Dynamics and Ecosystems of Scientific Publication in Africa

A Scientometric Analysis over the Two First Decades of the 21st Century

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Abstract

A scientometric analysis of Africa's scientific publication over the past two decades shows first that eleven nations representing half of Africa's population provided 88% of its indexed scientific publications. These highly productive nations have English or Arabic as official language and were mainly under British colonization (except for the Maghreb countries and Ethiopia). The other half of Africa's population is settling for a modest 12% of internationally visible publications. A second finding is that African shares in the world indexed publications seem to stabilize to a level of 3.3% in 2021 while they only weighed 1.3% in 2001. These shares are relatively high in Public Health, Agricultural and Biological Sciences, Immunology, Environmental Sciences and Economics and very low in Neuroscience, Cognitive Sciences and Nanoscience. A comparison of publication dynamics among the most productive African nations highlights resilience of highly institutionalized, decentralized and autonomous research institutions and universities. This seems to be particularly the case in regions with former British colonial domination.

When comparing African publication dynamics, it appears clearly that the previously undisputed South African leadership is increasingly contested by Egypt which has recently accelerated the pace of its scientific publications outside Humanities and Social Sciences (HSS). In terms of research impact, number of internationally ranked universities and highly cited researchers, South Africa still has an undisputed leadership in the continent, followed by Egypt and far outstripping Nigeria, Kenya and the three main Maghreb countries: Algeria, Morocco and Tunisia. Our results thus show a recent resumption of the scientific dynamic in Nigeria after a slowdown in the early 2010s. The three Maghreb countries have comparable positions but very different dynamics. We note a continuous increase in Moroccan scientific production, an important loss of momentum in Tunisia and the same is also seen in Algeria but to a lesser extent. Senegal has a relatively high number of researchers per capita but still lacks visibility in terms of scientific impact. The last significant elements concern the recent important increase of Ethiopian publications and the stable scientific production systems of Ghana and Kenya. Finally, it is important to note that the scientometric analysis presented here is mainly based on numbers of articles, reviews and conference papers and their citations listed in the two major scientometric databases (Scopus and Web of Science). It has consequently biases related to an underrepresentation of HSS and journals published in Africa and to the strategic agendas of the two private companies producing these databases.

Keywords

Africa, Science, Research policy, Bibliometrics, Research assessment, Scientific impact, Institutionalization, Postcolonialism, Social context

Introduction

Innovation and scientific research could provide the African continent with strategies and technologies needed to meet its vital coming challenges: climate change, social, digital and environmental transitions, economic, educational and health inequalities, etc. However, this would require first "a deep African scientific and technological transition that has never taken place" (Ba & Cury, 2022, p. 30) so far. This scientific transition will involve, as suggested by Arowosegbe (2016, p. 336), a continental debate on whether "the colonial moment is truly over in Africa" and on the reasons, urgency and ways of a "necessary decolonizing knowledge production on [and in] Africa" (Crawford, et al., 2021). Without this essential epistemological transition Ba and Curry (2022, p. 30) stated that "Africa risks the inability to govern generations that would accept neither poorly patched-together public policy nor the deepening of global inequalities".

Arowosegbe (2016) depicts a pessimistic landscape (nevertheless realistic in many African countries) of "a phenomenal decline of postcolonial universities resulting from government neglect, the attitudes of incompetent and opportunistic senior academics, mismanagement, political interference and underfunding" (Arowosegbe, 2016, p. 335). In the same vein, Fonn et al. (2018) stated that if "the 1960 and 1970 were something of golden era for higher education in Africa" its decline has started in the 1980's and is recently accelerating with the increasingly "limited funding of universities by African governments" (Fonn et al., 2018, p.1164).

While I agree with Arowosegbe (2016) and Fonn et al. (2018) that in many African countries scientific knowledge production is directly impacted by recurrent political, economic and social crises leading "not only to brain drain but also to despair and disillusionment for those trapped in the dismal conditions at home" (Arowosegbe, 2016, p. 326), the purpose of the present work is to show, mainly using indexed publication statistics, that African countries have very different research and innovation systems in terms of achievements, strategies and dynamics with some optimistic signals here and there. Scientometric indicators provide a first comparative analysis of these ecosystems and afford a measure of their resilience, ability and efficiency in helping these countries meet the challenges they will face in the coming decades.

The present work aims to give a scientometric insight on the dynamics of scientific publication in Africa during the two first decades of the 21st century. Three main indicators are analyzed and compared among African nations:

- The number of indexed[1] publications (articles, reviews and conference papers) and their citations listed in the two major scientometric databases: Scopus and Web of Science.
- The number of top 2%-highly cited scholars working in African universities and research centers provided annually and jointly by Stanford University and Elsevier.
- The three main international university rankings compiled annually by Shanghai University, Times Higher Education (THE) and Quacquarlly Symonds (QS).

Several previous works studied the state of African scientific publications. Sooryamoorthy (2018) studied (using data from Web Of Science) African scientific publications during the period of 2000 to 2015 and found that the leading African countries are: South Africa, Egypt, Tunisia, Nigeria, Morocco and Algeria. According to this study, South Africa and Egypt produced more than 47% of all publications in Africa during the period of 2000 to 2015. South Africa (26%) and Egypt (21%) are far ahead of a homogeneous group of five countries: Tunisia (8%), Nigeria (6%), Morocco (6%), Algeria (6%) and Kenya (4%).

1 Scopus for example claims that "New content is added to Scopus after a rigorous evaluation process by the subject experts of the Content Selection and Advisory Board (CSAB): an international group of scientists, researchers and librarians who represent the major scientific disciplines".

Using data from Web of Science on the period of 2005 to 2016 Mouton and Blackenberg (2018) found that Africa's share of world scientific production increased from 1.5% to 3.2% between 2005 and 2016. Annual article output by country shows again the dominance of South Africa followed by Egypt, far behind are the Maghreb countries (Tunisia, Algeria and Morocco) together with smaller but significant contributions from Nigeria, Kenya, Uganda and Tanzania.

The previous works confirm the existence of two incontestable leaders for scientific publication in Africa: South Africa and Egypt and five emerging publishing ecosystems: Nigeria, the three central Maghreb countries and Kenya.

If we leave aside South Africa and Egypt, almost all African countries suffer from the same structural problems preventing the emergence of sustainable and efficient national scientific ecosystems able of successfully squaring the circle of mastering local issues while being visible and competitive internationally.

A study of the African Union in 2013 (AOSTI, 2013) identified the following governance problems of African scientific research:

1. 'Most African countries do not have well-established and dynamic scientific policy processes'.
2. 'Policy gestation is too long in most African countries'.
3. 'Scientific policy-making tends to be isolated from economic, social, technological, political and environmental issues'.
4. 'Public awareness of scientific issues and related national policy-making agenda is very low'.

In his diagnosis of African science, Mouton (2018) mentioned that many African scientific institutions are fragile, under-resourced, and suffer of a lack of rational scientific governance. Mouton (2018) noted that the de-institutionalization of research institutions is the main problem of African science. Mouton (2018) noted that this de-institutionalized African science exhibits five characteristics: "weak scientific institutions, dependence on international funding, individualism in research, inadequate reproduction of the scientific and academic workforce and the weak importance given to science by African societies". Mouton identified six important factors explaining these problems: "the legacy of colonial science in many countries, the destabilizing influence of political events and civil wars, the impact of World Bank policies on higher education in Africa, the role of international agencies in shaping African sciences, the continuing low investment in science by African governments and the continuing effects of the brain drain".

