	-0.8239	37

WISER rank of selected repositories is shown in Table 6. Here, the University of Nairobi Digital Repository occupies the highest rank, followed by UPSpace - the IR of the University of Pretoria and Khartoum space - Repository of the University of Khartoum. Also, Table 6 shows data of the total rich file with the sum of PDF, PPT, DOC., as well as the number of citations covered in the Google Scholar database of such repositories. The correlation between ranking of WISER and WIF (in-link) is presented in Table 7.

Table 7 WISER and WIF (IN-LINK) ranking

Repository Name	WISER (x)	WIF (INLINK) (Y)	Square (X)	Square (Y)	XY	X=(X-Xbar)	Y=(Y-Ybar)	XY	SQUARE (X)	SQUARE (Y)
AgriSearch Repository (Dept of Agricultural Research, Lesotho)	33	1	1089	1	33	14	-18	-252	196	324
Ahmadu Bello Univ.IDR	14	5	196	25	70	-5	-14	+70	25	196
Bindura University of Science Education IR	20	8	400	64	160	1	-11	-11	1	121
Bouira University Digital Space	15	31	225	961	465	-4	+12	-48	16	144
DSpace at MOUAU	37	35	1369	1225	1295	+18	+16	+288	324	256
DSpace at My University: Alzaïem Alazhari University Repository	32	32	1024	1024	1024	+13	+13	+169	169	169
DSpace: University of Biskra	11	29	121	841	319	-8	+10	-80	64	100
dspace@UABT- University of Tlemcen	5	25	25	625	125	-14	+6	-84	196	36
Egerton University IR	17	15	289	225	255	-2	-4	+8	4	16
EUC Repository - Embu University College Repo.	21	19	441	361	399	+2	0	0	4	0
Federal University of Technology, Minna IR	23	13	529	169	299	+4	-6	-24	16	36
Federal University Oye	24	17	576	289	408	+5	-2	-10	25	4

Ekiti Repository

Haramaya University IR	18	11	324	121	198	-1	-8	+8	1	64
HITScholar-Harare Inst. of Tech. Repository	22	28	484	784	616	+3	+9	+27	9	81
IAPRA: Irish African Partnership Research Archive	36	36	1296	1296	1296	+17	+17	+289	289	289
JKUAT Digital Repository-Jomo Kenyatta Univ of Agri.and Tech	12	18	144	324	216	-7	-1	+7	49	1
KARI e-repository (Kenya Agricultural Research Institute)	29	23	841	529	667	+10	+4	+40	100	16
Khartoumspace-University of Khartoum	3	22	9	484	66	-16	+3	-48	256	9
Mahider-CGIAR - International Livestock Research Institute	25	6	625	36	150	+6	-13	-78	36	169
National University of Rwanda Repository	35	37	1225	1369	1295	+16	+18	+288	256	324
Nelson Mandela African Inst. of Sci. and Technology Repository	26	12	676	144	312	+7	-7	-49	49	49
OceanDocs: Institut National des Sciences et Technologies de la Mer	28	10	784	100	280	+9	-9	-81	81	81
Repository of the Egyptian Agricultural Research Centre, Egypt	6	14	36	196	84	-13	-5	+65	169	25
Repo.of the Agricultural Research Corporation (ARC) - Sudan	30	2	900	4	60	+11	-17	-187	121	289
Rongo University Repository	31	16	961	256	496	+12	-3	-36	144	9
RUFORUM IR	16	21	256	441	336	-3	+2	-6	9	4
IDEP DOCUMENT SERVER of African Inst. of Economic Dev. and Planning	19	4	361	16	76	0	-15	0	0	225

Sokoine Univ. of Agriculture IR	10	26	100	676	260	-9	7	-63	81	49
UNAM Scholarly Repo.	8	27	64	729	216	-11	8	-88	121	64
University of Biskra Theses Repository	13	20	169	400	260	-6	1	-6	36	1
University of Cape Coast IR	4	33	16	1089	132	-15	14	-210	225	196
University of Dar es Salaam Research Repository	9	30	81	900	270	-10	11	-110	100	121
University of Fort Hare IR	34	34	1156	1156	1156	15	15	+225	225	225
IR of the University of Limpopo (ULSpace)	7	3	49	9	21	-12	-16	+192	144	256
University of Nairobi Digital Repository	1	24	1	576	24	-18	5	-90	324	25
University of Nigeria Nsukka IR	27	9	729	81	243	8	-10	-80	64	100
UPSpace- the IR of the University of Pretoria	2	7	4	49	14	-17	-12	+204	289	144
Total	703	703	17575	17575	13596	0	0	-239	4218	4218

Hence, the Mean for the variable (X & Y) can be calculated as:

N

$$\bar{X} = \frac{1}{N} \sum_{i=1}^N x_i = \frac{1}{N}(x_1 + x_2 + \dots + x_N)$$

i=1

In this case, mean (X & Y) are the same i.e. $\bar{X} = \bar{Y} = 19$. Standard deviation is calculated with the help of the following formula: **N**

$$\sigma_x = \sqrt{\frac{1}{N} \sum_{i=1}^N (x_i - \bar{X})^2}$$

i=1 Where N=37.

