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Does the Type of Open Access Matter in Research Impact in Sub-Saharan Africa? An Informetric Study, 2012-2021

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Abstract

This study examines the publication pattern of open access (OA) and paywalled scholarly works, determines the citations and views impact of publications published through the different forms of OA, and disaggregates the scholarly outputs and impact across the different types of OA in sub-Saharan African countries, in order to assess whether the types of OA matter in research impact in sub-Saharan Africa. Data from the SciVal database, utilising bibliographic, citation, and views data drawn from Scopus, formed the foundation of this study. The research scope encompassed documents published over a decade, from 2012 to 2021. Research output, quantified as the number of publications (papers), constituted the primary focus, while citation-based and views-based metrics were utilised as proxies for measuring research impact. The findings underscore a steady rise in OA scholarly publications, indicating a growing inclination and uptake of OA scholarship within sub-Saharan African nations. Across most sub-Saharan African countries, OA publications comprised over 50% of the total publications. The study discerns a preference hierarchy for OA models: Green OA emerged as the foremost choice, trailed by Gold OA, and Bronze OA, while Hybrid-Gold OA registered as the least favoured model. Notably, publication counts exhibited robust associations with citation and viewing figures, displaying varying strengths in correlation with other citation and viewing metrics.

Keywords: Open Access, Sub-Saharan Africa, Informetric, Scholarly Publishing.

Introduction and Problem Statement

Open access (OA) publishing is undoubtedly transforming the way researchers now disseminate their findings (Else, 2018). The OA movement gained momentum in the early part of the 21st Century with the signing of the Budapest Open Access Initiative (BOAI) in 2002 (BOAI, 2002). This marked a major milestone in the history of OA. The BOAI defined OA as we know it today as the unrestricted availability of research publications on the Internet thereby enabling interested persons to read, copy, download, or share the publications (BOAI, 2002). The BOAI also rallied together the key stakeholders in the scholarly communication landscape to support

the OA movement. These included representatives of researchers, publishers, professional associations, universities, librarians, research foundations, and diverse OA advocacy groups. The fundamental principle of the BOAI is to equalise access and use of scholarly materials by reducing or removing access barriers to the research literature through the establishment of self-archiving platforms and OA journals. Besides the BOAI, the Bethesda Statement on OA publishing was made in April 2003 to explore strategies for enhancing access to primary biomedical research literature (Bethesda Statement on OA Publishing, 2003). This was followed by the Berlin Declaration in October 2003 to promote access to research knowledge in the humanities (Borges, 2008). Beyond the need to open up access to scholarly materials, the OA movement was also motivated by the publishing opportunities created by the emerging technologies exemplified by the Internet. It is argued that the emergence of the World Wide Web (WWW) and the portable document format (PDF) attracted scholars and publishers to online spaces (Rempel, 2022) giving rise to the emergence of scholar-led publishing. The main aim of the scholar-led publishers was not only economic but also to disseminate their own research using the emerging techno-based platforms. These scholar-led publishers positioned themselves as the transparent channel for scholarly communication as opposed to the expensive and exploitative proprietary publishers (Moore, 2020). Chan (2004) asserted that OA publishing is a scholars' move to take control of the dissemination of their works and maximise the readership of their scholarly works. OA is a means of democratising the scholarly communication landscape and opening it up for the benefit of researchers and the public (Panda, 2020).

OA publishing has gained popularity globally as an alternative to commercial academic publishing (Moore, 2020). This is reflected in the increasing uptake of and growing advocacy to promote OA publication channels (Wei, 2020). For instance, there is a policy-driven campaign to increase the proportion of OA publications in academic library collections as a means of taming the skyrocketing subscription costs (Gaind, 2019). The growing acceptance of OA publishing is also evident in the increasing number of OA repositories indexed in the Registry of OA Repositories (ROAR) and OA journals listed in the Directory of OA Journals (DOAJ) (Nestor et al., 2020). Funding for OA publishing can also be a metric for assessing the acceptance of OA publishing. In this case, an analysis of funding opportunities and volumes would demonstrate the extent to which OA has been accepted as a scholarly communication channel (Morillo, 2020). Resistance to commercial publishing exemplified by the emergence of illegal platforms, such as Sci-Hub, to circumvent paywalls and open up access to scholarly materials also emerged (Meagher, 2021). Similarly, legal efforts to help users of research locate OA versions of publications, such as the OA Button, have also been developed. The popularity and acceptance of OA are also evidenced by the growing inclusion of OA journals by renowned indexing and abstracting service providers such as the Web of Science and Scopus (Dodds, 2019).

Most of the scholars and libraries in the Global South, including sub-Saharan Africa, face the gravest challenges in accessing global knowledge (Christian, 2008). OA publishing, therefore, offers a great opportunity for these scholars to maximise access, readership, and uptake of existing knowledge. Whereas most of the literature on OA publishing in developing countries focuses on promoting this scholarly communication channel, little is known about the types of OA publishing that hold the optimal potential for scholars in the Global South. Equally important is the influence of the types of OA publishing on enhancing the impact of research. As a result, the research questions in this study are: does the type of OA publishing matter in research impact in sub-Saharan Africa? How much impact is generated through each type of OA in the region? Is there a preferred type of OA in sub-Saharan African countries? Sub-Saharan Africa has long grappled with limited access to global knowledge due to various barriers, hindering impactful research and scholarly communication (Bwalya and Akakandelwa 2021). The emergence of OA publishing represents a transformative opportunity for scholars in this region, offering a pathway to circumvent access constraints and amplify readership and utilisation of existing knowledge resources. Moreover, while discussions on OA in sub-Saharan Africa often revolve around its promotion (Ondari-Okemwa, 2007; Bakuya, 2014), a critical gap exists in understanding the nuanced impacts of different types of OA

publishing in the region. Exploring the influence of OA types on research impact in sub-Saharan Africa can offer invaluable insights into optimising this scholarly communication channel for maximal benefit. Additionally, the heightened attention OA has garnered among scholars, funders, and governments in sub-Saharan Africa underscores its strategic importance. The increasing demands from funders and research institutions for OA publishing underscore its growing relevance and recognition as a crucial component of scholarly dissemination in the region and worldwide. Finally, several countries in sub-Saharan Africa are formulating policies regarding OA publishing (Bwalya and Akakandelwa 2021), and therefore, the findings of this study will serve as a pivotal foundation upon which discussions and decisions surrounding OA-related policies can be shaped, offering empirical insights crucial for policy formulation and strategic planning within the region's academic and research landscape.

Purpose of the Study

The purpose of the study was to examine the research impact associated with the different types of OA in an attempt to answer the main research question: does the type of OA matter in research impact? The study specifically assessed the trend of publication of research through OA, the proportion of OA and paywall publications, and the influence of OA publishing on the impact of research in the four OA types, the number of publications, using citations- and views-based metrics as variables.

OA Publishing in Sub-Saharan Africa: A Brief Literature Review

The upward trend in freely accessible, online OA publishing, driven by the WWW era (Gargouri et al., 2010; Piwowar et al., 2018; Robinson-Garcia et al., 2020), has significantly enhanced global research dissemination. Despite this growth, scholars in Sub-Saharan Africa face challenges accessing OA literature (Iyandemye and Thomas, 2019). OA models, sometimes referred to as routes, include Gold OA (exclusively in OA journals), Hybrid-Gold OA (offering OA publishing choice), Bronze OA (alternative free-to-read versions with or without specific licenses), and Green OA (depositing the published version or manuscript in a free-to-read repository) (see Moya-Anegón, Guerrero-Bote and Herrán-Páez 2020; Scopus, 2022).

Sub-Saharan Africa has a rich academic landscape with diverse research contributions. However, the global visibility of these contributions is often hindered by restricted access, limited resources, institutional barriers, and subscription costs to research publications (Ondari-Okemwa, 2007; Bakuya, 2014) Ajibade and Muchaonyerwa (2023) observe that "information technology infrastructure, Internet connectivity, platform agility and institutional governance remain significant challenges to OA publishing on the African continent." Furthermore, differences in OA uptake levels between countries vary due to other factors such as financial policies, research profiles, national OA policies, access to expensive subscription journals, and higher publication fees (Wang et al., 2014; Matheka et al., 2014; Houghton and Sheehan, 2009). Bakuwa --(2014) observed that sub-Saharan Africa's low uptake of OA may be associated with few African journals indexed by ISI Web of Science. This contributes to sub-Saharan African countries' poor showing on the global map as reflected by the number of recipients of Nobel Prize awards, as well as position and number of African universities on world university rankings.

