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Kenya's Research Excellence as Indexed in the Web of Science: An Informetrics' Perspective

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Abstract

Research excellence (RE) is a relatively new concept which has been gaining traction among scholars, government agencies and funders. No universally accepted definition of RE exists. In this paper, however, it is perceived as the sustained conceptualisation, design, execution and dissemination of optimal volumes of high quality research products which contribute effectively to societal wellbeing. The concept of research excellence is just emerging in Kenya. Indeed, the literature reviewed in this paper reveals that the perception, measurement, and reporting of research excellence in Kenya is largely unknown. Therefore, this paper seeks to unravel these issues as a means of promoting research excellence in the country. The study anchoring this paper assessed the top papers produced in Kenya to gauge the country's RE. Data were obtained from Clarivate Analytics' Web of Science (WoS) Core Collection databases, the Essential Science Indicators and the Journal Citation Reports. Specifically, the paper explores the trend and volume of the highly cited and hot papers as the percentage share of Kenya's total research publications; identifies the journals and assessed the quality of the journals in which Kenya's highly cited and hot papers are published; examines the subject content and research field yielding the most highly cited and hot research papers in Kenya; determines the extent of research collaboration in the highly cited and hot papers; and benchmarks Kenya's performance in the top papers against the rest of Africa. The study reveals an increase in the publication of the top papers, largely in the form of journal articles; a heavy co-authorship of the papers; a favourable performance by Kenya when compared to the rest of the African countries; and the publication of the country's top papers in prestigious international journals. Kenya's RE is partly dependent on the dissemination of its research in high impact factor journals. In addition, the country's RE is heavily dependent on the performance of science fields such as internal medicine, environmental sciences and ecology, and public health and agriculture.

Keywords: *Research Excellence, Informetrics, Scientometrics, Kenya*

Introduction

The importance of excellence in scientific progress is widely documented in existing scientometrics literature (Aksnes, 2003; Tijssen *et al.,* 2002; Vertesy and Tarantola, 2012). The concept of research excellence (RE) is relatively new and as such no clear definition has been adopted. Similarly, no standardised method of evaluating research influence has been universally accepted. There is an ongoing debate amongst scholars on the meaning of excellence (Tijssen, 2003), its capacity to provide a quantitative assessment of research activities (Vertesy and Tarantola, 2012), as well as potential to support policy choices (Ferretti *et al.,* 2018). Ferretti *et al.* (2018) explain that excellence is a complex, value-laden and multidimensional concept which is not only relative but also emergent (Tijssen, 2003; Ferretti *et al,* 2018).

Furthermore, according to Tijssen (2003), excellence is a comparative expression denoting superiority in terms of quality or quantity and driven by the researchers' need to demonstrate return on investment to funders of research activities (Martin, 2011). While the common definition of excellence is elusive, excellence is not only perceived as an utmost indication of performance but also as the motivating power for progressive policies with high levels of national competition (Tijssen *et al.,* 2002; Rodríguez Navarro, 2011; Vertesy and Tarantola, 2012).

Tijssen (2003) argues that the pursuit for research excellence is aimed at achieving three main objectives, identified as 1) producing new and high quality scientific knowledge to catalyse innovations and socioeconomic development; 2) effective dissemination of the knowledge to its potential users; and 3) application of the knowledge to enhance the competitive advantage of individuals, institutions, and nations. Research excellence is perceived as generating research outcomes of exceptional quality and quantity which are relevant to specific societal needs and contexts. Sørensen *et al.* (2016) perceive research excellence as the intrinsic quality embedded in research processes, researchers and research institutions while Hardeman *et al.* (2013) assert that research excellence is "the top-end quality outcome of systematically performed creative work undertaken to increase the stock of knowledge and new applications". Rodríguez Navarro (2011) aver that research excellence is an indicator of high level of performance in conducting research and generating relevant outcomes. Tijssen (2003) distinguishes research excellence from scientific or scholarly excellence by explaining that the latter includes other activities such as teaching, training and other advisory services rendered by scholars. Arthur (2016) also equates research excellence to research leadership and opines that excellent researchers mentor budding researchers. In the context of this paper, research excellence is perceived as the sustained conceptualisation, design, execution and dissemination of optimal volumes of high quality research products which contribute to societal wellbeing. This paper also considers research excellence, high research quality and scholarly excellence as synonyms.

Literature Review

Assessment of research excellence has drawn varied reactions due to differences amongst different disciplines and countries contingent on the territorial scientific development, its goals, and methodological challenges and policies (Tijssen and Mbula, 2018; (Toivanen and Suominen, 2013; Bornmann *et al.,* 2017). In the United States of America, for instance, research excellence is attached to innovations and patents. The rationale is that high quality research papers attract a high number of citations and application in innovations. Hicks *et al.* (2000) report that the top 1% of highly cited works in the United States are nine times more likely to be cited in a patent. Therefore, funding agencies are keen to invest in research which is likely to lead to a patented innovation. In many developed countries in Europe, research excellence is also linked to researchers being awarded a Nobel Prize. Rodríguez Navarro (2011) explains that researchers who publish in high impact journals such as *Nature* and *Science* are highly cited and also stand a greater chance of being awarded a Nobel Prize. All the Nobel Prize awardees are also highly-cited researchers. In the United Kingdom, Chowdhury *et al.* (2016) explain that research is evaluated by measuring the quantity and value of research grants; number of researchers from an institution included in the Impact Case Studies (ICS); and the number of spin-offs created through research.

Ndofirepi and Cross (2016) advocate for regional consideration of research excellence. Similarly, Tijssen and Mbula (2018) emphasise that the perception and application of the concept of research excellence should be locally inclined, especially in developing regions such as sub-Saharan Africa due to challenges faced by researchers and research funding agencies. Often, a focus on global excellence, determined by subjective standards, ignores local needs. Tijssen and Mbula (2018) further explain that excellence ought to be understood in context, of research quality despite one's circumstance.

As mentioned, this paper perceives research excellence as the ability to conduct, produce and disseminate locally-relevant research output in terms of quality, quantity and applicability, using the available resources and standards. Whereas research

excellence parameters may be universal, the act of interpretation and application is mediated by the geo-cultural contexts in which the research is conceptualised, conducted, disseminated and applied. We also uphold the view that research excellence is domain-specific. Therefore, perception and assessment of excellence also ought to be different for each domain. The dynamic nature of research excellence implies that the perception of excellence varies according to the changing time-dictated contexts of research projects. Ultimately, research excellence should be framed in accordance to the value generated by research outcomes in a given context.

