Research Journal of Applied Sciences 9 (12): 1158-1162, 2014
ISSN: 1815-932X

Comparative Analysis of the National Scientific and Educational Systems of Sub-Saharan African Countries with the Help of Open Access Sources

Vladimir M. Moskovkin, Sizyoongo Munenge, Tatyana V. Balabanova and Evgeny E. Tonkov
Belgorod State University, Pobedy St. 85, 308015 Belgorod, Russia

Abstract: On the basis of open access sources, the methodology of comparative analysis of the national scientific and educational systems was elaborated. It has been verified for example on the countries of Sub-Saharan Africa. Based on open access data matrix (N_{ij}) with a dimension (m×n) is constructed. In which N_{ij} represents the number of objects (Universities, Research Centers, OA repositories, OA journals, Scopus journals) of ith country, belonging ith objects type, m is the number of countries, n is the number of objects type. With the aim of clustering Sub-Saharan African countriesin terms of the degree of the development of their scientific and educational potential based on the matrix (N_{ij}), we introduced an integral indicator in form of a vector $\vec{N}_i = (N_i, n_i)$ where $N_i = \sum_{j=1}^{n} N_{ij}$ n_i is the number of non-zero elements in the ith line of matrix (N_{ij}). Coordinate N_i shows the aggregated potential of scientific and educational system in selected set of indicators and n_i is the degree of diversification of the system. Based on the calculation of the vector $\vec{N}_i$, we identified 7 clusters of Sub-Saharan African countries. The first two leading clusters were South Africa, Nigeria, Kenya, Tanzania, Ghana, Sudan, Ethiopia and Uganda.

Key words: National scientific and educational systems, Sub-Saharan African countries, comparative analysis, open access sources, global university rankings, ROAR, DOAJ, SCIMAGO, webometrics, QS, SIR, URAP, OA, repositories, scopus-journals

INTRODUCTION

There are a large number of publications of scientometric nature on countries of Sub-Saharan Africa. The majority of these are published in the journal Scientometrics. One of such first researches was done by scientometric analysis of the institutional sectors of "mainstream" science production in Sub-Saharan Africa for the period from 1970-1979 (Davis, 1983). Temporal dynamics of the Web of Science-publications in these countries for the period from 1997-2007 was studied in the work of (Ondari-Okemwa, 2007). Similar researches were conducted in the works of (Arvanitis *et al*., 2000; Narvaez-Berthelemot *et al*., 2002; Jeenah and Pouris, 2008; Pouris and Pouris, 2009; Megnigbeto, 2013a). There are a series of works which studies international collaboration in Sub-Saharan Africa (Boshoff, 2009; Mgnigbto, 2013b; Pouris and Ho, 2014), one of the first is the problem which looks at it from the aspect of neo-colonialism, taking into consideration the fact that nearly 80% of the articles published from Central Africa with partners outside the region (46% in collaboration with scientists from European countries and 14% in collaboration with scientists from the United States of America).

The study examines the current state of scientific and educational systems in Sub-Saharan Africa on the basis of global university rankings and open access data with Webometrics, DOAJ, ROAR, SCIMAGO platforms.

MATERIALS AND METHODS

Comparative analysis of scientific and educational potential of an arbitrary group of countries can be based on the available data on the number of universities, included in the well-known Global University rankings, number of OA-repositories included in ROAR, number of journals included in DOAJ and SCIMAGO platforms, number of OA repositories and research centers included in Webometrics.

Based on open access data matrix (N_{ij}) with a dimension (m×n) is constructed. In which N_{ij} represents the number of objects (Universities, Research Centers, OA repositories, OA journals, Scopus journals) of ith country, belonging ith objects type, m is the number of countries, n is the number of objects type.