Siyao et al. (2017) explored the role of libraries in promoting open science in four sub-Saharan African countries, namely Ghana, Nigeria, Tanzania, and Uganda, using a multi-case study research design. The study revealed a scarcity of scholarly journals available in OA for most African academic institutions in the mentioned countries. The authors recommended a heightened emphasis on open science advocacy within academic libraries in Sub-Saharan Africa. Building on this theme, Asare, et al. (2021) conducted a bibliometric analysis of 1,858 peer-reviewed articles published between 2010 and 2018 by researchers based in sub-Saharan Africa. They evaluated the prevalence of OA publishing in educational publications from the region. While they observed a consistent rise in OA publishing between 2010 and 2018, the proportion of OA publications remained relatively low. This was attributed to the high processing fees associated with OA in reputable journals, prompting many authors in sub-Saharan Africa to choose pay-walled, higher-quality journals over lower-quality OA journals. However, Bwalya

and Akakandelwa (2021) expressed an optimistic view, noting a positive transformation in the OA landscape with the rise of OA publishing initiatives and platforms in Sub-Saharan Africa such as African Journals Online (AJOL), Africa Academy of Sciences (AAS) Open Research, and Scientific African.

Simard et al. (2022) provided a global perspective of OA adoption by countries using indicators such as publications in OA and references to OA articles. Their findings revealed that sub-Saharan Africa exhibited a higher rate of publishing and citing OA compared to high-income countries, with a notable preference for both green and gold OA. The study attributed this trend to the waiver of Article Processing Charges (APCs) for low-income countries, emphasising the need for more OA initiatives at various levels to foster broader adoption of open scholarship. In contrast, Robinson-Garcia et al. (2020) conducted a worldwide study on OA adoption, analysing universities listed in the 2019 edition of the Leiden Ranking. Their research classified OA publications into four types: gold, green, hybrid, and bronze. About 41% of all publications in their dataset were OA, with Green OA being the most prevalent, followed by Gold OA, Bronze OA, and Hybrid OA. The study noted variations in OA uptake at the continental level, with Europe leading, North America following, and Asia and Africa lagging behind. In Africa, South Africa, a country in sub-Saharan Africa, exhibited high levels of OA. Moreover, Verma and Sonkar (2021) compared OA performance in BRICS countries (Brazil, Russia, India, China, and South Africa) from 2011 to 2020, drawing data from the Scopus database. Their findings indicated that South Africa, being in Sub-Saharan Africa, contributed less to OA scholarly publications (5% in 2011–2020) compared to other BRICS nations, underscoring the need for context-specific considerations in evaluating OA performance across different regions.

Methods and Materials

The study adopted informetrics to assess the impact of the publications in the four different types of OA, namely Bronze OA, Gold OA, Green OA and Hybrid-Gold OA. Informetrics is defined as the quantitative assessment of patterns that show up in information, right from information production to use (Diodato,1994). Informetrics is commonly used to assess research production, dissemination, use and impact (Onyancha, 2020b). The current study obtained its data from SciVal, a research performance assessment tool that allows analysis of data indexed in the Scopus bibliographic and citation database. Scopus is one of the largest and most commonly used to assess the research performance of researchers, institutions and countries using a variety of research metrics and units of analysis. It is the preferred data source for bibliometric analyses of African research despite its limitations associated with coverage of publications and journals from developing countries (Boshoff and Akanmu 2017). Boshoff and Akanmu (2017) and several other scholars note that the constraints present in Scopus are less conspicuous when compared to the citation indexes found in the Web of Science (WoS). Scopus' constraints, like those inherent in other citation databases, are associated with database errors, assignment of journals to wrong field categories, and search algorithms, among others (Boshoff and Akanmu 2017). The constraints inherent in SciVal stem from the limitations inherent in the Scopus database, which serves as the primary data source for Scival's analytics and metrics.

This study focused on publications (herein interchangeably used with papers) as a unit of analysis using two broad indicators of research performance, namely scholarly output, on the one hand, and publications impact, on the other hand. Data was extracted from SciVal between 8 and 12 March 2023. SciVal provides several search options to extract data. Depending on the purpose of the study, one can search for and extract relevant data using any one of the following options/fields: institutions and groups; researchers and groups; publication sets; countries, regions and groups; topics and clusters; and research areas. This study searched within the 'countries, regions, and groups of countries/regions', using the names of countries in sub-Saharan Africa, to obtain the scholarly outputs and impact of papers published by each of the countries in sub-Saharan Africa. The search for relevant data using the names of countries was informed by the fact that SciVal has not aggregated the publications under 'sub-Saharan Africa', hence the search and extraction of the data using names of individual countries that comprise sub-

Saharan Africa.

The specific metrics that we found relevant to the study and therefore extracted from SciVal included the number of papers, number of citations, field-weighted citation impact, average citations per paper, number of views, field-weighted views impact, and average views per paper for each type of OA in each country (see Appendix A and Appendix B). Below is a definition of each of the aforementioned metrics:

- Scholarly outputs (number of publications) (P): the total number of papers published in a country, either through OA or paywall model.
- Citations (C): Citations counts in SciVal reflect the total number of citations received from the time an item was published, up to the date of the last data cut
- Field-Weighted Citation Impact (FWCI): FWCI in SciVal indicates how the number of citations received by an entity's publications compares with the average number of citations received by all other similar publications in the data universe: it is used to compare the citations received by an entity's publications with the world average.
- Citations per paper (C/p): number of citations divided by the number of papers published in an entity or a subject domain.
- Views (V): V indicates the total usage impact of an entity – the total views that an entity's (field, organisation, country, author or even a publication) publication has received.
- Field-Weighted Views Impact (FWVI): FWVI indicates how the number of views received by an entity's publications compares with the average number of views received by all other similar publications in the same data universe; it is used to compare the views received by an entity's publications with the world average.
- Views per paper (V/p): number of views divided by the number of papers published in an entity or a subject domain.

The quantification of publications attributed to each country and OA model, as presented in Appendix A and Appendix B, was accomplished using the complete count method, also referred to as the whole or normal count of publications. As Diodato (1994) and Onyancha (2013) detailed, this method mandates the full inclusion of each country or OA model, irrespective of publications associated with multiple countries or OA models. For instance, in cases where a publication was classified under Gold OA and Hybrid-Gold OA, each respective OA model was counted once in order to maintain a full paper allocation for each country and OA model. Once the data was extracted from SciVal, they were saved in Excel format files. We employed multiple analytical methodologies for data examination. Initially, a trend analysis was conducted to delineate the trajectory of OA publications in sub-Saharan African nations. Subsequently, descriptive statistics were used to compare the scholarly output and impact of OA and non-OA (NOA) research. Furthermore, we performed Pearson Correlation tests and regression analyses via IBM's Statistical Package for Social Sciences (SPSS). These tests aimed to scrutinise the association between scholarly publications within each OA classification and the impact concerning citations and views. Pearson's correlation coefficient, denoted as Pearson's r, quantifies the strength and direction of a linear relationship between continuous variables (Rumsey 2011). An r value of 1 signifies a perfect positive linear relationship, indicating that as one variable increases, the other proportionally increases, while -1 indicates a perfect negative linear relationship. Additionally, regression analysis, a statistical tool, explores how one dependent variable is influenced or forecasted by one or more independent variables (Rumsey 2011).

Results and Discussion

This section presents and discusses the findings with respect to the trend of OA vis-à-vis the non-OA publications; a comparison of OA and NOA scholarly outputs and their citation and views impact; and the scholarly outputs and impact per the type of OA.

Trend of publication of OA and NOA publications in sub-Saharan Africa, 2012-2021

Figure 1 provides the trend of OA and non-OA (NOA) publications in sub-Saharan African countries from 2012 to 2021, both years inclusive.

The OA publications encompassed works identified and designated by Scopus as Gold OA, Green OA, Bronze OA, or Hybrid-Gold OA (see Scopus 2022), whereas the non-OA publications included all works not classified under the OA categories. The Figure reveals that both the OA and NOA publications have continued to increase over time with the OA publications growing faster than NOA publications. By 2012, the number of OA papers stood at 268 while the NOA publications were 487 per country, a difference of approximately 82%, or 219 publications per country. This trend of growth continued with OA publications closing the gap each year until 2017, after which the number of OA publications per country surpassed the NOA publications. Since then, sub-Saharan Africa has reported more OA publications than NOA publications until 2021 when the average number of papers was 1195 and 784 for OA and NOA, respectively. The OA publications had, therefore, overtaken the NOA publications by 411 publications, accounting for a 52% difference.