The goal in this study consists in analyzing quantitatively the dynamics of African scientific production and identifying the few national systems that have succeeded in establishing sustainable and robust scientific ecosystems capable of withstanding the various geopolitical and economic hazards that characterize several African regions.

The scientometric analysis presented here is mainly based on numbers of articles, reviews and conference papers and their citations listed in the two major scientometric databases (Scopus and Web of Science). It has consequently important biases related to the strategic agendas of the two private companies producing these databases (Clarivate and Elsevier): profitability and financial allied to academic criteria, important regional and linguistic disparities in the choice of journals, the quasi-absence of journals published in Africa and overrepresentation of North-American and European reviews, etc. (see Asubiaro et al., 2024 for an analysis of these coverage disparities).

This scientometric approach is a first step which needs to be followed by the development of alternative approaches more adapted to the African context. A deep discussion of the paradigm, the philosophical challenges and the urgency of rethinking knowledge production and consequently rethinking the way scientific research should be (re)designed, organized, conducted and evaluated by African researchers can be found in Arowosegbe (2016) and Crawford et al. (2021).

After this introductive section the following point quantitatively depicts the situation of scientific publication in Africa during the two first decades of the 21st century. We then analyze the dynamics of African scientific publication, with a study of their social and economic context. Next, we describe the highly cited scholars and internationally ranked African universities, before discussing the main findings of this study and concluding.

African Scientific Production in Figures

Scientometric indices provide a first assessment of the intensity and dynamics of scientific production in Africa. The World Bank database[2] of scientific and technical journal articles provides several interesting scientometric indicators developed by Web of Science (Clarivate). The second database used in this work is taken from the SCImago platform[3] developed using Scopus database (Elsevier). SCImago covers all scientific fields (including humanities and social sciences) but counts exclusively Scopus-indexed articles, reviews and conference papers.

Figure 1 compares Africa's shares in international indexed publications in 2001 and 2021 in several areas. The percentage of African publications (all scientific fields) moved from 1.3% in 2001 to 3.3% in 2021[4] when its demographic weight is 16.5%. Africa increased its shares in all scientific fields between 2001 and 2021.

Figure 1 shows that parts of Africa in the world publications are relatively high in the following fields: Agricultural and Biological Sciences (5.2% in 2021), Immunology (4.7%), Environmental Sciences (4.5%) and Economics (4.2%) and particularly in Public Health (6.5%). African publications are particularly underrepresented in: Neurosciences (1.5% of 2021 world publications) and Physics (2.2%). When focusing on NBIC emerging sciences, contributions of African science become surprisingly low: in 2021 African publications weighed only 0.6% of the world Cognitive Sciences publications, in Nanoscience this share was 1.2%, 2.5% in Artificial Intelligence and 3.6% in Biotechnology.

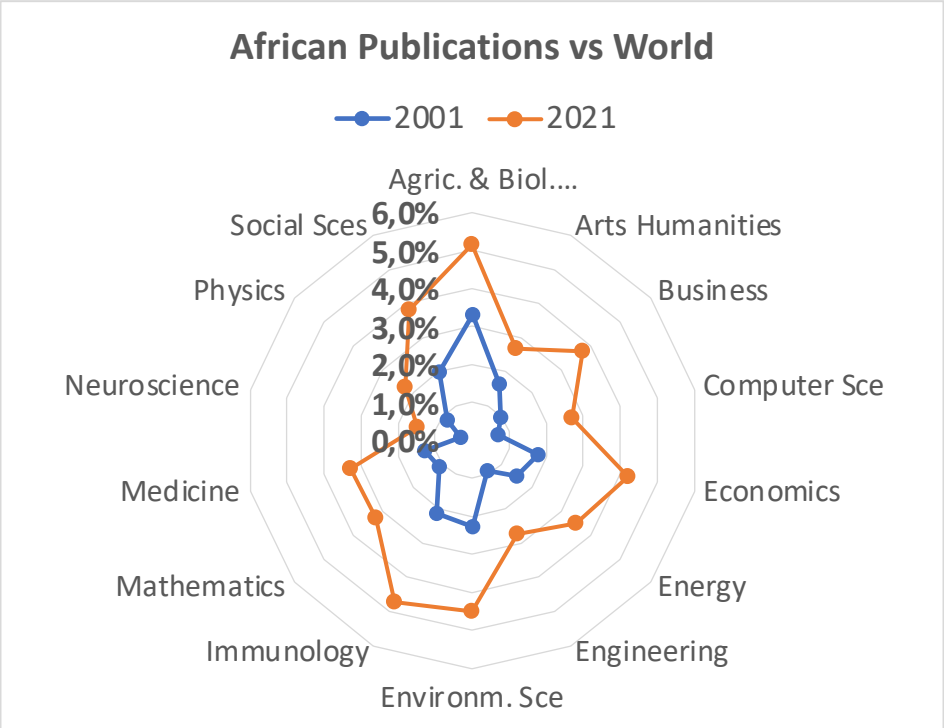


Figure 1: Shares of Africa in world scientific publications in 2001 (blue) and 2021 (orange).

Data source: author's calculations based on raw data from www.scimagojr.com.

2 https://data.worldbank.org/indicator/IP.JRN.ARTC.SC. Data provided annually by the National Science Foundation and giving the number of scientific and engineering articles published in the following fields: physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences. The NSF considers article counts from a set of journals covered by Science Citation Index (SCI) and Social Sciences Citation Index (SSCI) provided by Web of Science (Clarivate).

3 https://www.scimagojr.com

4 Mouton and Blackenberg (2018) found 3.2% for 2016 suggesting a relative stabilization between 2016 and 2021.

Parts of South Africa and Egypt among African publications decreased significantly from 51.8% in 2001 to 42.7% in 2021. A group of eleven leading African nations (South Africa, Egypt, Kenya, Nigeria, Tunisia, Morocco, Algeria, Ethiopia, Ghana, Uganda and Tanzania) holds 88% of African publications in 2021 (this percentage was 83% in 2001) while they represent half of Africa's population[5] while the other half participates by the modest remaining 12%.

Figure 2a (Web of Science) represents the evolution of the number of scientific and technical articles published in the nine most scientifically productive African countries. Figure 2b (Scopus) gives the number of indexed publications in all scientific fields. Figures 2a and 2b based on different databases give the same trends. They confirm the findings of the literature (Sooryamoorthy, 2018; Mouton & Blackenberg, 2018): the presence of two African scientific giants, namely South Africa and Egypt clearly advancing a group of four apparently homogeneous countries: Nigeria, Morocco, Algeria and Tunisia. This group is ahead of Ethiopia which increased significantly its production since 2015 and overtook Kenya and Ghana.

The story told by data is different if only publications from some selected fields[6] in HSS are studied: Figure 2c (semi-log scale) shows only two mature African publication ecosystems (South Africa and Nigeria) which reached in 2021 publication paces of respectively 2400 HSS papers/year in South Africa and 1000 in Nigeria. Nigeria being particularly productive in Philosophy. All the other African countries (including Egypt and the Maghreb) seem to have invisible HSS ecosystems either because of immaturity or because they are using alternative or non-indexed channels of research-output dissemination.