With the aim of clustering countries in terms of the degree of development of their scientific and educational potential based on matrix (N_{ij}), we introduced an integral indicator in form of a vector $\vec{N}_i = (N_i, n_i)$ where $N_i = \sum_{j=1}^{n} N_{ij}$, n_i

Correspoding Author: Vladimir M. Moskovkin, Belgorod State University, Pobedy St. 85, 308015 Belgorod, Russia

is the number of non-zero elements in the ith line of matrix (N_{ij}). Coordinate N_i shows the aggregated potential of scientific and educational system in the selected set of indicators and n_i is the degree of diversification of the system.

Based on the indicators matrix (N_{ij}), a series of relative (for example, share of universities included in some rankings) and specific (for example, number of Scopus-journals per one academic institution) indicators of global competitiveness of scientific and educational systems are introduced.

RESULTS AND DISCUSSION

In order to conduct a comparative analysis of scientific and education potential of Sub-Saharan Africa, we have selected 49 countries of Sub-Saharan Africa. Universities of Sub-Saharan African countries are presented in four Global University Rankings-Webometrics (Spain, TOP-21000), QS (UK, TOP-800), URAP (Turkey, TOP-2000) and SIR (Spain, TOP-2000). In the first ranking, apart from university ranking, OA repository and research centers are presented. According to the data of DOAJ, ROAR and SCIMAGO the numbers of OA journals, OA repositories and Scopus-journals are presented.

Having collected data from the above mentioned platforms, we came up with Table 1 which is represented by matrix (N_{ij}) with a dimension 43×9. Based on the calculation vector $\overline{N}_i$, we identified seven clusters of Sub-Saharan African countries (Table 2).

Apart from cluster 1 of the leading countries with a large number of universities, there are cluster 2, 4 and 5 of Sub-Saharan Africa having from 1-4 high quality universities in URAP and SIR.

This approach of clustering countries is useful for planning strategies of development of scientific and educational systems. Out of the 49 countries in Sub-Saharan Africa, six countries had zero elements in the constructed matrix. As such, they were not included in the matrix. This applies to countries such as Comoros, Eritrea, Guinea Bissau, Congo Brazzaville, Sao Tome and Principe and South Sudan. A more detailed distribution of Scopus-journals on countries of Sub-Saharan Africa on the SCIMAGO platform is shown in Table 3.

Here in addition to the total number of Scopus-journals, presented the number of journals with IF≥1.0 and also the names of Scopus-journals with the highest impact factor (IF_{max}) are listed. From this Table 3 we see that out of 49 countries in Sub-Saharan Africa, only 11 countries have their own scientific journals included in database Scopus. The leaders of these countries are two countries which we identified incluster 1 (Table 2) of which South Africa has three journal with IF≥1.0. From the names of the leading journals as indicated in Table 3 above we see that they mainly deal with medical problems and socio-economic development. This shows that these problems are a priority for the countries in question.

A considerable number of Sub-Saharan African countries (14) have OA journals, registered in DOAJ (Table 1). Some of the countriesnot included in Table 3 are Burundi, Cote D'ivoire, Madagascar, Niger, Sierra Leone and Zambia. Basically, these are journals with a medical profile. Most of OA journals are in South Africa (67) and Nigeria (41). The 17 countries in Sub-Saharan Africa have their own OA-repository (Table 1). The Maximum number of OA repositories observed for South Africa (37), Kenya (8) and Nigeria (8). The more OA journals and OA repositories a country has the better the country is integrated into the international movement of open access. This shows that the leaders of this movement in Sub-Saharan Africa are South Africa and Nigeria.

Based on the indicators in Table 1, we come up with the following relative and specific indicators of global competitiveness of scientific and educational systems:

- $\rho_{URAP} = N_{URAP}/N_{UN}$ share of universities included in the URAP rankings
- $\rho_{SIR} = N_{SIR}/N_{UN}$ share of universities included in the SIR rankings
- $I_{SC} = N_{SC}/N_{UN}+N_{RC}$ number of Scopus-journals (N_{SC}) per one academic institution
- $K_{OA} = N_{OA\text{-}jour}+N_{OA\text{-}rep}$ factor involvement in OA movement (number of OA journals and OA repositories per one academic institution)

In which N_{URAP}, N_{SIR}, N_{UN} is the number of universities in the URAP, SIR and Webometrics rankings, N_{RC} is the number of research centers included in the Webometrics rankings, N_{SC} is the number of Scopus-journals, placed on SCIMAGO platform, $N_{OA\text{-}rep}$ is the number of OA repositories included in the Webometrics rankings, $N_{OA\text{-}jour}$ is the number of OA-journals included in the DOAJ.