This pattern of growth of OA publications was reported by Piwowar *et al.* (2018) who noted that OA publications accounted for only 28% of the total number of publications published prior 2015. The authors, however, hastened to add that the proportion of OA publications was rapidly growing, driven particularly by growth in Gold OA and Hybrid-Gold OA. Indeed, several other scholars have noted that the number of OA publications has continued to increase (see (Archambault *et al.,* 2013; Chen 2013; Gargouri *et al.*, 2012; Laakso *et al.*, 2011; Laakso and Björk, 2012). It is worth noting that all the aforementioned studies were conducted and used data that was available by or before 2018 when the number of OA publications surpassed the NOA publications in the current study. But, (Piwowar *et al*., 2018) had noticed that although the number of OA publications comprised 28%, those published in 2015 accounted for approximately 50% of all the publications they analysed in that one year in their study.

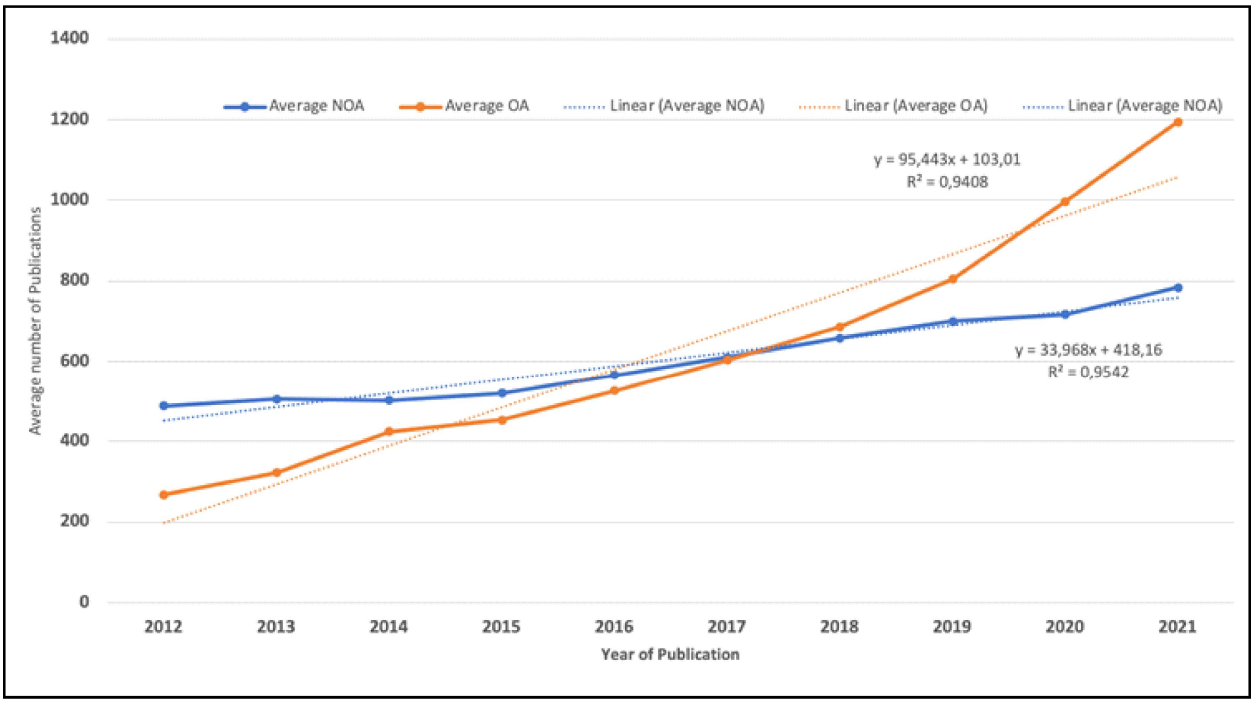

Figure 1: Trend of OA and NOA publications in sub-Saharan Africa, 2012-2021

An examination of the trend of OA publications according to the OA types or routes in Figure 2 shows that while the number of papers per country has continued to increase, the Green OA has remained the dominant OA route throughout the period of study. The average number of Gold OA publications surpassed the Hybrid-Gold OA publications in 2015 and has remained above the latter group of publications until 2021. It was further noted that the Bronze OA publications have remained at the bottom throughout the study period, having recorded only 34 publications in 2012 and 74 publications in 2021, a percentage increase of 118%. Comparatively, the Gold OA publications grew by 553%, while Green OA and the Hybrid OA publications registered a growth rate of 356% and 190%, respectively, between 2012 and 2021.

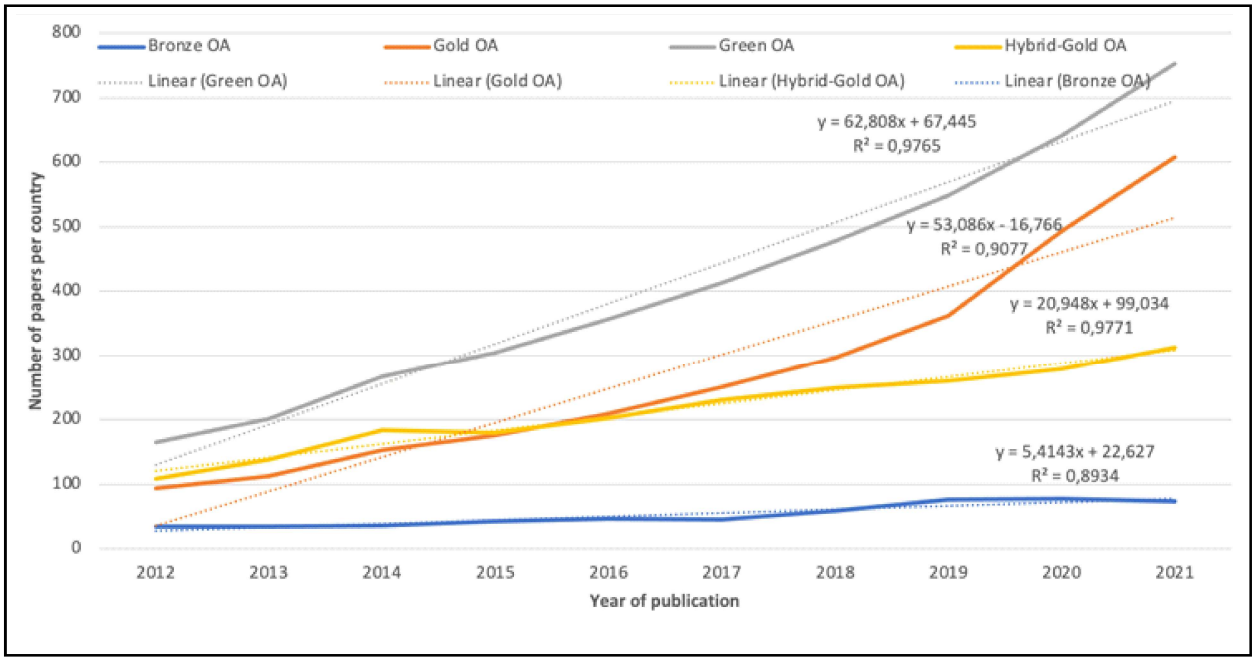

Figure 2: Trend of publications of OA publications according to OA route, 2012-2021

Table 1: Descriptive statistics with respect to the open and non-OA publications

		Mean	Median	Range	Minimum	Maximum
Non-OA	Number of Papers	6049,84	935	132255	25	132280
	Number of Citations	60916,92	8156	1438754	188	1438942
	Field-Weighted Citation Impact	0,82	0,8	1,04	0,43	1,47
	Citation per Paper	10,37	10,3	16,8	5	21,8
	Views	141708,88	18071	3209857	613	3210470
	Views per Paper	23,07	22,7	19,5	16,4	35,9
	Field-Weighted Views Impact	0,96	0,94	0,75	0,73	1,48
OA	Number of Papers	6146,27	1421	115114	41	115155
	Number of Citations	139938,76	34956	2516857	554	2517411
	Field-Weighted Citation Impact	2,06	1,73	4,76	0,87	5,63
	Citation per Paper	26,07	22,9	57,1	10,2	67,3
	Views	208854,88	60471	3713880	2152	3716032
	Views per Paper	40,24	32,4	104,6	18,6	123,2
	Field-Weighted Views Impact	1,99	1,63	4,27	0,91	5,18

Overall, sub-Saharan Africa published more than 50% of its publications through one or more of the OA models. Table 2 indicates that the region produced 6146.27 publications per country on OA while pay-walled publications numbered 6049.84 per country. Similarly, Appendix B shows that all but 10 countries in sub-Saharan African countries recorded more OA than pay-walled publications. The exceptions where the number of OA publications accounted for less than 50% of a country's total number of publications included Botswana (44.04%), Djibouti (43.49%), Lesotho (49.43%), Mauritania (48.82%), Mauritius (31.11%), Namibia (46.23%), Nigeria (41.84%), South Africa (46.54%), Sudan (43.48%), and Togo (49.17%). All the other countries except Uganda (OA = 50.00%) yielded more OA than NOA publications. The top 10 countries in which OA constituted the biggest share of a given country's total number of publications were: The Gambia (n = 1647, 84.33%), Guinea-Bissau (n = 397, 72.45%), Malawi (n = 5363, 71.55%), Liberia (n = 555, 70.08%), Sierra Leone (n = 1055, 70.05%), Equatorial Guinea (n = 126, 69.23%), Mozambique (n = 3103, 68.64%), Mali (n = 1995, 68.09%), Zambia (n = 4242, 67.90%), and South Sudan (n = 153, 67.70%).