The standard deviations of X (i.e. σ_x) & Y (i.e. σ_y) is 10.6770782 and 10.6770782 respectively. The correlation coefficient is used to relate the strength and direction of linear relationship between two variables. The coefficient of determination represents the % of data closest to the line of best fit. Correlation will always be between -1.0 and +1.0. If the correlation is positive, we have a positive relationship. If it is negative, the relationship is negative. The coefficient of determination (i.e., r^2) is such that $0 < r^2 < 1$, and denotes the strength of the linear association between x and y. The formula can be given as follows:

$$\text{Correlation}(r) = \frac{N \sum XY - (\sum X)(\sum Y)}{\sqrt{[N \sum X^2 - (\sum X)^2][N \sum Y^2 - (\sum Y)^2]}}$$

$$\text{Or } r = \frac{\text{COV}(X, Y)}{\sigma_x \sigma_y} = \frac{[(1/N) \sum XY - \text{mean}(X) * \text{mean}(Y)]}{\sigma_x \sigma_y}$$

Where, N=37; $\sum X = 703$; $\sum Y = 703$; $\sum XY = 13596$; $\sum X^2 = 17575$; $\sum Y^2 = 17575$ (For upper one Equation i.e. for r)

Or

Mean (X) = mean(Y) = 19; $\sigma_x = 10.6770782$ and $\sigma_y = 10.6770782$ (for lower one Equation i.e. For r^2) Therefore, the calculated value of r would be = +0.0566619, which implied that there is much association or closeness between two ranking methods where N is the number of pairs of data and R denotes the correlation coefficient, where σ_x is the standard deviation of X and σ_y standard deviation of Y.

9 Major findings

Calculating the Web Impact Factor, link analysis and WISER ranking of agricultural repositories in Africa is still an unexplored area of webometric research. The following are the major findings of this study i.e.:

- Digital Repository websites of the University of Nairobi ranks top with 1361000 total web pages and 12300 total Google scholar citations.
- The KARI e-repository-Kenya Agricultural Research Institute websites at the first rank with 77 (102467.5325%) simple links.
- The repository websites of AgriSearch Repository (Dept of Agricultural Research, Lesotho) is on top with the 03 (0.428571429%) external links and 03(0.428571429%) external links.
- The websites of the repository of the Egyptian Agricultural Research Centre, Egypt is on top with 9890 (0.453993933%) total self-links.
- The repository websites of the KARI e-repository-Kenya Agricultural Research Institute at the first rank with the Simple Web Impact Factor (SWIF) are reflected in Table 3 and the Repository of the Agricultural Research Centre occupies the first place with 0.453993933% Self Web Impact Factor. The second and third place goes to the AgriSearch Repository (Dept of Agricultural Research, Lesotho), and the Institutional Repository of Federal University of Technology, Minna.
- Repository of the Egyptian Agricultural Research Centre, Egypt occupies the first place with 4490 Self Link Pages and 9890 web pages with 0.453993933 SWIF.
- AgriSearch Repository (Dept of Agricultural Research, Lesotho) occupies the first place with 07 web pages, 03 link pages and its ELWIF is 0.428571429.
- AgriSearch Repository (Dept of Agricultural Research, Lesotho) \ ranked first position with 07 web pages and 03 in-link web pages and 0.428571429 RWIF.
- The calculated value of $r = +0.0566619$, which is shown in Table 7. This implies that there is an association or closeness between the value of WISER Indicators and In-links WIF. Therefore, the number of web pages play a significant role in influencing the value of two ranking methods i.e., WIF and WISER of any repositories.

10 Conclusion

In this digital era, the web is playing a very significant role in the dissemination of scholarly literature. Repositories around the world maintain their websites to provide unrestricted access to research outputs on a global scale. The domain of agricultural repositories in Africa is no exception. Websites, as well as the Internet, play an integral part in digital repositories across the world, including Africa. Webometrics has become an important field through which information professionals analyse websites to find the best repositories. This study analyses the WIF and links of agricultural repository websites in Africa. Furthermore, it focuses on the rank of the WISER index value rather than link architectures, which is another field of Webometrics research. This analysis provides an overall idea of the distinct types of link pages and the visibility of repositories websites in Africa. It will enable the readers to identify and compare the repositories' websites by their WIF. It will also assist them in identifying a website's utility and its overall effect on the Web. In addition, self-links also reflect the logical structures of selected repositories used for organising web pages on the local server. The external link impact factor, on the other hand, has shown the connectivity and relationship of repositories' websites under study with the outside, as suggested by Ingwersen (1998). The In-Link Web impact factor as shown in Table 6 will help readers measure the visibility of respective repositories over the web. In addition, the correlation between the In-link WIF and WISER value as per Table 7, indicates the potency and weaknesses of selected websites, which will help scholars to improve their repositories. Therefore, the results of this investigation may be employed as a blueprint for evaluating repository websites all over the world, irrespective of subjects and disciplines.

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