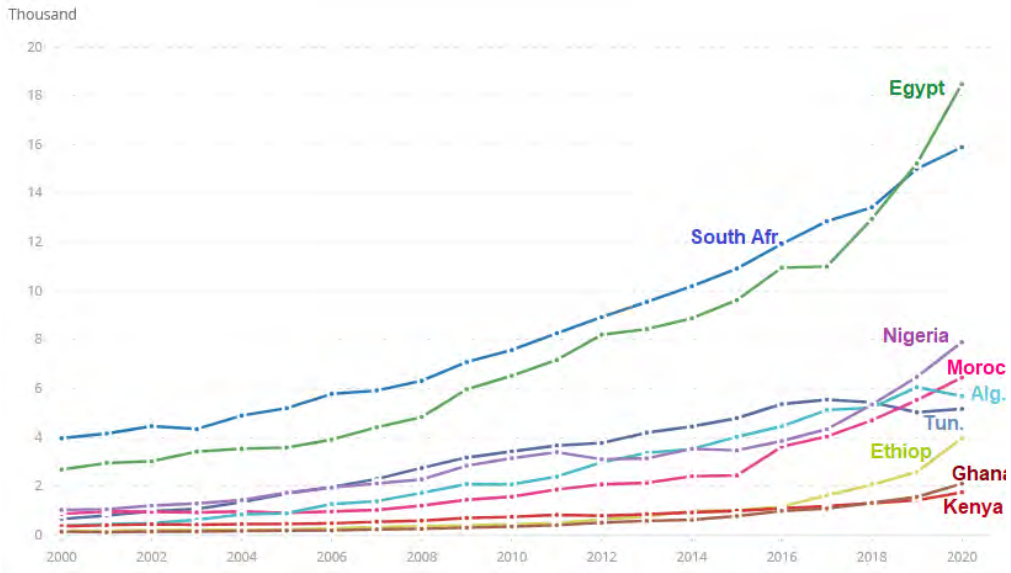


Figure 2a: Number of scientific and technical publications of the nine most productive African countries between 2000 and 2020.

Data source: World Bank (from Web of Science)
(https://data.worldbank.org/indicator/IP.JRN.ARTC.SC).

5 Holding 70% of Africa's GDP in 2021.
6 Namely the following areas listed in SCImago database: History, Philosophy, Social Sciences-miscellaneous-, Social Work, and Sociology and Political Science.

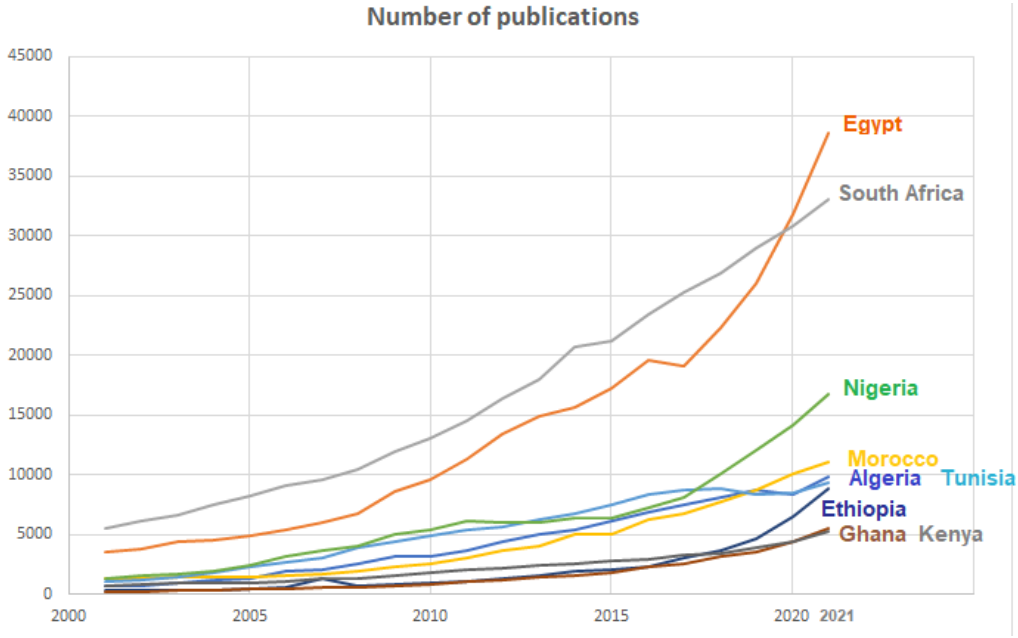


Figure 2b: Number of scientific publications (all scientific fields) of the nine most productive African countries between 2000 and 2021.

Data source: www.scimagojr.com.

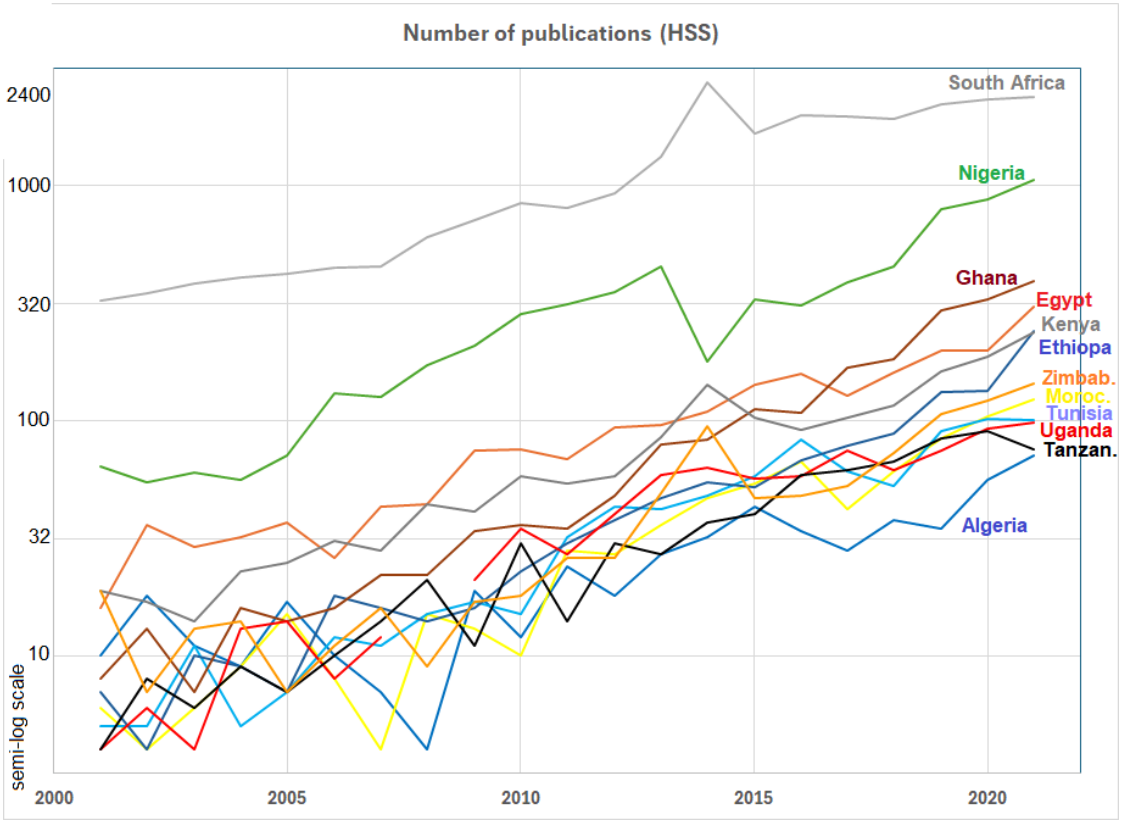


Figure 2c: Number of scientific publications in some Humanities and Social Sciences of the twelve most productive African countries between 2000 and 2021.

Data source: author's calculations based on raw data from www.scimagojr.com.