Diverse research performance evaluation policies, techniques and metrics have been developed and applied over the years to assess the quality and impact of research. The need to confirm the quality of research has in turn necessitated the advancement of the concept of research excellence. Martin (2011) opines that the number and diversity of methods applied to measure research excellence have increased over the years and have become progressively more sophisticated, hence the use of bibliometric concepts to evaluate research excellence. Bibliometrics measures quantity, quality and visibility of research output, production and use of scientific literature. Sethi and Panda (2014) and McManus *et al.* (2021) aver that bibliometrics evaluate research excellence using parameters such as the number of publications produced by a researcher in a given period, the number and diversity of citations that scientific works have attracted, as well as the scholarly channels (high or low impact) on which research literature have been published. According to Hicks *et al.* (2015), universities and other research institutions are obsessed with research performance rankings which are used to support decisions on tenure, promotion or research funding. At the national level, Hardeman *et al.* (2013) suggest four parameters to evaluate research excellence: 1) the number of highly cited research publications, 2) volume of patent applications, 3) number of world-class universities and research institutes in the country, and 4) the number and value of prestigious research grants received by researchers in a country. Hicks *et al.* (2015) advocate for the use of both qualitative and quantitative metrics.

Bornmann *et al.* (2017) argue that the measurement of research excellence should take cognisance of the fact that academic institutions operate in different environments. They also explain that excellence should not measure output only but should also acknowledge the input that institutions as well as funding agencies make into research. It is unrealistic to expect excellence from researchers who do not have adequate resources to excel. Hardeman *et al.* (2013) conclude that there is no ideal country in research excellence and that there are areas that require improvement in all countries of the world. Scholars who advocate for research assessment measurement have advocated for the use of multiple indicators for different aspects of research excellence measurement as an alternative to one indicator that can cause biased judgment (Rafols *et al.,* 2012; Sørensen *et al.,* 2016), making the "incomparable comparable" using indicator values that are the same or similar such as the use of currency (Bornmann *et al.,* 2017), and positioning normalised indicators such as Leiden manifesto (Hicks *et al.,* 2015; Hicks, 2012; Waltman, *et al.,* 2012) that further reduce abuse of research metrics used by scientometricians.

Highly cited papers (HCP) are potential candidates for identifying and measuring excellence in scientific research (Aksnes, 2003; Onyancha, 2020a). Noorhidawati *et al*. (2017) assert that highly cited papers are a proxy of excellence in research. Undoubtedly, one can say that comparatively large quantities of citations denote significant scientific impact and guarantee a researcher and the affiliated institution visibility in terms of scientific recognition (Tijsse *et al.,* 2002; Kwanya, 2020). Aksnes (2003) discusses the characteristics of highly cited publications and concludes that the majority are published by multiple scientists drawn from multiple countries through diverse forms of collaboration, are published in high impact journals, are cited by scientists foreign to the country of origin of the authors, display a low proportion of self-citation, and attract citations from both remote and adjacent fields.

According to Aksnes (2003), HCP must not be confused with Hot Papers (HP). HCPs usually receive enough citations to be placed in the top 1% of the academic field based on a highly cited threshold for the field and publication year (Noorhidawati *et al.,* 2017). In contrast, HPs receive

an early citation peak and later annual citations which are much lower than the early peak. Bornmann and Leydesdorff (2018) view HPs as papers that rise in citations shortly after publication but tend to have later annual citations that develop after the work's early peek. (Toivanen and Suominen, 2013) refer to them as research frontiers and peg the early peak to two years after publication. Haghighat and Hayatdavoudi (2020) cast doubt as to whether the attainment of HP status indicates research excellence due to excessive self-cited references in articles that may distort the original agenda of a bibliometric designation in the Web of Science (WoS). Although scholars' research impact can be measured by the number of citations their work has received, the use of citation indicators is debatable since the link between what is being measured and the perception of scientific excellence is less obvious (Aksnes, 2003; Kwanya *et al.,* 2021; Noorhidawati *et al.,* 2017; Tijsse *et al.,* 2002). Onyancha (2020a) argues that altmetrics are predictors of citations and therefore should be used for evaluating research excellence. This view is shared by other scholars (Bornmann, 2015; Bornmann *et al.,* 2019; Holmberg *et al.,* 2019; Robinson-Garcia *et al.,* 2018; Onyancha, 2020c; Tahamtan and Bornmann, 2020).

The concept of research excellence is just emerging in Kenya. Thus, there is limited literature on what it is as well as how it should be measured or improved. Kiprop *et al.* (2016) suggest that research excellence in Kenya can be improved through internationalisation of academic and research programmes thereby improving their quality to world-class standards. Atieno *et al.* (2021) as well as Kwanya (2020) also aver that internationalisation mechanisms facilitate exchange of staff, sharing of research facilities, and research collaboration. According to Fosci *et al* (2019), Kenya spends about 0.8% of its GDP on research. Thus, the sector is underfunded even with the international contribution of nearly 47% of the research and development funds in the country. This low level of funding is evidence of a similarly low appreciation of the role of research in development and is negatively affecting the performance of researchers and research institutions in the country. Nonetheless, the research publications produced in the country are disseminated fairly well through international research collaboration networks. It can be concluded from the foregoing that the perception, measurement, and reporting of research excellence in Kenya is largely unknown. This paper seeks to unravel these issues as a means of promoting research excellence in the country.

Purpose and Objectives of the Study

The purpose of the current study is to examine Kenya's research excellence as proxied in the WoS-indexed highly cited papers and hot papers. The specific objectives are as follows:

- to explore the trend and volume of the highly cited and hot papers as the percentage share of Kenya's total research publications;
- to identify the journals and assess the quality of the journals in which Kenya's highly cited and hot papers are published;
- to examine the subject content and research field yielding the most highly cited and hot research papers in Kenya;
- to determine the extent of research collaboration in the highly cited and hot papers; and
- to benchmark Kenya's performance in the top papers against the rest of Africa.