Calculated values of these indicators for the countries of Sub-Saharan Africa satisfied the condition $N_{UN}+N_{RC}\geq 30$ shown in Table 4. From this table we see that all of these indicators are far ahead of those of South Africa. The values of the last two indicators for this country exceed 1. This suggests that each Academic Institute of South Africa has at least one Scopus-journal as well as one OA-journal or OA-repository. Followed by South Africa on the values of these indicators with a five-tenfold gap are Nigeria and Ethiopia.

Table 1: Matrix of universities, OA-repositories, research centers and journals belonging to different rankings, registers and databases for Sub-Saharan African countries

	Webometrics									
Countries	Uni.	Rep.	R.C	DOAJ	ROAR	QS	Scimago	URAP	SIR	$\overline{N}_i$
Angola	23	-	-	-	-	-	-	-	-	(23.1)
Benin	7	-	-	-	-	-	-	1	-	(8.2)
Botswana	5	1	3	-	1	-	-	1	1	(12.6)
Burkina Faso	4	-	2	-	-	-	-	1	-	(7.3)
Burundi	5	-	-	1	-	-	-	-	-	(6.2)
Camerooon	14	-	2	-	1	-	-	4	1	(22.5)
Cape Verde	3	1	-	-	-	-	-	-	-	(4.2)
Central African Republic	1	-	-	-	-	-	-	-	-	(1.1)
Chad	1	-	-	-	-	-	-	-	-	(1.1)
Cote D'ivoire	4	-	1	1	-	-	-	2	1	(9.5)
Congo. Dem. Rep	14	-	-	-	-	-	-	-	-	(14.1)
Djibouti	1	-	1	-	-	-	-	-	-	(2.2)
Equatorial Guinea	1	-	-	-	-	-	-	-	-	(1.1)
Ethiopia	31	1	1	6	2	-	3	2	1	(47.8)
Gabon	1	-	2	-	-	-	-	-	-	(3.2)
Gambia	1	-	2	-	-	-	-	-	-	(3.2)
Ghana	35	2	2	2	5	-	3	2	2	(53.8)
Guinea	1	-	-	-	-	-	-	-	-	(1.1)
Kenya	59	3	17	7	8	-	4	1	3	(102.8)
Lesotho	1	-	-	-	3	-	-	-	-	(4.2)
Leberia	3	-	-	-	-	-	-	-	-	(3.1)
Madagascar	7	-	-	-	1	-	-	-	-	(8.2)
Mauritius	6	-	1	-	-	-	-	-	-	(7.2)
Malawi	7	-	-	1	-	-	-	-	1	(9.3)
Mozambique	9	1	-	-	2	-	-	-	-	(12.3)
Mali	1	-	2	-	-	-	1	-	-	(4.3)
Mauritania	3	-	-	-	-	-	-	-	-	(3.1)
Namibia	4	2	3	-	2	-	-	-	-	(11.4)
Niger	1	-	1	1	-	-	-	-	-	(3.3)
Nigeria	125	3	4	41	8	-	19	7	10	(217.8)
Rwanda	7	1	-	-	1	-	-	-	-	(9.3)
Senegal	9	-	3	-	2	-	1	-	1	(16.5)
Seychelles	2	-	-	-	-	-	-	-	-	(2.1)
Sierra Leone	27	-	-	1	-	-	-	-	-	(28.2)
Somalia	27	-	-	-	-	-	-	-	-	(27.1)
South Africa	25	22	37	67	40	6	75	12	22	(306.9)
Sudan	36	-	3	1	5	-	1	1	1	(48.7)
Swaziland	2	-	-	-	-	-	-	-	-	(2.1)
Togo	2	-	-	-	-	-	-	1	-	(3.2)
Tanzania	33	1	3	3	5	-	2	3	3	(53.8)
Uganda	24	2	4	4	2	-	1	1	1	(39.8)
Zambia	8	-	2	3	-	-	-	1	1	(15.5)
Zimbabwe	11	1	-	-	6	-	1	1	1	(21.6)