Table 1 further shows that not only do researchers in sub-Saharan Africa publish more OA than NOA publications but also that the OA publications generate a superior impact than their counterparts. All the OA impact metrics recorded higher average impact scores (i.e., means) per country than NOA impact metrics in terms of the number of citations (C), field-weighted citation impact (FWCI), citations per paper (C/p), number of views (V), views per paper (V/p), and field-weighted views impact (FWVI). This scenario is not unique to sub-Saharan Africa; it is a worldwide occurrence as many studies have demonstrated (see Archambault et al 2016; Piwowar et al 2018). Whether this pattern is similar across all types of OA was the subject of this paper.

Impact of Publications Based on the Types OA

The impact of research is assessed using traditional metrics (citation-based metrics) and alternative metrics (simply referred to as Altmetrics) (see Akella et al. 2021; Onyancha 2020b). Despite their limitations (see Shakeel et al. 2022), citation-based metrics and Altmetrics (including the publication views) have been extensively used to measure the impact of research. To answer the question 'Does the type of OA have a bearing on research impact?', we first examined the OA scholarly outputs, on the one hand, and citations and views, on the other hand, as a percentage share of all OA publications and impact, respectively, for each of the OA models (see Table 2). Second, we subjected the publications and citation metrics in each of the OA models to analysis using descriptive statistics, correlation and regression analyses to examine any relationships between the two sets of variables (see Table 3 and Table 4; and Figure 3 and Figure 4).

Table 2: Performance of each type of OA relative to all OA publications in sub-Saharan Africa

	Papers		Citations			Views		
	n	%	n	%	C/p	n	%	V/p
Bronze	42596	8,87	884095	7,73	20,76	1150024	6,83	27,00
Gold	175157	36,49	2413520	21,09	13,78	4146400	24,62	23,67
Green	229793	47,87	6382003	55,78	27,77	8909889	52,91	38,77
Hybrid-Gold	32532	6,78	1761741	15,40	54,15	2632744	15,63	80,93
TOTAL (N)	480078	100,00	11441359	100,00	23,83	16839057	100,00	35,08

Table 2 provides the number of papers, citations and views in each type of OA, together with the corresponding percentage share of the total number of OA publications, citations, and views. As explained in the methodology, the whole count approach was used to quantify publications, citations, and views in each type of OA as well as in the computation of the TOTAL (N) figures in the last row in Table 2. Regarding the scholarly outputs, Table 2 shows that Gold OA and Green OA yielded the highest number of publications, accounting for 84% of the total number of OA publications. The Green OA publications constituted the most (47.87%) followed by Gold OA (36.49%), while the other two types of OA, Bronze OA and Hybrid-Gold OA, accounted for approximately 16% of the OA publications in sub-Saharan Africa. In terms of citations and views, Gold OA and Green OA contributed higher figures than Bronze OA and Hybrid-Gold OA, with Green OA yielding 55.78% of the citations and 52.91% of the views. The Hybrid-Gold OA publications, however, were the most impactful in terms of the average number of citations (i.e., 54.15) and views per paper (i.e., 80.93). These results suggest the preference of Gold OA and Green OA publishing in sub-Saharan Africa, similar to the findings of Piwowar *et al.* (2018). This preference, evident from the substantial percentage shares in scholarly outputs, showcases a strategic utilisation of these OA models. Green OA, constituting the largest share in publications, reflects an active engagement of scholars in leveraging repositories and self-archiving practices. Similarly, the significant presence of Gold OA signifies a proactive approach to publishing in open-access journals. The dominance of Green OA and Gold OA aligns with the overarching goal of enhancing accessibility to scholarly work within sub-Saharan Africa. This may be attributed to the co-authorship behavior of publications. Impact-wise, the Green OA publications accounted for 55.78% of all the citations and 52.91% of the views generated by the publications, thereby signaling the dominance of the Green OA model over the other models of OA in sub-Saharan Africa. However, it was the Hybrid-Gold that yielded superior average citations and views per paper, despite yielding the lowest number of scholarly outputs.

Table 3: Descriptive statistics of scholarly output and impact of Bronze, Gold, Green, and Hybrid-Gold OA publications in sub-Saharan Africa, 2012-2021

		Number of Papers	Number of Citations	Field-Weighted Citation Impact	Citations per paper	Number of Views	Views per Paper	Field-Weighted Views Impact
Bronze	Mean	869,31	18042,76	1,47	18,61	23469,88	27,33	1,34
	Median	194	5003	1,28	18	6996	26,2	1,22
	Range	17137	425360	4,54	43,2	487444	28,2	1,99
	Min	4	19	0,43	4,8	65	15,8	0,68
	Max	17141	425379	4,97	48	487509	44	2,67
Gold	Mean	3574,63	49255,51	34,31	14,06	84620,41	25,13	1,15
	Median	885	12963	1,08	14	19095	23,3	1,09
	Range	57422	801881,09	1628,23	14,2	1509548	78	2,87
	Min	22	0,91	0,77	9,2	1294	16,5	0,8
	Max	57444	801882	1629	23,4	1510842	94,5	3,67
Green	Mean	4689,65	130244,96	2,36	30,67	181834,47	45,06	2,24
	Median	1165	33516	2,09	26,3	48701	38,1	1,88
	Range	85117	2225318	5,28	62,3	3095421	117,4	4,88
	Min	32	529	1,08	12,6	1857	20,2	0,92
	Max	85149	2225847	6,36	74,9	3097278	137,6	5,8
Hybrid-Gold	Mean	663,92	35953,90	7,71	92,07	53729,47	131,87	7,31
	Median	144	10182	4,15	52,5	15467	75,1	4,08
	Range	12681	433394	44,92	506,8	666285	582	32,8
	Min	2	7	0,39	3,5	37	18,5	0,76
	Max	12683	433401	45,31	510,3	666322	600,5	33,56

In addition to the analysis of the data according to the average impact (i.e., citations and views) per paper, this study sought to examine the average impact per country. The descriptive statistics in Table 3 portray similar patterns to those in Table 2, wherein Green OA yielded superior values to the other three types of OA in terms of the average number of papers, citations, and views per country. For instance, the average number of Green OA papers and citations per country was approximately 4690, 130245, and 181834, respectively; the closest category of Gold OA's corresponding values were 3575 papers, 49256 citations, and 84620 views per country. An examination of the performance of the OA models using the other impact metrics, namely the weighted and average scores of citations and views, reveals mixed results. The Green OA, however, performed poorer than Bronze OA, Gold OA, and Hybrid-Gold OA in terms of weighted citation and views impact, as well as the average number of citations and views per country. The median and range equally produced mixed results whereby no one model was superior to others. These mixed results are not unique to this study, as many studies have yielded different results in their analysis of the different types of OA. For example, Piwowar *et al*. (2018) found that Bronze OA publications were the most common in their study titled "The State of OA: A Large-scale Analysis of the Prevalence and Impact of OA articles" (Robinson-Garcia, Costas and van Leeuwen, 2019)witnessed disparities not only between countries but also between institutions within a country in terms of the number of OA publications per type of OA, with some institutions having more Gold OA publications than Green OA publications and Green OA publications enjoying higher traction within the majority of countries. In India (Nazim, 2021) found that Green OA publications' proportion of the total OA publications was 17.78%, followed by Gold OA (10.26%), Bronze OA (3.41%) and Hybrid OA (2.48%). On their part, Singh *et al.* (2020) observed that Gold OA was the most common throughout their study period (2014-2018), with about 10-12% of the articles being Gold OA and Green OA coming second with 6%, followed by Bronze OA (5%) and Hybrid OA (3%). These disparities can partly be associated with the usage of different sources of data such as Sci-Hub, Unpaywall, Scopus, and the Web of Science.