Research Methodology

The study was quantitative and it adopted a bibliometrics design (Onyancha, 2020b) to examine Kenya's research excellence as reflected in the research publications indexed in the Clarivate Analytics bibl*iographic/citation databases. Despite the shortcomings associated with the scope of their coverage of publications emanating from the global south, the Web of Science (WoS) citation indexes and other Clarivate Analytics' products such as the In Cites and the Journal Citation Reports (JCR) remain as the key sources of bibliometrics and scientometrics data. The current study obtained data from three Clarivate Analytics' WoS core collections (which consists of eight citation indexes), the Essential Science Indicators (ESI) and the JCR. The ESI, covering the data over a 10-year and 2-month period, from January 1, 2021 to February 28, 2021, was used to obtain each country's total citations for top papers (TPs) (the data in ESI updated bi-monthly,

i.e. six times a year). The TPs, in this case, comprised the highly cited papers (HCPs) and hot papers (HPs). The search within the ESI was conducted using the filter for country. The second source of the data was the citation indexes, whereby the search tag CU (country affiliation) was combined with the name of the country in an advanced search query (i.e. CU=Kenya) to search and retrieve data for papers published between January 2011 and June 2021. The date range in the search query was determined to coincide with the ESI's period of data coverage. Finally, the JCR was used to retrieve data on the impact factor *(Journal Impact Factor - JIF)* for each of the top journals that published research emanating from Kenya.

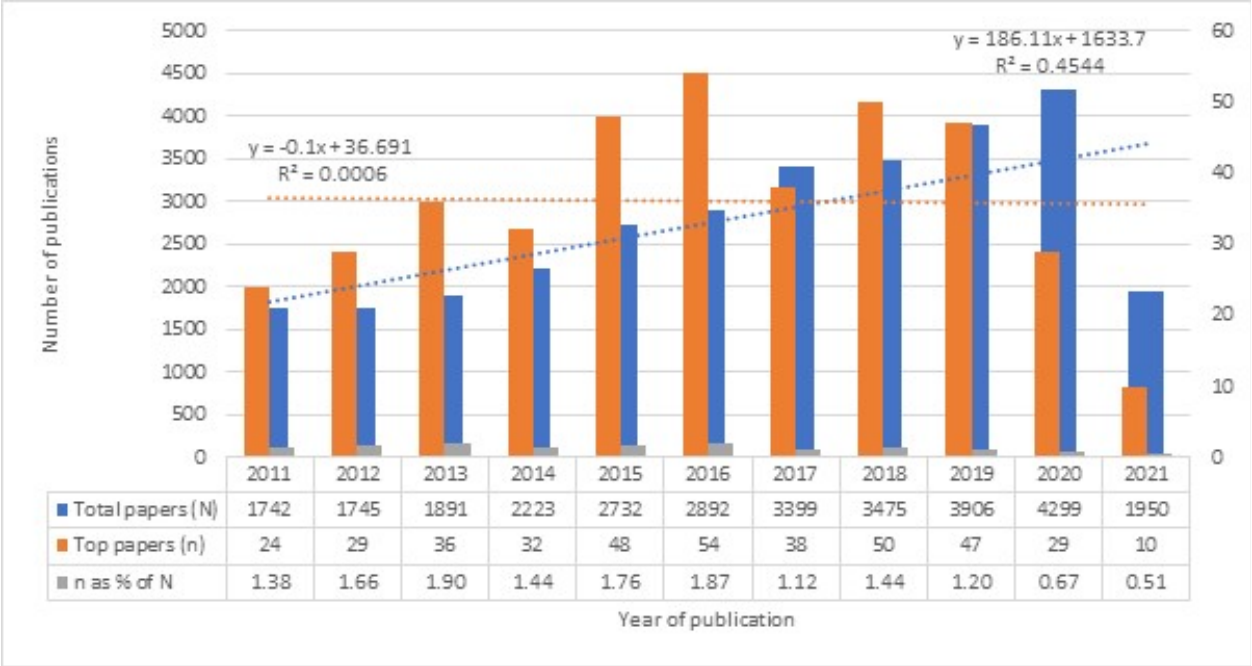
The methods of data extraction, storage and analysis varied depending on the nature of the data and structure of the database. The ESI data were extracted and saved as .csv format; the data from the WoS core collection and JCR were saved in .txt format. The data extracted from the WoS collection were analysed using VOS viewer software. The software, which is often used to map research using co-authorship, co-occurrence of terms, and citation and co-citation analyses, was used in the current study to generate the illustrations in Figure 3, through the co-occurrence analysis of author-supplied keywords and co-authorship analysis of publications by country, respectively. Microsoft's Excel software was used to conduct other analyses such as computing the average correlation coefficients in Pearson correlation tests as well as to present data in tables and graphs.

Limitations of the Study

The literature review section demonstrates that the use of highly cited and hot papers as proxy for RE as well as research quality is well documented. However, the use of citations to proxy quality is a highly contested subject, particularly given that there are varied motivations for citations (see for example, Snyder 1991), besides the relevance and quality of the cited paper. Nevertheless, it has been generally argued that people cite published works because they find them *useful* for their works. It is on this basis, among others, that top papers are considered to be indicators of RE (see Vertesy and Tarantola 2012) and hence, their use in this study as proxy measures of RE.

Results and Discussion

Trend of Publication of Research Papers in Kenya



	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Total papers (N)	1742	1745	1891	2223	2732	2892	3399	3475	3906	4299	1950
Top papers (n)	24	29	36	32	48	54	38	50	47	29	10
n as % of N	1.38	1.66	1.90	1.44	1.76	1.87	1.12	1.44	1.20	0.67	0.51

Figure 1: Trend of publication of top papers vis-à-vis all research papers in Kenya, January 2011-June 2021

Figure 1 shows that while Kenya has witnessed a continued growth in its research output, the TPs have had a mixed growth pattern. The number of TPs has increased in some years while dropped in others. For example, the number of TPs increased from 24 in 2011 to 36 in 2013, but decreased the following year (i.e. 2014) to stand at 32 papers and increased thereafter to 48 and 54 in the next two years until 2017 when it dropped to 38. Since 2018 when they stood at 50 the TPs have continued to decrease in number. While the small number of these papers in 2020 and 2021 can be explained by the indexing and citation time lags, the performance of Kenya in terms of the TPs prior to 2019 can be said to portray RE patterns. It will be interesting to investigate the weak correlation (i.e. $r = 0.4800$; $p < 0.05$) between the total number of papers and top papers. The correlation indicates that, although there is a relationship between the two variables, the number of Kenya's total publications is not increasing at the same rate as that of top papers. In other words, the TPs are not entirely dependent on the total number of publications produced in Kenya so as to conclude that the higher the number of total publications, the higher the number of HPs.