The data was collected in September, 2013. No information was found on Comoros, Eritrea, Guinea Bissau, Congo Brazzaville, Sao Tome and Principle and South Sudan. For this reason, they were not included in Table 1; Uni. Universities, Rep. OA-Repositories, R.C. Research Centers; Webometrics ranking of World Universities: http://www.webometrics.info/en/Africa; Directory of open Access journals (DOAJ): http://www.doaj.org/; Registry of Open Access Repositories (ROAR): http://www.roar.eprints.org/; QS World University Rankings: http://www.topuniversities.com/university-rankings; Scimago Journal and country Rank: http://www.scimagojr.com/journalrank.php; University Ranking by Academic Performance: http://www.urapcenter.org/2013/; Scimago Institutions Ranking: http://www.scimagoir.com

Table 2: Clusters of Sub-Saharan African countries according to the level of development of their scientific and educational potential

Clusters	Countries	$\overline{N}_i$	Cluster characteristics
1	South Africa	(306.9)	Broad network of universities (from 25-125) with a lot of universities in URAP (from 7-12) and
	Nigeria	(217.8)	SIR (from 10-22) and many Scopus journals (from 19-75). South Africa is the only Sub-Saharan African country with universities in the QS
2	Kenya	(102.8)	Broad network of universities (from 24-59) with universities present in URAP and SIR (from
	Tanzania	(53.8)	1-3) and Scopus journals (from 1-4)
	Ghana	(53.8)	
	Sudan	(48.7)	
	Ethiopia	(47.8)	
	Uganda	(39.8)	
3	Sierra Leone	(28.2)	Broad network of universities (from 23-27) without the presence of universities in URAP, SIR
	Somalia	(27.1)	and scopus journals
	Angola	(23.1)	

Table 2: Countinous

Clusters	Countries	$\vec{N}_i$	Cluster characteristics
4	Cameroon	(22.5)	Moderately developed network of universities (from 8-14) with presence of universities in URAP
	Zimbabwe	(21.6)	(from 1-4) and SIR (1). Zimbabwe has one Scopus-journal
	Senegal	(16.5)	
	Zambia	(15.5)	
5	Botswana	(12.6)	Underdeveloped network of universities (from 4-7) with presence of universities in URAP (from 1-2)
	Cote D'ivore	(9.5)	and SIR (1) without Scopus-journals
	Malawi	(9.3)	
	Benin	(8.2)	
	Burkina Faso	(7.3)	
6	CongoDem.Rep.	(14.1)	Weak and moderate university networks (from 4-14) without universities in both URAP and
	Mozambique	(12.3)	SIR and no Scopus-journals
	Namibia	(11.4)	
	Rwanda	(9.3)	
	Madagascar	(8.2)	
	Mauritius	(7.2)	
	Burundi	(6.2)	
7	Other 21 countries		Individual universities (not >3) low quality with the exception of one university in Togo which is present in URAP. Mali has one Scopus-journal

Table 3: Distribution of Scopus-journals on SCIMAGO platform for Sub-Saharan Africa countries

	No. of Journals			
Countries	Total	IF≥1.00	IF_{max}	Name of the Journal with a IF_{max}
Ethiopia	3	-	0.69	Ethiopian Medical Journal
Ghana	3	-	0.32	Ghana Medical Journal
Kenya	4	-	0.55	African Journal of Biotechnology
Mali	1	-	0.05	Le Mali Medical
Nigeria	19	-	0.96	Journal Of Medicinal Plant Research
Senegal	1	-	0.07	Africa Development
South Africa	75	3	1.32	South African Journal of Enology and Viticulture
Sudan	1	-	0.38	Arab journal of nephrology and transplantation
Tanzania	2	-	0.38	Tanzania Journal of Heath Research
Uganda	1	-	0.78	African Health Sciences
Zimbabwe	1	-	0.05	Journal of Social Development in Africa