Rank	Country	H-index	Number of documents in 2021	Top 2% highly cited researchers
1	South Africa	567	33019	700
2	Egypt	349	38651	358
3	Kenya	310	5249	43
4	Nigeria	260	16745	104
5	Tunisia	235	9400	23
6	Morocco	232	11021	22
7	Algeria	213	9785	24
8	Uganda	209	3041	15
9	Tanzania	205	2658	15
10	Ethiopia	193	8876	21
11	Ghana	191	5467	21
12	Cameroon	167	2661	8
13	Malawi	166	1277	
14	Zimbabwe	164	1455	13
15	Zambia	151	997	5
16	Senegal	146	1046	7
17	Gambia	145	319	
18	Côte d'Ivoire	134	822	2
19	Congo	133	462	
20	Mozambique	130	814	1
21	Botswana	127	985	
22	Burkina Faso	126	842	
23	Mali	124	376	4
24	Gabon	120	305	
25	Namibia	119	675	3
26	Sudan	119	1704	4
27	Benin	117	900	1
28	Madagascar	113	511	4
29	Rwanda	107	999	4
30	Mauritius	104	515	

Table 1: Top 30 African countries in 2021 in terms of H-index and number of top-2% world cited researchers.

Data source: www.scimagojr.com (for H-index and number of documents) and Stanford University in partnership with Elsevier (Top 2% highly cited researchers).

Back to the study of all scientific fields together, Table 1 gives the 30 first African countries in terms of H-index[7] (up to 2021), the number of publications in 2021 listed by SCImago and the number of researchers in the 2021 world list[8] of top-2% highly cited researchers developed by Stanford University and Elsevier. These three indicators confirm once more the ranking of leading African nations.

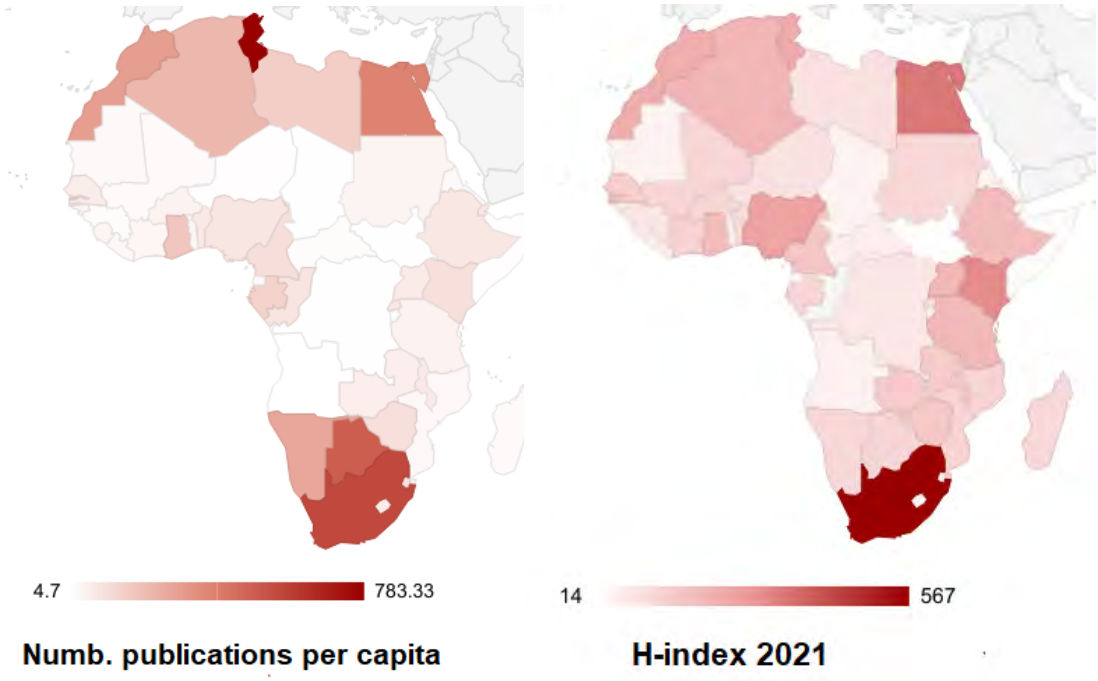


Figure 3: Left: number of scientific publications per million inhabitants in 2021.
Right: H-index (2021).

Data source: www.scimagojr.com.

The left side of Figure 3 shows the continental high productive ecosystems (Tunisia, South Africa, Botswana and Egypt) in terms of number of scientific publications per capita (in 2021) while its right side gives the continental most visible ecosystems (South Africa, Egypt and Kenya) in terms of research impact measured by the national H-indices (up to 2021).

7 Country's number of articles (H) that have received at least H citations. For example, till the end of 2021, there were no more than 567 scientific publications of researchers from South Africa that were cited (each one) at least 567 times.
8 Established by Stanford University and Elsevier https://elsevier.digitalcommonsdata.com/datasets/btchxktzyw/4

Figure 4: Number of articles per million inhabitants and number of citations per publication in 2021.

Data source: www.scimagojr.com.

Figure 4 represents on the horizontal axis the number of scientific publications per million inhabitants (in 2021) while the vertical axis represents the impact of these publications measured by the average number of citations per publication. The diameters of the circles represent the H-index of each country measuring the total cumulative impact of all its scientific publications up to 2021. The two continental leaders, South Africa and Egypt, far exceed the average performance in both quantity (horizontal axis) and quality (vertical axis). When considering the number of publications per million inhabitants (horizontal axis) Tunisia becomes the continental leader before South Africa, Botswana and Egypt.

When Tunisia and Botswana perform well in terms of number of publications per million inhabitants, they are below the average in terms of publications' impact. A group of seven countries (Mozambique, Gabon, Kenya, Congo, Mali, Zambia and Uganda) are characterized by a relatively high publication impact even if their numbers of publications per capita are relatively low. Weak performances in terms of quantity and impact are observed in Côte d'Ivoire, Senegal, Ethiopia, Burkina Faso, Cameroon and Zimbabwe.

	South Africa	Egypt	Kenya	Nigeria	Tunisia	Morocco	Algeria	Uganda	Tanzania	Ethiopia	Ghana	Senegal
R&D expend. (% of GDP)	0.62% (2019)	0.96% (2021)	0.69% (2010)	0.13% (2007)	0.75% (2019)	0.75%[9] (2016)	0.53% (2017)	0.48% (2010)	0.53% (2013)	0.27% (2017)	0.38% (2010)	0.58% (2015)
Researchers in R&D per million people	484 (2019)	838 (2020)	169 (2022)	23 (2019)	1660 (2020)	1074 (2016)	819 (2017)	29 (2014)	18 (2013)	91 (2017)	89 (2015)	564 (2015)

Table 2: Research & Development expenditure (% of GDP) and number of researchers in R&D10.