The second approach used to assess whether the type of OA matters in research impact was the correlation analysis of the number of papers, on the one hand, and the impact metrics, on the other hand. The Pearson correlation coefficients in Figure 3 show that there was a strong correlation between the number of citations and views in all models of OA, with the highest correlation coefficient being registered with views in the Green OA category ($r = 0.998$), followed by papers vs. citations in Gold OA ($r = 0.995$), and papers vs. views in Gold OA ($r = 0.994$). There were several instances where the correlations registered negative coefficients, implying inverse relationships between the number of papers and some impact indicators such as citations per paper, field-weighted citation impact, views per paper, and field-weighted views impact. Figure 3 further shows that the majority of the coefficients ranged between 0 and 0.5, implying weak to very weak relationships between the papers and impact indicators. A similar pattern was witnessed when we correlated the number of papers and impact indicators for all OA papers irrespective of the type of OA, whereby we obtained the following coefficients: The region's correlations were as follows: paper vs. citations ($r = 0.992$), papers vs FWCI ($r = -0.113$), papers vs. citations per paper ($r = -0.095$), papers vs. views ($r = 0.997$), papers vs. views per paper ($r = -0.122$) and papers vs. FWVI ($r = -0.143$). It is worth noting, however, that this relationship can be attributed to the normalised metrics used to proxy impact. The four metrics in terms of field-weighted citation impact, citations per paper, field-weighted views impact, and views per paper were normalised, while the number of papers with which they were correlated was not normalised. When benchmarking the coefficients obtained for each type of OA against those obtained for all OA papers, we noted that the correlation coefficients between papers and impact indicators in each OA model were higher than those obtained for all OA papers.

Bronze Open Access

	P	C	FWCI	C/p	V	V/p	FWVI
P	1,000						
C	0,975	1,000					
FWCI	0,059	0,096	1,000				
C/p	0,082	0,135	0,899	1,000			
V	0,996	0,990	0,076	0,105	1,000		
V/p	-0,018	0,024	0,659	0,676	0,006	1,000	
FWCVI	-0,042	0,000	0,744	0,679	-0,020	0,882	1,000

Gold Open Access

	P	C	FWCI	C/p	V	V/p	FWVI
P	1,000						
C	0,995	1,000					
FWCI	-0,055	-0,058	1,000				
C/p	-0,036	0,000	-0,180	1,000			
V	0,994	0,996	-0,051	-0,019	1,000		
V/p	-0,054	-0,048	0,021	0,230	-0,038	1,000	
FWVI	-0,078	-0,070	0,037	0,230	-0,059	0,983	1,000

Green Open Access

	P	C	FWCI	C/p	V	V/p	FWVI
P	1,000						
C	0,996	1,000					
FWCI	-0,102	-0,062	1,000				
C/p	-0,065	-0,023	0,964	1,000			
V	0,998	0,999	-0,063	-0,027	1,000		
V/p	-0,111	-0,080	0,827	0,827	-0,075	1,000	
FWVI	-0,130	-0,094	0,916	0,874	-0,090	0,960	1,000

Hybrid-Gold Open Access

	P	C	FWCI	C/p	V	V/p	FWVI
P	1,000						
C	0,961	1,000					
FWCI	-0,128	-0,042	1,000				
C/p	-0,130	-0,043	0,988	1,000			
V	0,965	0,999	-0,049	-0,052	1,000		
V/p	-0,133	-0,039	0,933	0,938	-0,038	1,000	
FWVI	-0,138	-0,036	0,964	0,950	-0,038	0,975	1,000

Figure 3: Correlation of scholarly outputs and impact of OA publications in sub-Saharan Africa by type of OA, 2012-2021

Key: P (papers); C (citations); FWCI (field-weighted citation impact); C/p (citations per paper); V (views); V/p (views per paper); FWVI (field-weighted views impact)

Table 4: Model summary for each type of OA

	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
Bronze	1.000[a]	.999	.999	81.439	.999	8238.773	6	42	<.001
Gold	.996[a]	.993	.991	836.870	.993	931.653	6	42	<.001
Green	.999[a]	.997	.997	706.409	.997	2576.934	6	42	<.001
Hybrid-Gold	.975[a]	.950	.943	450.861	.950	132.977	6	42	<.001

Key: [a] = Predictors: (Constant), Field-Weighted Views Impact, Number of Citations, Citations per paper, Views per paper, Field-Weighted Citation Impact, Views

Bronze Open Access

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	157.693	52.724		2.991	.005
Number of Citations	-.025	.001	-.585	-17.439	<.001
Field-Weighted Citation Impact	16.094	40.407	.005	.398	.692
Citations per paper	1.500	3.328	.005	.451	.654
Views	.057	.001	1.575	47.106	<.001
Views per paper	-9.238	4.068	-.023	-2.271	.028
Field-Weighted Views Impact	20.048	70.242	.003	.285	.777

Gold Open Access

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	1787.051	725.039		2.465	.018
Number of Citations	.047	.012	.647	3.915	<.001
Field-Weighted Citation Impact	-.145	.532	-.004	-.272	.787
Citations per paper	-95.098	46.946	-.029	-2.026	.049
Views	.014	.007	.348	2.111	.041
Views per paper	52.399	61.421	.063	.853	.398
Field-Weighted Views Impact	-1464.009	1622.970	-.067	-.902	.372

Green Open Access

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	628.410	261.871		2.400	.021
Number of Citations	-.010	.007	-.252	-1.309	.197
Field-Weighted Citation Impact	931.338	586.455	.084	1.588	.120
Citations per paper	-54.591	35.162	-.061	-1.553	.128
Views	.034	.005	1.246	6.491	<.001
Views per paper	49.333	24.612	.083	2.004	.052
Field-Weighted Views Impact	-1638.588	649.040	-.145	-2.525	.015

Hybrid-Gold Open Access

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	-25.910	100.526		-.258	.798
Number of Citations	-.036	.021	-1.309	-1.699	.097
Field-Weighted Citation Impact	46.492	66.441	.227	.700	.488
Citations per paper	2.095	5.392	.117	.389	.700
Views	.041	.014	2.273	2.947	.005
Views per paper	.511	2.797	.037	.183	.856
Field-Weighted Views Impact	-112.583	59.825	-.467	-1.882	.067

Figure 4: Regression coefficients per OA model

Finally, Table 4 shows the model summary for each type of OA and the regression coefficients of the independent variables, which are the different impact indicators of OA types in this study. Statistically, they are also known as the predictor variables, while papers, standing for the preferred mode of OA, were treated as the dependent variable. As shown in Table 3 and for the Bronze OA, three of the predictor variables were found to have a significant prediction, and they consist of the number of citations ($\beta = -.585$, $t = -17.439$, $p < 0.05$), views ($\beta = 1.575$, $t = 47.106$, $p < 0.05$) and views per paper ($\beta = -.023$, $t = -2.271$, $p < 0.05$). However, the field-weighted citation impact ($\beta = .005$, $t = .398$, $p < 0.05$), citation per paper ($\beta = .005$, $t = .451$, $p < 0.05$) and the field-weighted views impact ($\beta = .003$, $t = .285$, $p < 0.05$) did not significantly explain the publication patterns in Bronze OA. For the Gold OA, three predictor variables, namely the number of citations ($\beta = .647$, $t = 3.915$, $p < 0.05$), citation per paper ($\beta = -.029$, $t = -2.026$, $p < 0.05$) and views ($\beta = .348$, $t = 2.111$, $p < 0.05$) were found to have a significant account of the number of papers. However, other predictors such as the field-weighted citation impact, views per paper and field-weighted views impact did not have a significant influence on the papers in Gold OA. For the Green OA, two predictor variables, views ($\beta = 1.246$, $t = 6.491$, $p < 0.05$) and the field-weighted views impact ($\beta = -.145$, $t = -2.525$, $p < 0.05$) were found to have a significant influence on the papers in Green OA. This implies that other predictors such as the number of citations, field-weighted citation impact, citation per paper, and views per paper did not show any significant impact on the papers in Green OA. For the Hybrid-Gold OA, one predictor variable, views ($\beta = 2.273$, $t = 2.947$, $p < 0.05$) was found to have a significant impact. The other predictors, such as the number of citations, field-weighted citation impact, citation per paper, views per paper, and field-weighted views impact, did not significantly influence the papers in Hybrid-Gold OA. Importantly, views, as an independent variable, were found to be a single predictor of all the types of OA, including papers published in them. It is also important to note that the influence of views on papers published based on the type of OA was most noticeable and remarkable in Hybrid-Gold OA, followed by Bronze OA. From Table 3, an author is most likely to publish two papers or more in Hybrid-Gold because he/she is certain that the papers will be viewed at least once. In Gold OA, an author is most likely to publish almost two papers because he/she is certain that the papers will be viewed at least once. Also, in Green OA, an author is likely to publish one paper because he/she is certain it will be viewed at least once.