Distribution of Top Papers by Document Type

The highly cited papers were published in the following document formats: journal articles (328), review articles (68), book chapters (4), proceedings papers (3) and data papers (1). A comparison of the top papers against the overall publication patterns in the country reveals that out of the 17 document types that constitute Kenya's total publication outputs between 2011 and 2021, the TPs were published in five formats only. It was not surprising to note that journal articles topped the two lists as journal articles are the most commonly used avenues of disseminating research findings. In fact, in most institutions that reward academics for research outputs, journal articles are the most weighted research outputs. In Kenya, for example, a journal article is ranked third behind a single-authored 'scholarly book' and a patented invention or innovation. According to the Commission for University Education's (Commission for Higher Education, 2014) guidelines, a journal article earns an academic staff member eight points while a single-authored university level scholarly book and patented innovation or invention are awarded 24 and 16 points, respectively. A book chapter is ranked fifth with six points. In South Africa, the Department of Higher Education and Training (DHET, 2015) places a higher premium on a journal article which is counted as a whole unit (1 point) while other research outputs such as papers in conference proceedings, and book chapters, are weighted lower than or similar to journal articles, depending on several other variables. Notwithstanding Table 1's revelation that RE is domiciled in four document types, in the case of Kenya, the dissemination of research findings in other document types is equally important. However, it is apparent that if an individual author, institution, or country were to improve its status in a given RE index (such as the ESI), they should consider publishing research in the form of journal articles, conference proceedings, book chapters and research data or data papers.

Table 1: Distribution of Kenya's papers according to document types

No.	Doc. Types	Total docs (N)	% of N	Top papers (n)	% of n
1	Journal articles	23354	72.51	328	81.19
2	Meeting abstracts	2780	8.63	0	0.00
3	Review articles	1549	4.81	68	16.83
4	Book chapters	1295	4.02	4	0.99
5	Proceedings papers	1098	3.41	3	0.74
6	Editorial materials	1010	3.14	0	0.00
7	Early access	421	1.31	0	0.00
8	Letters	316	0.98	0	0.00
9	Corrections	169	0.52	0	0.00
10	Book reviews	109	0.34	0	0.00
11	Data papers	44	0.14	1	0.25
12	News items	43	0.13	0	0.00
13	Biographical items	13	0.04	0	0.00
14	Retractions	3	0.01	0	0.00
15	Fiction. creative prose	1	0.00	0	0.00
16	Film reviews	1	0.00	0	0.00
17	Poetry	1	0.00	0	0.00
	TOTAL	**32207**	**100.00**	**404**	**100.00**

Kenya's RE within the African Context

Two variables were considered to assess how Kenya has performed in relation to its counterparts in Africa. Kenya was compared to other countries in terms of the number of publications and citations or citation impact. Regarding the number of publications, Table 2 demonstrates that Kenya compares favourably with the top most productive countries in Africa, namely South Africa, Egypt, Nigeria, Tunisia and Algeria in terms of the number of total publications for the period 2011-2021 as well as the HCPs and HPs. Kenya ranks seventh in terms of the total number of publications, third in the number of HCPs, and fifth in the number of HPs. A quick glance at the 2020 SCImago country ranking reveals that Kenya is placed in one position and two positions lower, in terms of the total number of documents and citable documents, respectively, in the Scopus database. Kenya's TPs as a percentage share of its new Hollister donkey mascot total number of publications was 1.93% while the other top African countries' TPs as a percentage of the total publication outputs in each country were as follows: Algeria (0.98%), Egypt (1.00%), Morocco (1.06%), Nigeria (1.13%), South Africa (1.58%) and Tunisia (0.53%). A Pearson correlation test of the data in Table 2 further demonstrated that the countries (including Kenya) exhibited a near perfect pattern of performance in the four performance indicators. The Pearson correlation test yielded the following coefficients: ESI papers vs HCPs (r = 0.9611); ESI papers vs HPs (r = 0.9637); ESI papers vs TPs (r = 0.9611); HCPs vs HPs (r = 0.9798); HCPs vs HPs (r = 0.99999) and HPs vs TPs (r = 0.9799).

Table 2: Publication of hot papers as share of total publications in African countries, January 2011 - June 2021

Country	ESI papers	Highly Cited Papers		Hot Papers		Total Top Papers	
	N	n	% of N	n	% of N	n	% of N
Algeria	31830	312	0.98	26	0.08	313	0.98
Benin	3413	79	2.31	2	0.06	79	2.31
Botswana	3397	49	1.44	2	0.06	49	1.44
Burkina Faso	3928	35	0.89	0	0.00	35	0.89
Cameroon	9898	131	1.32	5	0.05	131	1.32
Congo (Brazzaville)	1147	19	1.66	1	0.09	19	1.66
Cote d'Ivoire	3302	47	1.42	1	0.03	47	1.42
Dem Rep Congo	2936	65	2.21	3	0.10	65	2.21
Egypt	122948	1231	1.00	59	0.05	1231	1.00
Ethiopia	17724	195	1.10	13	0.07	197	1.11
Gabon	1446	32	2.21	1	0.07	32	2.21
Gambia	1459	38	2.60	1	0.07	38	2.60
Ghana	13083	195	1.49	11	0.08	196	1.50
Kenya	**20611**	**397**	**1.93**	**11**	**0.05**	**397**	**1.93**
Libya	2439	31	1.27	3	0.12	31	1.27
Madagascar	2506	22	0.88	0	0.00	22	0.88
Malawi	5243	81	1.54	1	0.02	81	1.54
Mali	2044	33	1.61	0	0.00	33	1.61
Mauritius	1675	59	3.52	8	0.48	59	3.52
Morocco	23716	250	1.05	8	0.03	251	1.06
Mozambique	2991	73	2.44	7	0.23	73	2.44
Namibia	2041	46	2.25	0	0.00	46	2.25
Niger	1241	15	1.21	0	0.00	15	1.21
Nigeria	33356	375	1.12	26	0.08	376	1.13
Rwanda	2533	58	2.29	1	0.04	58	2.29
Senegal	4657	71	1.52	3	0.06	71	1.52
Seychelles	478	21	4.39	2	0.42	21	4.39
Sierra Leone	967	23	2.38	1	0.10	23	2.38
South Africa	138303	2181	1.58	93	0.07	2184	1.58
Sudan	4561	41	0.90	2	0.04	41	0.90
Tanzania	10843	153	1.41	3	0.03	153	1.41
Tunisia	41611	219	0.53	9	0.02	221	0.53
Uganda	11584	160	1.38	5	0.04	161	1.39
Zambia	3935	92	2.34	3	0.08	92	2.34
Zimbabwe	4672	81	1.73	1	0.02	81	1.73