Data source: World Bank. (https://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS)

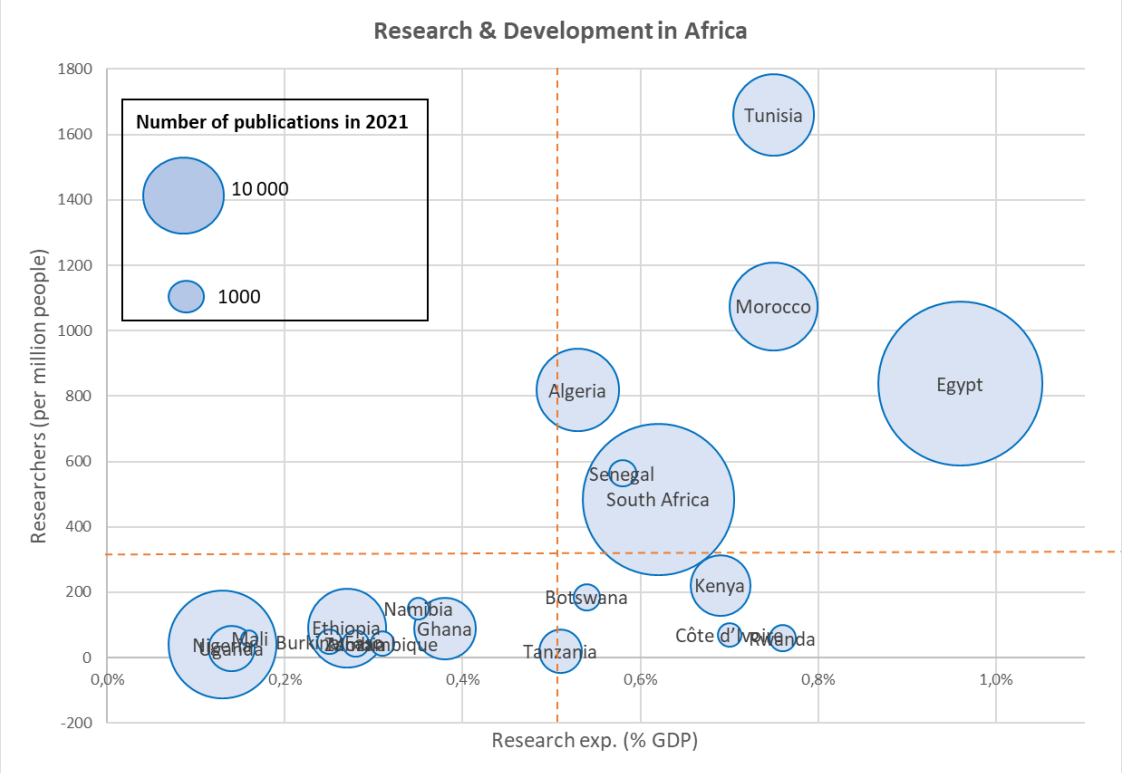


Figure 5: Research investment in Africa.

Data sources: World Bank (and SCImago for the H-index).

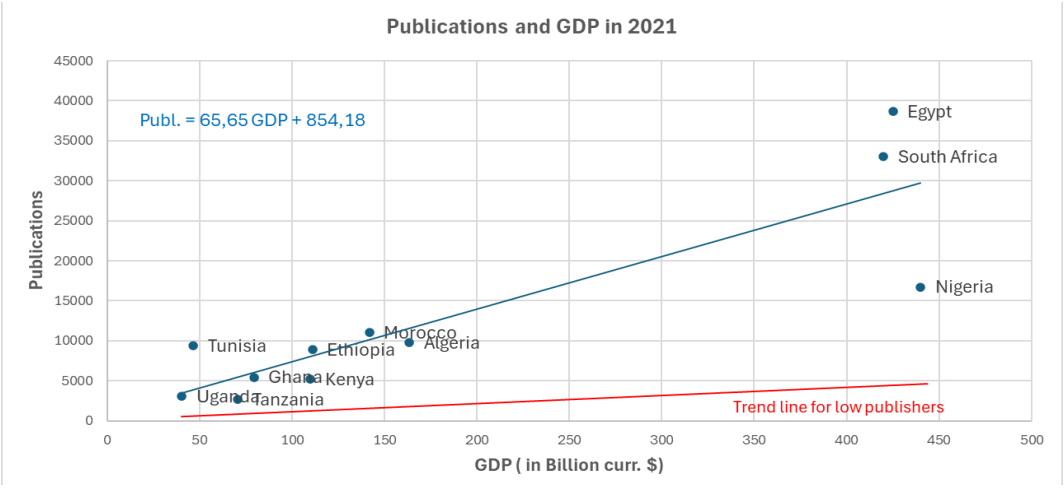
9 Report of Académie Hassan II des Sciences et Techniques February 2019 (for year 2016).

10 https://data.worldbank.org/indicator/SP.POP.SCIE.RD.P6 The number of researchers engaged in Research &Development (R&D), expressed as per million. Source: UNESCO Institute for Statistics (UIS) apiportal.uis.unesco.org/bdds.

Table 2 and Figure 5 analyze the African financial and human investments in scientific research. The ratios of gross domestic expenditure on R&D (or GERD) to GDP and the number of researchers per million inhabitants are depicted. Table 2 and Figure 5 show very significant disparities in terms of efforts and investments between six leading investing countries (South Africa, Egypt, Tunisia, Morocco, Kenya and Algeria) and all the other countries on the continent, even though Senegal is doing well with a number of researchers per million inhabitants of 564 and R&D expenditures representing 0.58% of GDP but with surprisingly small number of indexed publications (small circle in Figure 5).

The horizontal axis of Figure 5 shows that Egypt, Tunisia, Morocco and Rwanda are the nations that are investing the most in research (with regard to their GDP).

The number of researchers per million inhabitants (vertical axis of Figure 5) confirms that when the number of researchers is related to the population, Tunisia becomes the continental leader with 1660 researchers per million inhabitants, followed by Morocco (1074 researchers), Egypt (838), Algeria (819), Senegal (564) and South Africa (484). A considerable gap separates these six nations from all the others.



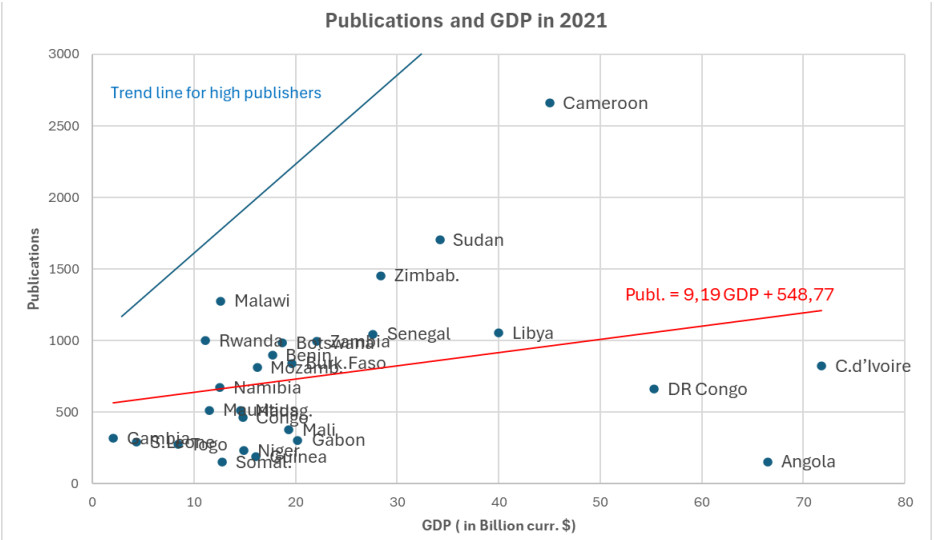


Figure 6: Research productivity in 2021: Publications and GDP.
Top: for the group of high publishers. Down: for the group of low publishers.

Data sources: World Bank and SCImago.

Finally, Figure 6 studies the relationship between scientific knowledge publication and economic wealth by relating the numbers of publications to the nominal GDP (in 2021 current US$) in the group of 11 highly publisher nations (top of Figure 6) and the group of low publishers (down of Figure 6). The difference in terms of research productivity seems very important (compare the blue and red lines). The average ratio publications/GDP in the eleven highly African publishers is around 70 (comparable to the developed economies) while it is only of 33 for the second group. We notice some over-productive (with regard to their GDP) ecosystems (Tunisia, Egypt and South Africa) and a clearly under-productive Nigerian ecosystem. For the second group Angola, DR Congo and Côte d'Ivoire should clearly have a higher knowledge production considering their GDP.