The Adjusted R-Square was used to determine which of the OA models performed best or was the fittest of all the models. Unlike the R-Square, this was preferred because of its power to penalise irrelevant variables. From Table 4, the Adjusted R-Square values for the Bronze, Gold, Green, and Hybrid-Gold OA were 99.8%, 98.2%, 99.4%, and 88.9%, respectively. These are the percentages of the predictors used in this study to explain the number of papers. From these percentages, the regression model of the Bronze OA performed best or was the best fit of all the models. The reason is that this model can help to explain or account for 99% of the papers published or to be published in Bronze OA given the number of citations, field-weighted citation impact, citation per paper, views, views per paper and field-weighted views impact as predictor variables. This was followed by the Green OA model with 99.4% prediction power and the Gold OA model with 98.2% prediction power. The last of the models was the Hybrid-Gold with 88.9% power of prediction.

Conclusion

In view of the findings in sub-Saharan Africa regarding OA publishing and its influence on research impact across various OA models, it becomes evident that the landscape is nuanced and complex. While Green OA and Gold OA exhibit favorable contributions to scholarly output and impact, the correlation analyses showcase intricate relationships. Notably, citations emerge as significant predictors for Bronze OA and Gold OA, albeit with inverse associations, signaling that higher publication numbers may not necessarily correlate with increased citations in these models within the region. Surprisingly, the views impact demonstrates a varying pattern, with Hybrid-Gold OA displaying the highest increase followed by Bronze OA and Green OA, highlighting an unexpected trend in the region's scholarly visibility. The performance of Bronze OA stands out as the most robust among the models studied, suggesting its potential significance in the context of sub-Saharan African research impact. These findings imply that while certain OA models display distinct advantages in terms of scholarly output and impact, their relationships with citation and views indicators exhibit complexities that merit further exploration. Such nuanced insights are pivotal for refining strategies, policies, and support mechanisms aimed at bolstering research visibility and impact within the unique ecosystem of Sub-Saharan Africa.

Recommendations

The findings of this study reveal that sub-Saharan African countries have continued to substantially contribute to the pool of OA scholarly output. However, there are some countries that have published less than 50% of their publications through any of the OA routes. Therefore, there is need to continue promoting OA publishing by Sub-Saharan African scholars especially in view of OA's being hailed as a development imperative for Africa (Adegbilero-Iwari, Adetoro and Salawu 2023). A sustained growth in the volume of research output on OA publishing channels is likely to increase their impact. In the context of this paper, the following interventions are likely to improve both the output and impact of OA publishing in Sub-Saharan Africa:

1. Although this research revealed that no specific type of current OA publishing generates better research impact than the other, scholars in the region may need to conduct more studies to develop OA publishing theories and models which may work best for sub-Sahara Africa.
2. Many researchers and scholars are still unaware of the potential of OA publishing on the impact of research. Universities and other research institutions can address this by strengthening the capacity of their staff and partners to take full advantage of the benefits of OA publishing while also a avoiding the pitfalls therein. Specialised digital literacy programmes which address OA competencies may be useful.
3. OA publishing relies heavily on technology. Many universities and research institutions in sub-Saharan Africa are deficient in these. Promoting sustainable OA publishing will require the institutions to develop and maintain essential digital infrastructure. These may include digital repositories, directories, journals and libraries.

4. Create and promote national, regional and global collaborations to share resources and knowledge about OA publishing. A Sub-Saharan OA regional network may also conduct advocacy campaigns resulting in facilitative policies and resources for OA publishing in the region. The policies may include acceptance, funding and assessment of scholarly OA publishing in the region.

5. Quality is one of the challenges hindering the impact of OA research. Sub-Saharan African institutions are encouraged to develop open access quality standards and enforcement mechanisms. These can benefit from the global best practices and case studies.

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Appendix A: Scholarly output and impact of OA publications by type of OA

Country	Type of OA	Number of Papers	Number of Citations	Field-Weighted Citation Impact	Citations per paper	Views	Views per paper	Field-Weighted Views Impact
Angola	Bronze	78	1020	1,28	13,1	2015	25,8	1,57
	Gold	408	4492	0,79	11	10979	26,9	1,16
	Green	548	14248	2,37	26	25874	47,2	2,7
	Hybrid	65	7589	13,28	116,8	12213	187,9	13,57
Benin	Bronze	344	3827	0,88	11,1	7653	22,2	0,99
	Gold	1760	22816	0,98	13	40767	23,2	1,11
	Green	2204	115617	4,26	52,5	171818	78	4,42
	Hybrid	330	66168	16,89	200,5	99644	302	17,99
Botswana	Bronze	439	6004	1,16	13,7	10056	22,9	1,04
	Gold	1581	20153	1,03	12,7	42276	26,7	1,27
	Green	2117	68637	2,69	32,4	117404	55,5	3,03
	Hybrid	280	17358	5,57	62	44926	160,5	9,9
Burkina Faso	Bronze	500	8950	1,17	17,9	14381	28,8	1,2
	Gold	2290	34027	0,97	14,9	52019	22,7	0,99
	Green	3021	57434	1,27	19	84524	28	1,2
	Hybrid	371	7638	1,63	20,6	11355	30,6	1,39
Burundi	Bronze	49	619	1,02	12,6	1519	31	1,1
	Gold	221	2786	0,95	12,6	5140	23,3	1,09
	Green	280	13803	4	49,3	21103	75,4	3,98
	Hybrid	45	9940	18,64	220,9	14772	328,3	18,3
Cameroon	Bronze	1084	16091	1,14	14,8	26433	24,4	1,16
	Gold	5115	68345	0,97	13,4	113173	22,1	1,02
	Green	6325	195840	2,4	31	287736	45,5	2,35
	Hybrid	601	84071	11,96	139,9	117181	195	11,52
Cape Verde	Bronze	35	371	0,82	10,6	864	24,7	1,17
	Gold	148	1506	0,77	10,2	4511	30,5	1,56
	Green	210	3672	1,82	17,5	10952	52,2	2,46
	Hybrid	24	1261	7,66	52,5	4690	195,4	9,13
CAR	Bronze	51	824	1,13	16,2	1659	32,5	1,81
	Gold	212	3611	0,99	17	4752	22,4	1,01
	Green	297	7527	1,45	25,3	10066	33,9	1,53
	Hybrid	21	976	2,25	46,5	1211	57,7	2,52
Chad	Bronze	45	381	0,65	8,5	765	17	0,82
	Gold	192	2428	0,97	12,6	4678	24,4	1,08
	Green	249	5116	1,63	20,5	10849	43,6	2,28
	Hybrid	44	1640	3,69	37,3	5222	118,7	7,11
Comoros	Bronze	12	64	0,44	5,3	332	27,7	0,85
	Gold	72	804	0,99	11,2	1294	18	0,84
	Green	91	1227	1,27	13,5	1857	20,4	0,92
	Hybrid	8	69	0,94	8,6	161	20,1	0,76
Congo	Bronze	373	11730	2,47	31,4	13376	35,9	1,6
	Gold	1547	25737	1,25	16,6	38234	24,7	1,15
	Green	2301	88615	3,01	38,5	122338	53,2	2,74
	Hybrid	300	34093	9,68	113,6	49655	165,5	9,53
Cote D'Ivoire	Bronze	411	5900	1,1	14,4	10313	25,1	1,22
	Gold	1549	21544	0,97	13,9	37191	24	1,09
	Green	2154	80869	3,08	37,5	116988	54,3	2,86
	Hybrid	294	31969	9,38	108,7	43052	146,4	8,23