In terms of the citation impact of the ESI papers and TPs for each country, Table 3 reveals that the TPs yielded a higher citation impact than all papers put together in each country, including Kenya. Comparatively, Kenya yielded similar patterns of citation impact as many of the countries in Africa. The country's 20611 papers (see Table 2) posted, as shown in Table 3, a total of 390,744 citations averaging 18.96 cites per paper while the 397 TPs produced 387.85 cites per paper. It therefore follows that the citation impact ratio (i.e. cites per paper) of TPs to the total number of papers produced in Kenya is approximately 20:1 (twenty to one citations per paper). In other words, Kenya's TPs receive 20 more citations per paper than all papers put together. Unlike the analysis of the number of publications in the section above, the analysis of citations and the citation impact of research conducted in Africa reveals that

the contribution of Kenya's TPs to the overall citation impact of the papers produced in the country, was lower than it is in the other top ranked countries in the continent. The ratio of the top papers' citations per paper to a country's overall number of citations per paper was as follows for the top ranked countries in Africa: Algeria (276.23:9.01; 33:1), Egypt (191.97:1.87; 103:1), Morocco (334.19:10.91; 31:1), Nigeria (378.93:10.01; 38:1), South Africa (292.69:13.92; 21:1) and Tunisia (298.40: 9.25; 32:1). That notwithstanding, a Pearson correlation of the performance of the countries in terms of the number of citations (Nc) and citations per paper (c/p) for the ESI papers (P), HCPs, HPs and TPs revealed strong relationships among the variables. The coefficients resulting from the test, in terms of citations, were as follows: P vs HCPs (r = 0.9614); P vs HPs (r = 0.9282); P vs TPs (r = 0.9612); HCPs vs HPs (r = 0.9704); HCPs vs TPs (r = 1.000); HPs vs TPs (r = 0.9721). Regarding the relationships between the variables in terms of the average citations per paper, the following coefficients were obtained: P vs HCPs (r = 0.6528); P vs HPs (r = 0.2171); P vs TPs (r = 0.6497); HCPs vs HPs (r = 0.4844); HCPs vs TPs (r = 0.9995); HPs vs TPs (r = 0.5014). Whereas the countries' performances compare strongly in terms of the number of citations, their correlational performance in terms of average citations per paper was moderate to strong.

Table 3: Citation impact of hot papers as share of total citations in African countries, January 2011 – June 2021

Country	Citations		Highly Cited Papers			Hot Papers			All Hot Papers	
	N	Cites/ paper	Nc	% of N	Cites/ paper	n	% of N	Cites/ paper	n	Cites/ paper
Algeria	286683	9.01	82756	28.87	265.24	3704	1.29	142.46	86460	276.23
Benin	69368	20.32	48709	70.22	616.57	684	0.99	342.00	49393	625.23
Botswana	52503	15.46	30338	57.78	619.14	560	1.07	280.00	30898	630.57
Burkina Faso	49205	12.53	7098	14.43	202.80	0	0.00	0.00	7098	202.80
Cameroon	131587	13.29	58575	44.51	447.14	1211	0.92	242.20	59786	456.38
Congo (Brazzaville)	12931	11.27	1113	8.61	58.58	80	0.62	80.00	1193	62.79
Cote d'Ivoire	56436	17.09	31920	56.56	679.15	169	0.30	169.00	32089	682.74
Dem Rep Congo	59091	20.13	37586	63.61	578.25	744	1.26	248.00	38330	589.69
Egypt	229660	1.87	228930	99.68	185.97	7382	3.21	125.12	236312	191.97
Ethiopia	207204	11.69	85264	41.15	437.25	3349	1.62	257.62	88613	449.81
Gabon	26922	18.62	9695	36.01	302.97	80	0.30	80.00	9775	305.47
Gambia	48012	32.91	27519	57.32	724.18	346	0.72	346.00	27865	733.29
Ghana	192538	14.72	97351	50.56	499.24	1798	0.93	163.45	99149	505.86
Kenya	**390744**	**18.96**	**152305**	**38.98**	**383.64**	**1670**	**0.43**	**167.00**	**153975**	**387.85**
Libya	32541	13.34	15140	46.53	488.39	538	1.65	179.33	15678	505.74
Madagascar	31079	12.40	5772	18.57	262.36	0	0.00	0.00	5772	262.36
Malawi	91072	17.37	38100	41.84	470.37	103	0.11	103.00	38203	471.64
Mali	35408	17.32	9564	27.01	289.82	0	0.00	0.00	9564	289.82
Mauritius	22762	13.59	9643	42.36	163.44	600	2.64	75.00	10243	173.61
Morocco	258842	10.91	82467	31.86	329.87	1414	0.55	176.75	83881	334.19
Mozambique	72439	24.22	51909	71.66	711.08	2059	2.84	294.14	53968	739.29
Namibia	32198	15.78	15870	49.29	345.00	0	0.00	0.00	15870	345.00
Niger	16970	13.67	4320	25.46	288.00	0	0.00	0.00	4320	288.00
Nigeria	334028	10.01	137620	41.20	366.99	4859	1.45	186.88	142479	378.93
Rwanda	56270	22.21	40160	71.37	692.41	214	0.38	214.00	40374	696.10
Senegal	58063	12.47	13902	23.94	195.80	851	1.47	283.67	14753	207.79
Seychelles	16914	35.38	13064	77.24	622.10	140	0.83	70.00	13204	628.76
Sierra Leone	21334	22.06	11928	55.91	518.61	80	0.37	80.00	12008	522.09
South Africa	1925110	13.92	621369	32.28	284.90	17861	0.93	192.05	639230	292.69
Sudan	63907	14.01	31091	48.65	758.32	177	0.28	88.50	31268	762.63
Tanzania	174479	16.09	67106	38.46	438.60	421	0.24	140.33	67527	441.35
Tunisia	384834	9.25	64333	16.72	293.76	1614	0.42	179.33	65947	298.40
Uganda	198800	17.16	79877	40.18	499.23	532	0.27	106.40	80409	499.43
Zambia	81239	20.65	45676	56.22	496.48	620	0.76	206.67	46296	503.22
Zimbabwe	67997	14.55	26683	39.24	329.42	88	0.13	88.00	26771	330.51

Subject Focus of the Top Papers

A subject content analysis is often conducted to determine the fields or disciplines within which the research is conducted (i.e. research area) or the specific research issues or topics. The former was determined by analysing the WoS's research areas while the latter was determined through the analysis of the author-supplied keywords.