Dynamics of Scientific Publication in Africa

When dynamics depicted in Figure 2.b (reported to each country's population) are modeled using a temporal quadratic function, we get the following results:

- South Africa is the country which has the highest increase in the number of publications per capita in 2021 (annual increase of 34 publications per million inhabitants) followed by Morocco (a speed of 29), Egypt (27) and Tunisia (23) far before Ghana (16) and Algeria (13).
- Concerning the accelerations in numbers of publications per capita (i.e. the increase in publication pace): Morocco, Egypt, South Africa and Ghana have the highest accelerations (respectively 1.6, 1.3, 1.1 and 0.9) far before Ethiopia (0.5). Tunisia is clearly slowing down its production's speed (an important annual deceleration of 1.4).

Table 3 analyses in this article the growth of scientific publications during the two decades 2001-2010 and 2011-2020 using the SCImago (Scopus) database while Figure 7 reinforces the previous analyses using the World Bank (Web of Science) database. The comparison of these growth rates in Table 3 shows new elements regarding the different national dynamics of indexed scientific production. During the second decade 2011-2020, Ethiopia, Ghana, Morocco and Egypt respectively with annual growth rates of 22.0%, 17.3%, 14.2% and 12.2% are the countries that have the highest increase in their indexed scientific productions.

Comparing the two decades (three first rows of Table 3 and Figure 7), it is interesting to note:

- The strong and stable performances over the two decades of Egypt, Ghana and Kenya.
- The important increase of Moroccan publication paces between the first and the second decade.
- The continuous increase of the Ethiopian scientific production and the comeback of Nigeria after the slow-down of the period of 2006 to 2015.
- A slight recent slowdown in knowledge production for South Africa.
- The publication growth rates slowed down significantly between the first and second decade in Tunisia and Algeria with a worrying scientific downturn for the period of 2016 to 2020.

An initial economic-political analysis of publication dynamics

The dynamics described above will be related to the economic and political situations in this group of high publishing African nations.

The stable economic situations of Morocco and Kenya (ambitious structural reforms, important economic diversification, and strategic projects of infrastructure development) during the period going from 2000 to 2020 can partially explain their growing publication dynamics. Morocco, in particular, is experiencing exceptional (for Africa) long periods of political and economic stability

allowing coherent and long-term scientific strategies based on an increasing and incremental institutionalization of its ecosystem of scientific research with its double connection to local challenges and international networks.

The resilience of these ecosystems in Egypt, Ethiopia and Ghana (despite high inflation rates, local currency depreciations and trade deficits, political instability but with important development plans and reforms especially after 2015) deserves more detailed analyses.

The resilience of the Egyptian publication ecosystem could be explained by many factors:

- A proactive state policy (research expenditures -% of GDP- increased continuously from 0.2% in 2000 to 1.0% in 2021).
- A short revolutionary parenthesis (January 2011 – July 2013) which neither could nor wanted to change the relatively solid pillars of academic institutions.
- A highly institutionalized academic environment and strong academic institutions.
- A gentrification of the academic elite which was able to resist economic shocks thanks to multiple extra-salary sources of income (see Ali, 2024).

In the Ghanian case, the stable, democratic and peaceful political environment (see the high rank of Ghana in the 2020 Political Stability and Rule of Law in Table 3) is probably an indicator of institutional quality particularly relevant to the community of researchers and intellectuals.

	South Africa	Egypt	Kenya	Nigeria	Tunisia	Morocco	Algeria	Uganda	Tanzania	Ethiopia	Ghana
Average annual growth 2001-2010	10.0%	11.7%	11.3%	17.1%	18.7%	7.2%	19.5%	17.9%	14.9%	14.6%	15.9%
Average annual growth 2011-2020	7.6%	12.2%	9.0%	9.8%	5.3%	14.2%	9.7%	9.5%	9.7%	22.0%	17.3%
Comparison of the two decades	-2.4%	+0.5%	+2.3%	-7.3%	-13.4%	+7.0%	-9.8%	-8.4%	-5.2%	+7.4%	+1.4%
Depreciation of local currency[11] (vs US $) between 2001 and 2020	-59%	-78%	-36%	-74%	-54%	+12%	-49%	-58%	-35%	-79%	-94%
Average annual inflation[12] rate during 2001-2020	5,2%	10,2%	8,8%	12,4%	4,1%	1,5%	4,1%	6,4%	6,9%	12,9%	15,1%

11 https://databank.worldbank.org/source/global-economic-monitor-(gem)#
12 https://data.worldbank.orgA/indicator/FP.CPI.TOTL.ZG

Political Stability[13] & Absence of violence in 2000 and 2020 (percentile rank)	37,6	47,6	16,4	9,5	59,8	42,3	10,0	12,7	25,4	19,0	33,3
	39,1	11,8	14,6	4,7	25,0	34,0	17,9	18,9	27,4	6,1	52,8
Rule of Law[13] in 2000 and 2020 (percentile rank)	55,7	49,8	23,4	13,4	41,3	53,7	11,4	25,4	33,3	21,9	52,2
	45,2	41,4	30,5	21,0	55,7	47,1	22,4	41,0	29,0	38,1	51,9

Table 3: Evolution of scientific production in Africa with economic and institutional quality indicators.

Data source: www.scimagojr.com (scientometric) and World Bank (economic-institutional).

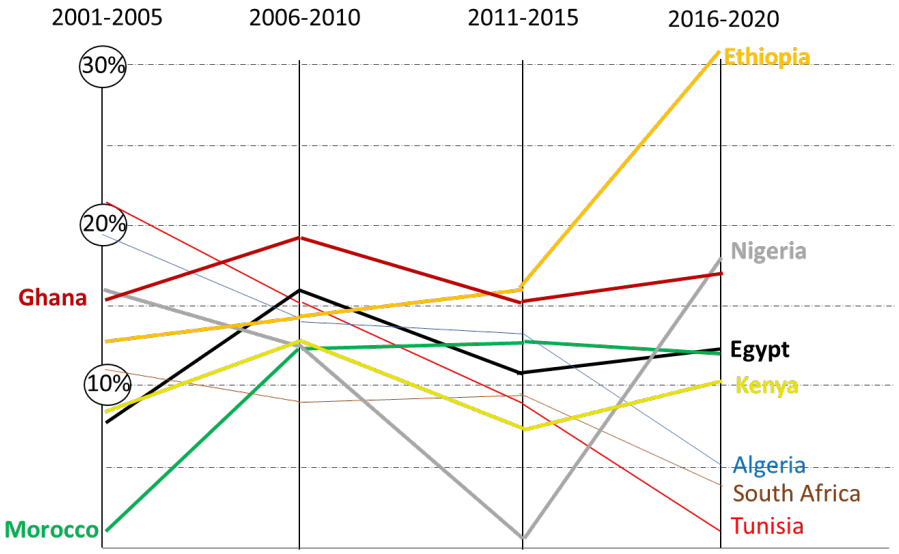


Figure 7: Average annual growth rates of scientific publications over the periods 2001-2005, 2006-2010, 2011-2015 and 2016-2020.

Data source: World Bank (from Web of Science).

The countries which growth rates slow down significantly between the first and second decade (see Table 3) are Tunisia (decrease from 18.7% to 5.3%), Algeria (decrease from 19.5% to 9.7%), Uganda (from 17.9% to 9.5%) and Nigeria (from 17.1% to 9.8%). All these countries had important economic crises with local currency depreciations during the studied decades (see row 4 of Table 3), high inflationary pressures and weak indicators of political stability (see rows 5 and 6 of Table 3) between 2000 and 2020.