Djibouti	Bronze	12	99	0,6	8,3	374	31,2	1,18
	Gold	75	910	1,3	12,1	1584	21,1	0,9
	Green	93	1434	1,34	15,4	2519	27,1	1,1
	Hybrid	4	44	0,53	11	100	25	0,97
DRC	Bronze	147	3059	2,72	20,8	4384	29,8	1,82
	Gold	885	8626	1	9,7	15932	18	1
	Green	1165	30615	2,48	26,3	45443	39	2,29
	Hybrid	144	15475	9,8	107,5	21008	145,9	9,43
Equatorial Guinea	Bronze	19	318	0,98	16,7	300	15,8	0,68
	Gold	87	1429	1,17	16,4	1731	19,9	0,91
	Green	106	5615	4,01	53	5572	52,6	2,8
	Hybrid	6	3062	45,31	510,3	3093	515,5	30,68
Eritrea	Bronze	28	361	0,98	12,9	540	19,3	0,91
	Gold	167	1732	0,89	10,4	2750	16,5	0,8
	Green	175	3111	1,28	17,8	4525	25,9	1,19
	Hybrid	15	756	1,54	50,4	699	46,6	1,62
Ethiopia	Bronze	1798	33591	1,4	18,7	45630	25,4	1,13
	Gold	17659	234192	1,03	13,3	332935	18,9	0,86
	Green	16982	391256	1,74	23	537686	31,7	1,58
	Hybrid	1584	106549	5,73	67,3	168324	106,3	5,97
Gabon	Bronze	192	5003	1,85	26,1	6259	32,6	1,62
	Gold	702	13921	1,22	19,8	16382	23,3	1,04
	Green	1083	32528	1,89	30	36889	34,1	1,54
	Hybrid	128	5130	2,58	40,1	6896	53,9	2,58
Gambia	Bronze	194	8770	2,5	46,2	7214	38	1,85
	Gold	922	21556	1,54	23,4	26816	29,1	1,33
	Green	1506	76796	3,32	51	78095	51,9	2,74
	Hybrid	282	25357	4,69	89,9	20341	72,1	4,19
Ghana	Bronze	1435	29804	1,59	20,8	43486	30,3	1,36
	Gold	9305	123266	1,01	13,2	214245	23	1,02
	Green	10548	320942	2,32	40,4	452776	42,9	2,07
	Hybrid	1412	100089	6,29	70,9	152512	108	6,08
Guinea-Bissau	Bronze	74	1845	2,09	24,9	1648	22,3	1,21
	Gold	214	3557	1,25	16,6	4989	23,3	1,12
	Green	341	6735	1,48	19,8	8835	25,9	1,24
	Hybrid	41	883	1,45	21,5	895	21,8	1,02
Guinea	Bronze	105	5040	4,97	48	4621	44	2,67
	Gold	441	7212	1,26	16,4	9612	21,8	1,03
	Green	591	17124	2,41	29	18317	31	1,53
	Hybrid	65	2491	3,14	38,3	2266	34,9	1,56
Kenya	Bronze	2386	59486	1,71	24,9	73772	30,9	1,4
	Gold	11179	188656	1,2	16,9	281444	25,2	1,12
	Green	16325	521631	2,24	32	667403	40,9	1,89
	Hybrid	2889	151697	4,18	52,5	221741	76,8	3,81
Lesotho	Bronze	63	760	1,05	12,1	1617	25,7	1,43
	Gold	210	2356	0,92	11,2	3793	18,1	0,83
	Green	231	4869	1,71	21,1	5380	23,3	1,07
	Hybrid	26	1887	6,86	72,6	909	35	2,01
Liberia	Bronze	99	2704	2,62	27,3	4269	43,1	2,5
	Gold	311	4437	1,3	14,3	8067	25,9	1,4
	Green	471	33516	6,36	71,2	44163	93,8	5,6
	Hybrid	53	20996	34,96	396,2	28889	545,1	33,56

Madagascar	Bronze	299	5698	1,22	19,1	8755	29,3	1,2
	Gold	1082	15218	0,97	14,1	23716	21,9	0,99
	Green	1684	33638	1,39	20	53561	31,8	1,45
	Hybrid	220	4999	1,95	22,7	8211	37,3	1,73
Malawi	Bronze	590	16250	1,97	27,5	15310	25,9	1,23
	Gold	2918	44484	1,15	15,2	68048	23,3	1,11
	Green	4755	121767	1,82	25,6	145682	30,6	1,46
	Hybrid	720	31839	3,62	44,2	38716	53,8	2,72
Mali	Bronze	251	6501	1,82	25,9	6996	27,9	1,46
	Gold	1059	17369	1,08	16,4	25525	24,1	1,08
	Green	1751	45204	1,7	25,8	54616	31,2	1,34
	Hybrid	260	10182	3,08	39,2	10401	40	1,71
Mauritania	Bronze	39	495	0,89	12,7	825	21,2	0,88
	Gold	197	1805	0,77	9,2	3502	17,8	0,84
	Green	249	3260	1,08	13,1	7895	31,7	1,64
	Hybrid	22	950	4,15	43,2	3232	146,9	8,6
Mauritius	Bronze	221	2692	1,26	12,2	7609	34,4	1,71
	Gold	521	9055	1,48	17,4	19095	36,7	1,63
	Green	749	26411	2,79	35,3	48701	65	2,77
	Hybrid	122	9083	6,73	74,5	14510	118,9	5,95
Mozambique	Bronze	388	10414	1,76	26,8	13155	33,9	1,67
	Gold	1832	27767	1,26	15,2	49228	26,9	1,28
	Green	2593	130557	4,02	50,3	168360	64,9	3,5
	Hybrid	372	63658	15,21	171,1	86540	232,6	13,95
Namibia	Bronze	363	7440	1,38	20,5	10244	28,2	1,54
	Gold	888	12963	1,09	14,6	23682	26,7	1,12
	Green	1402	51758	2,75	36,9	83755	59,7	3,08
	Hybrid	223	23940	9,06	107,4	39812	178,5	10,39
Niger	Bronze	153	2247	1,11	14,7	3348	21,9	1,01
	Gold	583	7674	0,99	13,2	14847	25,5	1,23
	Green	903	20030	1,55	22,2	28590	31,7	1,39
	Hybrid	137	6221	1,92	45,4	5320	38,8	1,48
Nigeria	Bronze	7207	77808	1,08	10,8	159282	22,1	1,01
	Gold	23684	253346	0,92	10,7	490777	20,7	0,91
	Green	23248	502384	1,68	21,6	807434	34,7	1,61
	Hybrid	3479	139578	3,19	40,1	216353	62,2	3,31
Rwanda	Bronze	353	6364	1,48	18	8392	23,8	1,22
	Gold	1674	21207	1,14	12,7	38514	23	1,15
	Green	2132	101547	4,24	47,6	152255	71,4	4,19
	Hybrid	350	53581	14,15	153,1	83950	239,9	14,82
Sao Tome and Principe	Bronze	4	19	0,43	4,8	65	16,3	1,24
	Gold	22	334	1,23	15,2	2078	94,5	3,67
	Green	32	529	1,17	16,5	2386	74,6	2,91
	Hybrid	2	7	0,39	3,5	37	18,5	1
Senegal	Bronze	637	12763	1,68	20	17152	26,9	1,33
	Gold	2407	36156	1,05	15	52551	21,8	0,97
	Green	3516	71270	1,43	20,3	101630	28,9	1,27
	Hybrid	394	8745	1,79	22,2	15467	39,3	1,62
Seychelles	Bronze	73	1612	1,33	22,1	3179	43,5	2,29
	Gold	141	2543	1,26	18	5084	36,1	1,75
	Green	333	24949	5,18	74,9	45824	137,6	5,8
	Hybrid	52	16953	23,67	326	31224	600,5	23,7