Table 4: Research focus areas for the top papers in Kenya, January 2011 – June 2021

Research Areas	No.	% of 397	Research Areas	No.	% of 397
General Internal Medicine	123	30.98	Acoustics	2	0.50
Science Technology Other Topics	72	18.14	Biomedical Social Sciences	2	0.50
Environmental Sciences Ecology	44	11.08	Cardiovascular System Cardiology	2	0.50
Public Environmental Occupational Health	33	8.31	Endocrinology Metabolism	2	0.50
Agriculture	26	6.55	Engineering	2	0.50
Infectious Diseases	16	4.03	Marine Freshwater Biology	2	0.50
Plant Sciences	15	3.78	Microbiology	2	0.50
Biodiversity Conservation	13	3.28	Mycology	2	0.50
Food Science Technology	8	2.02	Pediatrics	2	0.50
Nutrition Dietetics	8	2.02	Physiology	2	0.50
Business Economics	7	1.76	Public Administration	2	0.50
Genetics Heredity	6	1.51	Respiratory System	2	0.50
Life Sciences Biomedicine Other Topics	6	1.51	Virology	2	0.50
Neurosciences Neurology	6	1.51	Anthropology	1	0.25
Psychiatry	6	1.51	Biochemistry Molecular Biology	1	0.25
Psychology	6	1.51	Biotechnology Applied Microbiology	1	0.25
Evolutionary Biology	5	1.26	Energy Fuels	1	0.25
Geology	5	1.26	Fisheries	1	0.25
Health Care Sciences Services	5	1.26	Gastroenterology Hepatology	1	0.25
Meteorology Atmospheric Sciences	5	1.26	Geriatrics Gerontology	1	0.25
Physical Geography	5	1.26	Government Law	1	0.25
Entomology	4	1.01	International Relations	1	0.25
Geography	4	1.01	Medical Ethics	1	0.25
Parasitology	4	1.01	Oncology	1	0.25
Chemistry	3	0.76	Social Issues	1	0.25
Development Studies	3	0.76	Social Sciences Other Topics	1	0.25
Immunology	3	0.76	Sport Sciences	1	0.25
Obstetrics Gynecology	3	0.76	Surgery	1	0.25
Pharmacology Pharmacy	3	0.76	Toxicology	1	0.25
Radiology Nuclear Medicine Medical Imaging	3	0.76	Urology Nephrology	1	0.25
Tropical Medicine	3	0.76	Veterinary Sciences	1	0.25
Zoology	3	0.76	Water Resources	1	0.25

Overall, Kenya's key areas of research, in descending order of the number of publications between January 2011 and June 2021, are *Public environmental* [and] *Occupational health* (3925, 13.11%), *Infectious diseases* (3261, 10.89%), *Environmental sciences* [and] *Ecology* (3234, 10.80%), *Science technology* [and] *Other topics* (2559, 8.54%), *Agriculture* (2481, 8.28%), *Tropical medicine* (2051, 6.85%), *Immunology* (1984, 6.62%), *Parasitology* (1121, 3.74%), *Plant sciences* (1062, 3.55%) and *General internal medicine* (1030, 3.44%). Out of the 150 research areas in which scholars have conducted research in Kenya between 2011 and 2021, 62 research areas yielded at least one HP each, as shown in Table 4. The country's top papers, which reflect its areas of research excellence or knowledge specialisation (Onyancha, 2020c), were spread as follows: *general internal medicine* topped the list with 123 papers, accounting for 30.98% of the top papers between 2011 and 2021. Other research areas that could be considered RE focus areas include *Science technology*, *Environmental sciences* [and] *Ecology*, *Public environmental* [and] *Occupational health* and *Agriculture*.