Tunisia (with Algeria) had the highest average annual growth rates of publications in Africa (circ 19%) during the first decade 2000-2010. These positive and promising scientific dynamics stopped abruptly during the decade 2011-2020 with a weak annual growth rate of 5.3% the lowest among

13 https://databank.worldbank.org/Institutional-Quality/id/98e680fc#

the African leaders. When focusing on the period of 2016 to 2020 (see right hand side of Figure 7), the annual growth rate of Tunisian publications decreases even to 0.68% announcing an important and worrying slowdown. In fact, additionally to the persistent socio-economic crisis that followed the 2011 revolution and the resultant continuous impoverishment of the Tunisian middle-class, the scientific ecosystem in Tunisia was particularly fragilized by the changing of its whole governance system in 2011. The first post-revolution government decided in the early weeks following the fall of the regime to move from a centralized designation of academic authorities to a 100% elective mode, transferring instantly the whole Tunisian University from the Government authority (and political interference) to the control of the only remaining organized institutional actor: the national trade union organization. This yielded to the fragilization of an already weak academic institution where the previous (often) politically compromised academic authorities (chancellors, deans, scientific decision-makers) were most of the time replaced by elected (rather union co-opted[14]) authorities chosen for extra-academic motivations, goals and strategies.

In Nigeria, the average annual growth rate of publications decreased from 17.1% in the first decade to 9.8% in the second. But if we focus only on the period of 2016 to 2020 (see Figure 7) following the first peaceful political transition between two democratically elected governments, the annual growth rate of Nigeria's publications increases to 18.1% announcing an interesting recovery after the 2011-2015 slowdown (annual publication's growth rate of only 0.8%). This temporary Nigerian slow-down could be related to the economic shocks due to oil prices collapse and militant attacks on oil infrastructure leading to several episodes of Nigerian Naira depreciations between 2014 and 2016 before its stabilization starting from 2017 (see Livsey[2017] for a detailed analysis of the Nigerian case).

Scientific Publications and the Linguistic/Institutional Colonial Legacy

Figure 8 compares publication shares and demographic weights of seven African regions. Countries of each one of these seven regional groups have the same tertiary education language with (approximately) common colonial history.

Egypt produced 22.7% of African all-fields publications in 2021 (vs a demographic weight of 7.7%), its weight in 2021 African HSS publications decreases to 8.1%. The share of Maghreb countries in all-fields African publications (18.0%) is stable between 2001 and 2021 (a demographic weight of 6.6% in 2021) and (as for Egypt) these shares fall to 8.2% when we focus on HSS publications. These shares doubled between 2001 (4.0%) and 2021 (8.2%) signaling an increasing integration of Maghreb countries in the international HSS publication networks.

South Africa (holding 20% of Africa's publications) become a major actor if we focus only on Humanities and Social Sciences indexed publications: 37.4% of African publications in HSS are produced in South Africa and 60% are produced by researchers from South Africa, Nigeria or Ghana.

None of the 11 high publishing nations has French as official language. The major part of the remaining 43 low publishing countries were under French, Belgian or Portuguese colonial rule.

African countries where French is currently the official language (members of CAMES[15]) has a demographic weight of 26% and only 6.5% of the African indexed publications in 2021. A demographic giant like RD Congo (representing 7% of African population) contributed with only 0.4% of African publications in 2021. Senegal for example with one of the most stable (politically and institutionally) French-speaking African countries has a share of 0.6% of indexed publications in 2021 (halved in 20 years). Côte d'Ivoire published in 2021 (see Table 1) only 822 indexed publications (0.5% of African publications) for a demographic weight of 2% and a GDP of 71.8 Billion US$ (3.1%

14 The control of the national union over the academic world was, for example, symbolically ratified in January 2015 when Tunisia's largest university campus was renamed after the historic national union leader Farhat Hachad.

15 CAMES: a body coordinating their higher education issues and research systems https://www.lecames.org/. These 19 African countries are: Benin, Burkina Faso, Burundi, Cameroon, Central Africa, Chad, Congo, Côte d'Ivoire, DR Congo, Equatorial Guinea , Gabon, Guinea, Guinea-Bissau, Madagascar, Mali, Niger, Rwanda, Senegal and Togo.

of Africas's GDP) when Ghana (with comparable population and GDP) has published 7 times more (5467). Côte d'Ivoire and Ghana being different by their colonial history (see Broussalian, 2011) and [consequently] by their institutional quality indicators (Ghana with significantly higher indicators[13] for Political Stability and Rule of Law). The two demographically important Portuguese speaking countries Mozambique and Angola (circ 5% of African population) contributed in 2021 by only 0.6% of African publications. This apparently important impact of colonial legacy is clearly visible in Figure 8: regions formerly colonized by Great Britain (right-hand side of Figure 8) have high shares in African publications while those previously under French (except the Maghreb), Belgian or Portuguese colonization (left-hand side of Figure 8) still have very weak scientific publications. This apparently linguistic-institutional colonial legacy deserves deeper analyses that could start for example by focusing on the case study (Côte d'Ivoire vs Ghana). Is this a simple language barrier to get access to English speaking international knowledge and scientific networks or is it related to deeper cultural, historical, postcolonial, institutional, geographical, social, political and economic factors shaping the social context of academic life and scientific production ecosystems? What are the importance of alternative dissemination channels of scientific knowledge and research output in non-English speaking sub-Saharan Africa?

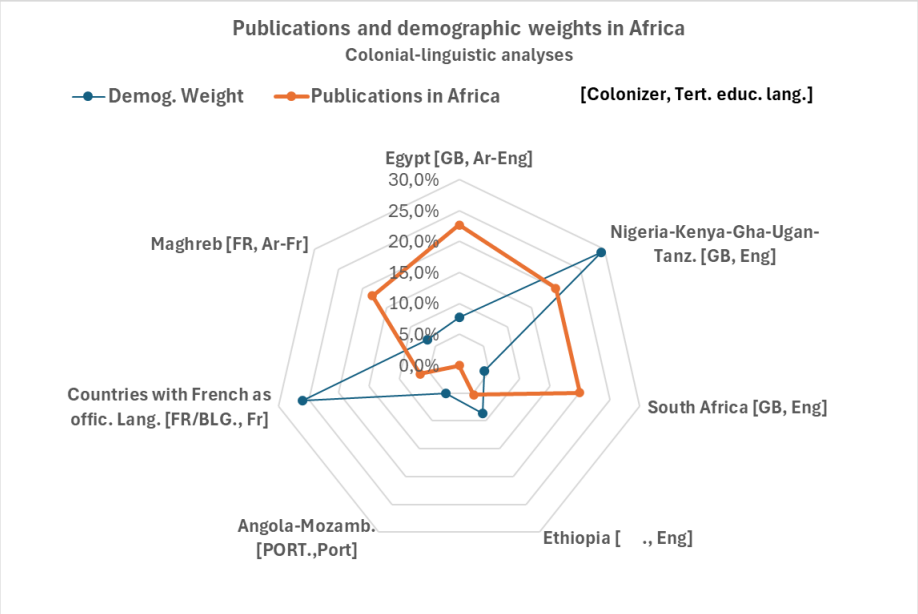


Figure 8: Shares of all-fields publications and demographic weights.

Data source: author's calculations based on raw data from www.scimagojr.com.

The scientometric analyses presented here suggest empirically a better scientific governance and a more institutionalized knowledge production in formerly British colonies. Their scientific ecosystems (mainly compared to the former French colonies) seem to have benefited from the British legacy with:

- A perfectly English-speaking scientific elite with much broader access to international academic resources and networks.
- Much more autonomous universities, decentralized education systems and institutionalized science; growth of independent publishers.
- A higher consideration given to liberal arts education and applicable knowledge in the excellence curriculum.