Sierra Leone	Bronze	140	3698	2,5	26,4	4576	32,7	1,87
	Gold	654	10636	1,47	16,3	15502	23,7	1,21
	Green	871	32385	2,45	37,2	30295	34,8	1,71
	Hybrid	126	11280	2,35	89,5	5512	43,8	1,5
Somalia	Bronze	31	320	1,06	10,3	682	22	0,93
	Gold	154	0,91	1629	10,6	4118	26,7	1,26
	Green	169	2294	1,27	13,6	5025	29,7	1,45
	Hybrid	16	157	1,03	9,8	512	32	1,49
South Africa	Bronze	17141	425379	1,85	24,8	487509	28,4	1,4
	Gold	57444	801882	1,11	14	1510842	26,3	1,19
	Green	85149	2225847	1,84	26,1	3097278	36,4	1,64
	Hybrid	12683	433401	2,64	34,2	666322	52,5	2,45
South Sudan	Bronze	17	101	0,44	5,9	319	18,8	1,01
	Gold	111	1189	1,1	10,7	1981	17,8	0,97
	Green	111	1403	1,16	12,6	2238	20,2	1,04
	Hybrid	15	128	0,88	8,5	289	19,3	0,9
Sudan	Bronze	675	8280	0,95	12,3	14853	22	1,09
	Gold	2802	36452	1,03	13	68756	24,5	1,17
	Green	2897	84793	2,12	28,4	114436	38,3	1,96
	Hybrid	345	8626	2,2	25	16075	46,6	2,58
Swaziland	Bronze	108	2152	1,52	19,9	3083	28,5	1,66
	Gold	352	5360	1,07	15,2	10050	28,6	1,18
	Green	510	10130	1,45	19,9	16396	32,1	1,46
	Hybrid	79	1443	1,52	18,3	2401	30,4	1,42
Tanzania	Bronze	1333	26831	1,49	20,1	32966	24,7	1,15
	Gold	6522	105509	1,14	16,2	150128	23	1,04
	Green	8888	251948	2,09	28,3	338874	38,1	1,88
	Hybrid	1292	80111	5,19	62	118238	91,5	5
Togo	Bronze	121	1336	0,81	11	2476	20,5	0,89
	Gold	576	5878	0,81	10,2	10939	19	0,85
	Green	704	31689	3,81	45	40987	58,2	3,29
	Hybrid	69	23098	29,33	334,8	25174	364,8	22,89
Uganda	Bronze	1410	35913	1,98	25,5	37000	26,2	1,26
	Gold	7338	106425	1,09	14,5	164710	22,4	1,03
	Green	10614	293408	2,11	27,6	377040	35,5	1,76
	Hybrid	1376	65554	4,13	47,6	103325	75,1	4,08
Zambia	Bronze	533	9727	1,47	18,2	11676	21,9	1,05
	Gold	2336	35435	1,2	15,2	56013	24	1,15
	Green	3535	128221	2,93	36,3	177215	50,1	2,71
	Hybrid	503	51800	8,76	103	77342	153,8	9,08
Zimbabwe	Bronze	536	13434	2,1	25,1	17092	31,9	1,5
	Gold	2608	34733	1,11	13,3	61420	23,6	1,02
	Green	3584	87804	1,82	24,5	120304	33,6	1,53
	Hybrid	643	19219	2,42	29,9	32026	49,8	2,43

Appendix B: Scholarly output and impact of OA and NOA publications

	Non Open Access Publications						Open Access Publications						TOTAL
	Papers		Citations		Views		Papers		Citations		Views		
Country	n	%	n	FWCI	n	FWVI	n	%	n	FWCI	n	FWVI	
Angola	564	45,45	4352	0,79	12364	0,92	677	54,55	15354	2,11	28799	2,42	1241
Benin	2455	45,66	22328	0,66	56220	0,87	2922	54,34	120492	3,39	184131	3,52	5377
Botswana	3733	55,96	32213	0,75	79687	0,98	2938	44,04	75847	2,19	134170	2,44	6671
Burkina Faso	2273	38,22	24295	0,68	55795	0,9	3674	61,78	62858	1,17	95835	1,12	5947
Burundi	354	48,90	4615	0,92	9790	1,05	370	51,10	14666	3,27	23230	3,28	724
Cameroon	7953	49,26	83784	0,82	173763	0,87	8192	50,74	210964	2,03	319821	1,99	16145
Cape Verde	178	40,64	2040	0,78	5143	1,12	260	59,36	4049	1,58	12141	2,2	438
CAR	237	40,31	2232	0,85	4445	0,83	351	59,69	8025	1,33	10993	1,44	588
Chad	205	38,61	1277	0,64	3361	0,74	326	61,39	5574	1,38	11982	1,91	531
Comoros	55	34,59	539	0,64	1217	0,86	104	65,41	1307	1,18	2152	0,91	159
Congo	1707	38,89	17935	0,69	36986	0,85	2682	61,11	95108	2,84	129906	2,49	4389
Cote D'Ivoire	2413	46,66	18368	0,58	50351	0,8	2758	53,34	85581	2,55	126980	2,4	5171
Djibouti	152	56,51	1378	0,69	3655	0,99	117	43,49	1648	1,31	2965	1,05	269
DRC	712	33,38	5998	0,67	14761	0,88	1421	66,62	32215	2,21	49646	2,05	2133
Equatorial Guinea	56	30,77	446	0,56	1082	0,8	126	69,23	5893	3,55	5872	2,47	182
Eritrea	224	49,02	1877	0,71	5979	1,12	233	50,98	3553	1,13	5338	1,06	457
Ethiopia	13374	36,90	141854	0,83	324983	0,96	22874	63,10	444861	1,53	642503	1,37	36248
Gabon	737	36,59	7128	0,64	14649	0,77	1277	63,41	34956	1,73	40010	1,41	2014
Gambia	306	15,67	6669	1,32	7568	0,99	1647	84,33	78901	3,13	81399	2,61	1953
Ghana	13237	48,34	135572	0,88	355012	1	14147	51,66	354044	1,96	526284	1,77	27384
Guinea	378	34,49	4781	1,07	7382	0,88	718	65,51	19623	2,4	20832	1,47	1096
Guinea-Bissau	151	27,55	2455	0,99	3404	0,94	397	72,45	7830	1,44	9771	1,2	548
Kenya	13031	39,29	153417	0,92	324295	1,05	20131	60,71	568935	2,02	757862	1,72	33162
Lesotho	354	50,57	1784	0,48	6232	0,77	346	49,43	5850	1,43	7666	1,08	700
Liberia	237	29,92	3212	1,34	5503	1,05	555	70,08	34290	5,63	45973	4,92	792
Madagascar	1514	42,71	15538	0,8	34419	0,88	2031	57,29	37491	1,32	60471	1,35	3545
Malawi	2132	28,45	28435	0,86	52408	1,03	5363	71,55	128502	1,74	157931	1,4	7495
Mali	935	31,91	12667	1,04	22377	0,94	1995	68,09	48676	1,63	60505	1,31	2930
Mauritania	326	51,18	2523	0,56	6069	0,85	311	48,82	3852	1,03	8932	1,46	637
Mauritius	2482	68,89	27239	0,92	89049	1,48	1121	31,11	30739	2,26	58708	2,3	3603
Mozambique	1418	31,36	17979	0,97	36686	1,16	3103	68,64	135781	3,52	179230	3,09	4521
Namibia	2187	53,77	16348	0,82	50049	1,11	1880	46,23	58054	2,36	94798	2,56	4067
Niger	690	38,50	8156	0,92	15300	0,91	1102	61,50	24494	1,45	32784	1,3	1792
Nigeria	54882	58,16	414596	0,67	1114935	0,84	39484	41,84	618169	1,31	1094044	1,27	94366
Rwanda	1938	41,09	19989	0,93	44061	1,02	2779	58,91	107327	3,5	165260	3,45	4717
Sao Tome and Principe	25	37,88	188	0,68	613	0,98	41	62,12	554	0,98	2528	2,51	66
Senegal	4061	48,51	32305	0,65	74357	0,79	4311	51,49	81206	1,4	115541	1,19	8372
Seychelles	243	39,07	3180	0,98	7359	1,16	379	60,93	25524	4,64	46706	5,18	622
Sierra Leone	451	29,95	8045	1,47	12053	1,28	1055	70,05	34234	2,24	33794	1,59	1506
Somalia	224	49,12	3471	1,14	5783	1,24	232	50,88	2742	1,14	6625	1,37	456
South Africa	132280	53,46	1438942	0,97	3210470	1,04	115155	46,54	2517411	1,62	3716032	1,46	247435
South Sudan	73	32,30	365	0,48	1533	0,84	153	67,70	1567	0,99	2847	0,98	226
Sudan	5260	54,52	48700	0,76	124639	1,02	4388	45,48	95856	1,7	142365	1,63	9648
Swaziland	648	48,91	5179	0,72	12951	0,84	677	51,09	11876	1,32	19445	1,3	1325
Tanzania	6235	36,72	72421	0,91	160426	1,04	10745	63,28	271872	1,9	377902	1,71	16980
Togo	953	50,83	5623	0,43	18071	0,73	922	49,17	32977	3,06	103325	4,08	1875
Uganda	5842	50,00	62810	0,87	143268	1,02	5842	50,00	62810	0,87	143268	1,02	11684
Zambia	2005	32,10	21341	0,86	44261	0,99	4242	67,90	135781	2,62	191350	2,42	6247
Zimbabwe	4562	49,72	38340	0,77	98971	0,91	4613	50,28	97080	1,65	143237	1,4	9175

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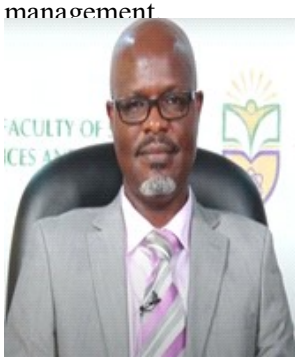

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