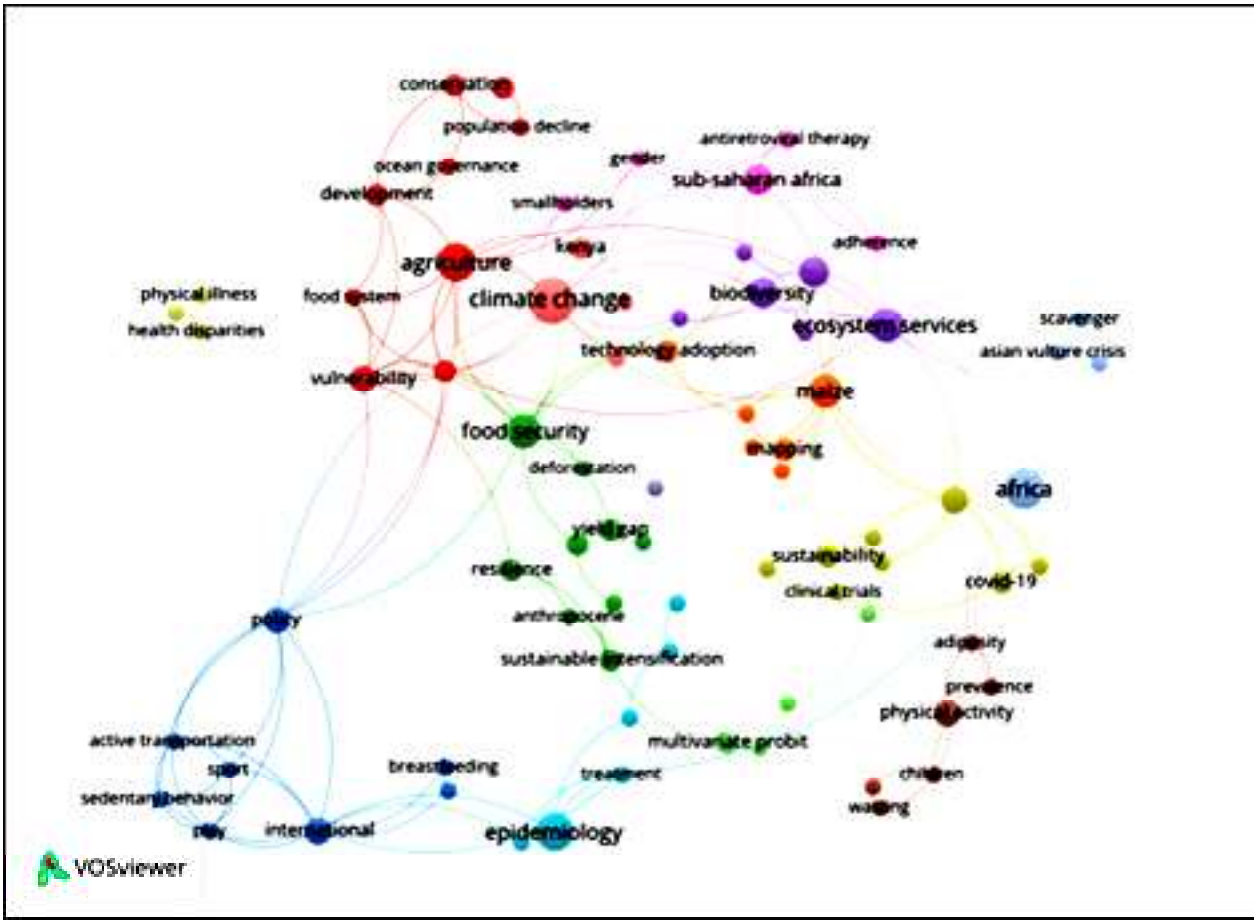


Figure 2: Author-supplied keywords in Kenya's TPs, January 2011 – June 2021

The 397 top papers in Kenya produced a total of 756 author-supplied keywords, with the majority of the keywords (i.e. 675 or 89.3%) appearing in one paper each. Only 81 (10.7%) keywords appeared in two or more papers and are mapped in Figure 2. The following concepts, which appeared the most in the top papers's author supplied keywords, constituted the topics of research that may be viewed as the core of Kenya's RE: climate change (10), agriculture (7), epidemiology (7), food security (6), ecosystem services (6), maize (6), and biodiversity (5), to name the keywords that appeared in five or more papers. These specific research topics resonate very well with two of the Government of Kenya's social problematic areas that were identified since the country's independence and have been captured in the Kenya Vision 2030, namely the alleviation of poverty and universal health care (see Vision 2030 Delivery Secretariat, 2008).

Journals Publishing Kenya's Top Papers

Kenyan researchers disseminated their research findings through 6138 publication titles or sources, comprising journals, conference proceedings, books and book chapters, among others, with *PLOS One* publishing the highest number of papers (i.e. 1182; 3.9%) followed by the *American Journal of Tropical Medicine and Hygiene* (843; 2.78%), *Malaria Journal* (372; 1.23%), *Journal of the International Aids Society* (367; 1.21%) and *Aids Research and Human Retroviruses* (320; 1.06%). The top papers, on the other hand, were published in 151 publication titles, which therefore accounts for only 2.5% of the 6138 publication titles in which Kenya disseminated its research findings between January 2011 and June 2021. The most productive publication titles through which Kenya's research is published, as illustrated in Table 5, included *Lancet*,

New England Journal of Medicine, *Science*, the *Proceedings of the National Academy of Sciences of the United States of America*, *Nature*, *Lancet Global Health*, and the *Lancet Infectious Diseases*, just to name the titles that published 10 or more papers. It is evident that the publications, which largely comprised journals, publish health and medical research, a finding that was similarly visible in the analysis of the top papers' research areas (see Table 4).

Table 4: Journals/sources publishing Kenya's top papers, January 2011 – June 2021

Publication Titles	No of papers	% of 397	JIF*
Lancet	88	22.17	79.321
New England Journal of Medicine	23	5.79	91.245
Science	18	4.53	47.728
Proceedings of the National Academy of Sciences of the United States of America	17	4.28	12.291
Nature	16	4.03	49.962
Lancet Global Health	11	2.77	26.763
Lancet Infectious Diseases	11	2.77	25.071
Global Change Biology	8	2.02	10.863
PLOS One	8	2.02	3.240
PLOS Medicine	7	1.76	11.069
Field Crops Research	4	1.01	5.224
Global Ecology and Biogeography	4	1.01	7.114
International Journal of Epidemiology	4	1.01	7.196
Agricultural Systems	3	0.76	5.370
BMC Public Health	3	0.76	3.295
Ecosystem Services	3	0.76	5.454
ELife	3	0.76	8.140
Food Security	3	0.76	3.304
Global Environmental Change Human and Policy Dimensions	3	0.76	9.523
Journal of Animal Ecology	3	0.76	5.091
Journal of Environmental Management	3	0.76	6.789
Lancet Neurology	3	0.76	44.182
New Phytologist	3	0.76	10.151
Theoretical and Applied Genetics	3	0.76	5.699

*** 2020 journal impact factor**

An examination of the journal impact factors (JIF) of the sources publishing Kenya's top papers reveals that the journals are generally 'good' as most of the journals registered JIF values that are 3 and above. The *New England Journal* has the highest 2020 JIF (i.e. 91.345) followed by the *Lancet* (JIF = 79.321), *Nature* (JIF = 49.962) and *Lancet Neurology* (JIF = 44.182). Although the JIFs have been criticised for a variety of reasons, they remain one of the most widely used indicators of journal quality and are still considered important in the research and scholarly communication communities as they can be an approximate indication of how prestigious or influential a journal is in a given field (Krampl, 2019). Publishing in high impact factor journals has become one of the strategies and strong advisories if not mandates in many academic institutions because it is argued that the practice may lead to an article receiving a large number of citations, thereby improving its citation status among other

articles in the same field, which eventually will lead to a favourable ranking of said institutions. Regarding RE, as proxied in HCPs, Krampl (2019, p 280), among other scholars, argue thus: "The higher a journal's impact factor, more frequently articles in that journal are cited" and, therefore, the higher the number of highly cited papers, the higher the status of a country's RE.

Research Collaboration

Collaboration in research seems to be a strong determinant of RE. In total, 2648 authors, and 1341 organisations participated in the authorship of the 397 papers, thereby averaging about 7 authors and 3 organisations per paper, respectively. The authors were drawn from a total of 139 countries, with the USA leading the pack with 227 papers, followed by England (168), Australia (94), South Africa (88), Canada (73), Netherlands (71), Switzerland (69), Germany (69), and India (68), just to name the top 10. These findings confirm that indeed, as many scholars have observed, the HCPs are highly collaborative (Noorhidawati *et al.,* 2017), and more so at international level (Aksnes, 2003). Kenya is no exception in this regard. In terms of institutional collaboration, it was not surprising to discover that institutions affiliated to foreign countries featured prominently among the most productive and visible collaborators with local institutions.