Maghreb countries seem to be initiating an efficient switch to English as a language of research and tertiary education. This seems not to be the case for sub-Saharan French-speaking countries.

The nexus science–language–postcolonialism (see Prah, 2018) goes far beyond mastering or not mastering English. Prah 2018 noted that "the real challenge is how to intellectualize African languages and bring them up to speed with the linguistic techniques of modernity and advanced contemporary thought" (Prah, 2018, p.30). He suggested that "post-colonial Asia may offer us a great deal that we can learn from … by adaptation that recognizes the primacy of our cultural heritage." (Prah, 2018, p.30).

Highly cited researchers and university rankings

Figure 9 and Table 1 show the number of researchers residing in Africa and belonging to the world's top 2% of the most cited researchers according to the 2021 list[16] established by Stanford University and the scientific publisher Elsevier. South Africa, with 700 highly cited researchers (HCRs), is far ahead of Egypt (358 HCRs), Nigeria (104) and Kenya (43). Ethiopia and Ghana with 21 HCRs are at the same level as the three Maghreb countries.

When considering the number of HCRs per capita (per 10 million inhabitants) described on the right part of Figure 9, South Africa with almost 120 HCRs per 10m inhabitants is far before Egypt (35) and Tunisia (19). The other nations are all far behind.

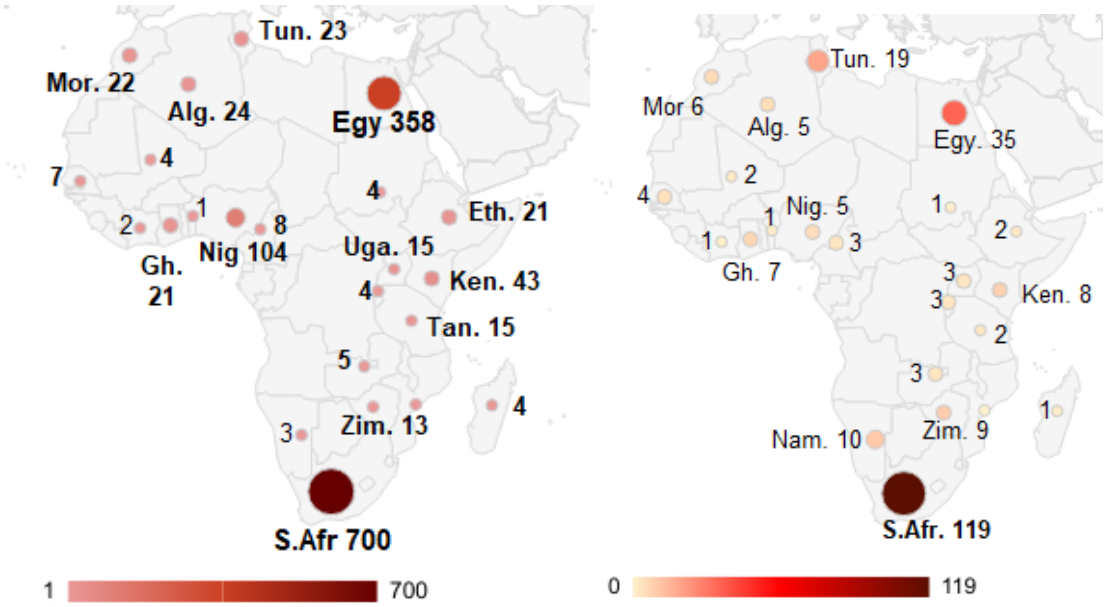


Figure 9: Left: Number of researchers in the top 2% of most cited researchers in 2021.
Right: number of HCR per 10 million inhabitants.

Data Source: Stanford University and Elsevier.

Scientific publications cannot be developed without a network of top-performing universities. Several international rankings have emerged over the past twenty years. These rankings are most often based on indicators that combine scientific production and shining, teaching quality and reputation among companies.

16 https://elsevier.digitalcommonsdata.com/datasets/btchxktzyw/4

Table 4 shows the number of African universities ranked in Shanghai (2023), THE-2023 (Times Higher Education) and QS (2023) lists. It emerges that for 2023 Shanghai list[17] giving the 1000 first universities only South Africa and Egypt are doing well by placing eight and seven universities (University of Cape Town among the first 300, University of the Witwatersrand and Cairo University are among the first 400). Nigerian University of Ibadan is ranked among the decile 801-900. Tunisia and Ghana has each one university ranked in the last decile 901-1000 (University of Sfax and University of Ghana).

	South Africa	Egypt	Kenya	Nigeria	Tunisia	Morocco	Algeria	Ethiopia	Ghana
Shanghai 2023 – top 1000 world universities	8	7		1	1				1
QS 2023 – top 1400 world universities	9	14	1		3	1			1
THE 2023 – top 1500 world universities	13	26	1	12	8	8	13	2	3

Table 4: Number of African universities in the three main international rankings.

Discussion and Conclusions

The scientometric approach used here is a first step in the analysis of scientific production in Africa. It provides a useful first dashboard that needs to be improved with alternative metrics and approaches more adapted to the African context.

Our quantitative analysis confirms the South African hegemony on African scientific production while showing a stable and continuous rise of Egypt during the two first decades of this century. The Egyptian case is interesting as it shows a surprisingly resilient ecosystem that resisted, till now, the instable economic situations. Egypt had even started to outperform South Africa in terms of number of STEM publications starting from 2020 as was discussed also by Kigotho (2021). This Egyptian upward trajectory could be explained by a strongly institutionalized academic environment and an ambitious national policy based on the provision of incentives to science, technology and innovation[18] with the highest ratio R&D-expend./GDP in Africa. One of these incentives are new academic promotion regulations based mainly on scientometric evaluation (Ali, 2024) even if such approaches for evaluating research activities can have several and important drawbacks[19] in the medium and long term.

17 https://www.shanghairanking.com/rankings/arwu/2023

18 Law no. 23 of 2018 on the provision of incentives to science, technology and innovation in Egyptian higher education institutions and scientific research bodies.

19 See the principles of DORA (https://sfdora.org/): San Francisco Declaration on Research Assessment promoting “the responsible use of metrics that align with core academic values” and a “broader representation of researchers in the design of research assessment practices that directly address the structural inequalities in academia”.

Our analysis seems to validate the strategic choices made over the last decade by Egypt, Morocco, Ethiopia and Kenya. These strategic choices concern the creation and development of internationally visible scientific clusters, the adoption of international standards for the training and evaluation of researchers, their retention, as well as a solid reverse brain-drain effort and effective networking with the scientific diaspora.

The Tunisian case seems to be symptomatic of many fragile African scientific ecosystems where both economic crises and political instability brought a sharp halt to a scientific dynamic that appeared very promising during the 1990s and the first decade of the 21st century.

The scientific strategies of French-speaking sub-Saharan Africa are perplexing: a very weak number of indexed publications implying most likely very weak networking with international scientific communities and consequently limited and slow access to recent scientific knowledge and innovations.

If the efforts of Morocco and Egypt and their strategies become more institutionalized, consolidated and accelerated over the next decades, they will give rise to two continental scientific and technological centers that will join South Africa to form three poles of scientific excellence on the continent. While waiting for the emergence of new poles in the West (probably Nigeria and Ghana) and East (Ethiopia and Kenya) of the continent, these poles should in the future focus much more on African-African international research cooperation (see for example Cerdeira et al., 2023). This will let these continental poles radiate out to the rest of the continent and fully assume a role of scientific, technological and intellectual beacons for the African youth.

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