Table 4: Relative and specific indicators of global competitiveness of Scientific-educational systems Sub-Saharan African countries

Countries	ρ_{URAP}	ρ_{SIR}	I_{SC}	K_{OA}
Ethiopia	0.07	0.03	0.09	0.22
Ghana	0.06	0.06	0.08	0.11
Kenya	0.02	0.05	0.05	0.13
Nigeria	0.06	0.08	0.15	0.34
South Africa	0.48	0.88	1.20	1.44
Sudan	0.03	0.03	0.03	0.03
Tanzania	0.09	0.09	0.06	0.11

CONCLUSION

Therefore, the research shows the possibility to conduct a clustering of countries according to their scientific and educational potential on the basis of data open access sources. For these purposes the vector quantity $\vec{N}_i = (N_i, n_i)$ has been proposed which characterizes aggregated potential of the scientific and educational systems within a selected set of indicators (N_i) and the degree of diversification of the systems $(n)_i$ lying on the basis of calculation of the vector $\vec{N}_i$ initial matrix (N_{ij}) with the dimension of (m×n) in which N_{ij} is the number of objects (universities, research centers, OA-journals, etc.) m is the number of countries, n is the number of objects type used to calculate some relative and specific indicators of global competitiveness of scientific and educational systems. The given methodology was used for Sub-Saharan African countries. Based on the calculation of the $\vec{N}_i$ vector, we identified 7 clusters of Sub-Saharan African countries in which the first two leading clusters had the form: cluster 1: South Africa (306.9), Nigeria (217.8); cluster 2: Kenya (102.8), Tanzania (53.8), Ghana (53.8), Sudan (48.7), Ethiopia (47.8), Uganda (39.8).

According to the relative (shares of universities included in the URAP and SIR rankings) and specific (number of Scopus-journals per one academic institution; number of OA journals and repositories per one academic institution) indicators introduced in this study South Africa is an absolute leader followed by Nigeria and Ethiopia.

ACKNOWLEDGEMENT

Research was done according to the Government task of the Ministry of Education and Science of the Russian Federation for 2014, project code-516.

REFERENCES

Arvanitis, R., R. Waast and J. Gaillard, 2000. Science in Africa: A bibliometric panorama using PASCAL database. Scientometrics, 47: 457-473.

Boshoff, N., 2009. Neo-colonialism and research collaboration in Central Africa. Scientometrics, 81: 413-434.

Davis, C.H., 1983. Institutional sectors of mainstream science production in Subsaharan Africa, 1970-1979: A quantitative analysis. Scientometrics, 5: 163-175.

Jeenah, M. and A. Pouris, 2008. South African research in the context of Africa and globally: Science policy. South Afr. J. Sci., 104: 351-354.

Megnigbeto, E., 2013a. Scientific publishing in West Africa: Comparing Benin with Ghana and Senegal. Scientometrics, 95: 1113-1139.

Megnigbeto, E., 2013b. International collaboration in scientific publishing: The case of West Africa (2001-2010). Scientometrics, 96: 761-783.

Narvaez-Berthelemot, N., J.M. Russell, R. Arvanitis, R. Waast and J. Gaillard, 2002. Science in Africa: An overview of mainstream scientific output. Scientometrics, 54: 229-241.

Ondari-Okemwa, E., 2007. Scholarly publishing in sub-Saharan Africa in the twenty-first century: Challenges and opportunities. First Monday, Vol. 12, No. 10. 10.5210/fm.v12i10.1966

Pouris, A. and A. Pouris, 2009. The state of science and technology in Africa (2000-2004): A scientometric assessment. Scientometrics, 79: 297-309.

Pouris, A. and Y.S. Ho, 2014. Research emphasis and collaboration in Africa. Scientometrics, 98: 2169-2184.