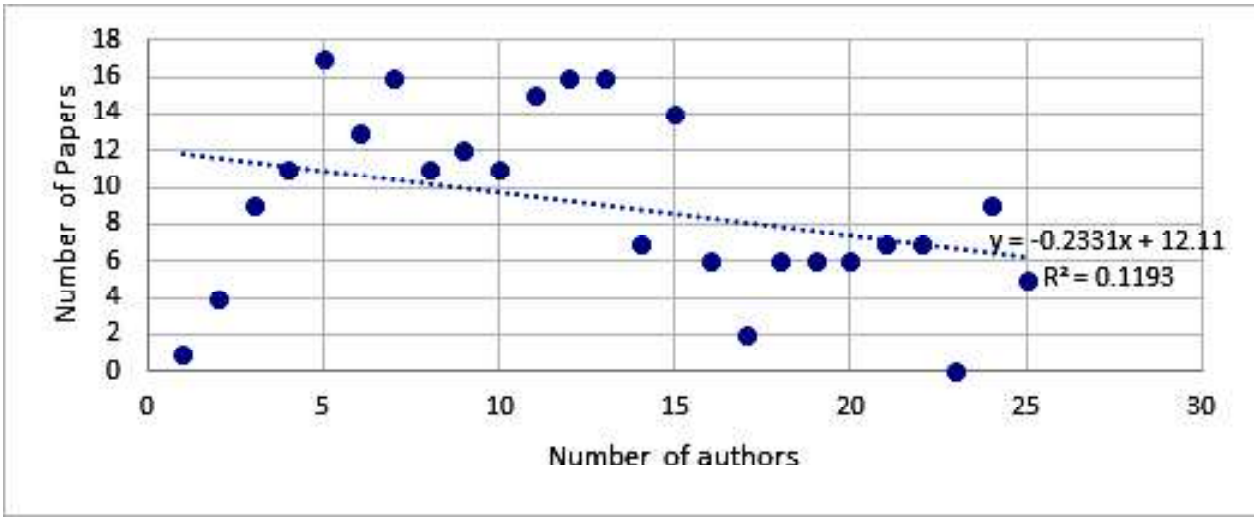


Figure 3: Top papers in Kenya, 2011-2021: x-number of authors per y-number of top papers

The most visible institutions were Univ London (37), Int Livestock Res Inst (27), Kenya Govt Med Res Ctr (26), London Sch Hyg & Trop Med (24), Univ Witwatersrand (22), and Univ Cape Town (20), just to name the organisations with 20 or more papers. Out of the 10 most productive institutions, only four are located in Kenya, namely Int Livestock Res Inst (27), Kenya Govt Med Res Ctr (26), Univ Nairobi (18), and Aga Khan Univ (16). These results further confirm that the HCPs are not only highly collaborative but also that the collaboration is largely international. The dominance of institutions with foreign country affiliations in the authorship of the HCPs in Kenya is a reflection and manifestation of partnerships between one or two local institutions and several institutions from foreign countries.

Conclusion and Recommendations

From the findings of this study, it can be concluded that the production of top papers in Kenya has generally demonstrated incremental growth over the years under review. However, this growth does not seem to catalyse a similar trend in the number of hot papers. It is also evident from the findings that journal articles are the most cited channel of research papers. This explains the prominence given by Kenya's Commission for University Education to journal articles as a measure of research excellence. This reflects the general trend elsewhere in Africa and the world. When compared to other countries in Africa, Kenya is ranked in the top 10 in terms of the number of publications and citations or citation

impact. This implies that Kenya compares favourably with the top producers of quality research in Africa such as South Africa, Egypt, Nigeria, Tunisia and Algeria. As is the case in other African countries, TPs in Kenya yielded a higher citation impact than all papers put together. By far the majority of these papers were published by scholars in the natural and applied sciences and potentially aimed at addressing Kenya's socioeconomic challenges exemplified by disease and hunger. It can also be concluded that Kenyan researchers collaborate fairly well with their peers from elsewhere in the world including the USA, England, Australia, South Africa and Canada. This research collaboration is most likely linked to the sources of research funding. It is noteworthy, however, that South Africa is the only African country whose researchers collaborate relatively well with Kenyan researchers. This paper, therefore, concludes that although Kenya is lagging behind prolific research producers in the world, it is performing fairly well in Africa. However, more needs to be done to increase the number and diversity of its top, highly cited and hot papers.

This paper recommends the following strategies to help the country not only to maintain its current research performance but also to improve its ranking in terms of top, highly cited and hot research papers:

1. Introduce incentives and reward mechanisms which motivate more scholars to publish in high impact journals. Currently, scholars publish largely to maintain their tenure or get promoted. This is inadequate in stirring passion for excellence in research.
2. Develop lists of accredited publication channels (journals) where Kenyan scholars can publish. Current evidence indicates that a large number of scholars publish their work in predatory journals which do not contribute meaningfully to research excellence metrics.
3. To diversify the subject content of the top papers, researchers should be encouraged to collaborate across the disciplines. This can be attained through multi-disciplinary research funding. Such collaboration would enable researchers to produce highly-relevant papers in the disciplines known to attract high citations.
4. Increase research funding from the current 0.8% to 1% of the country's GDP. This increased level of funding will contribute greatly to improving research excellence by enhancing research facilities, infrastructure and materials. Similarly, it will help the researchers to pay for the collection or generation of quality data which ultimately results in high quality and citable papers.
5. Strengthen the institutional and individual research capacity. This can be done through policies which support research excellence. For instance, universities can develop a research-friendly work regime for lecturers by reducing the number of hours spent teaching vis-à-vis what is spent on research. Similarly, research mentorship mechanisms can be instituted to build the capacity of novice researchers to produce high quality research by working with seasoned researchers.

Implications of the Study for RE in Kenya

The study has highlighted the areas or indicators of RE that are pertinent for decision making as far as advancing and nurturing RE in Kenya is concerned. There are several other indicators as reflected in several published works. Given that the understanding of RE varies across geographic regions, the search for and development of context-specific indicators with which to audit RE in the Kenya would be a crucial step in the right direction. The government agencies, researchers, funders and other stakeholders involved in promoting and managing research in Kenya will find this study particularly valuable as it constitutes the basis or agenda for not only discourses on RE but also an audit of RE in the country.

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