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Space Science Research in Africa: Publication Trends, Citation Analysis, and Collaborative Patterns

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Key Points:

- Africa contributes only 3.2% and 5.0% of the world publication output and citation volume respectively in Basic Space Science
- South-Africa leads in African research publication output with 40.9%, followed by Nigeria (14.3%) and Egypt (13.6%)
- African authors show a preference for publishing in Journals with high percentile score and high journal citation rates

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Abstract Content assessment of research metrics plays a pivotal role in the evaluation of scientific productivity globally, especially in a selected field and region. Data from 28 Space-Science Journals spanning 2014–2023, from the Scopus-database, based on African publication output, citations, views-counts, and Field-Weighted-Citation-Impact (Field-Weighted Citation Impact (FWCI)) metrics were used. The results revealed that Africa contributes only 3.2% of the world publication volume in Space Science. From the African output, South-Africa leads with 40.9%, followed by Nigeria (14.3%) and Egypt (13.6%). These three countries contribute ≈70% of the African publication volume. For the citation metrics, Africa contributed 5.0% of the world volume. Publication in Journal of Advances in Space Research is more sought after by African Authors, while Astrophysics and Space Science journal recorded the highest African-to-world publication output percentage (11.3%). African authors show a preference for publishing in Journals with high percentile score and citation rates. Citation-wise, South-Africa accounted for 64% of the total volume from Africa. Only seven countries present citation metrics above 1% of the total volume. South Africa (46%), Morocco (10%), Egypt (9%), Namibia (7%), and Nigeria (7%) are the five countries with publication View counts of above 4,000. Only Ethiopia and South-Africa had FWCI above the world average, with values of 1.47 and 1.25 respectively. North Africa region dominated the appearance list of the 10 top countries in publication, citation, counts views and FWCI while Southern Africa leads in volume. The work further situates the uniqueness/global acceptance of the Scopus and Web-of-Science databases as tools for research publication assessment.

Plain Language Summary Research in any field of study is not complete until it is communicated, either through product development, presentation, or publication. This work focused on the Publication feature of research dissemination on the global platform within Africa, using SCOPUS database from 28 Space-Science related journal spanning 10 years. The metrics of assessment are the publication output, citations, views-counts, and Field-Weighted-Citation-Impact. Africa was seen to contributes only 3.2% and 5.0% of the world publication output and citation volume in Space-Science field respectively, with South-Africa leading the statistics and the Northern African countries having more representation from the available data. The Population (a measure of the human capital) and Gross Domestic Product (a measure of the economic capacity) of any country are propelling factors aiding research publication output.

1. Introduction

The Basic Space Science in the context of the needs for the developing countries (including most African countries) during the first United Nations/European Space Agency (UN/ESA) workshop which held in India in 1991 was defined to cover five key areas including the Solar-terrestrial interaction and its influence on terrestrial climate, Fundamental space physics, Astronomy and astrophysics, Planetary and atmospheric studies, as well as the Origin of life and exo-biology (Haubold & Wamsteker, 2004). With these key areas, some applicable techniques as tools for the enactment of space science research were also enumerated. These include (a) Ground-based optical, and radio observations, (b) Remote sensing (from ground and space), (c) In situ measurements from

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rocket, balloon and satellite platforms, (d) Radio and optical telescopes with related equipment, and (e) measurements from ground-unreachable areas which can only be made through the use of instruments in Earth orbit. According to the authors, the discussions at the workshop identifies three implementation strategies toward assisting the developing countries viz: (a) The availability of research tools in a way that can allow for meaningful science to be done and maintained in the universities/research laboratories (e.g., Kitamura, 2003), (b) Availability of teaching materials allowing for basic space science to be introduced at the teaching level of fundamental mathematics, physics and chemistry courses in middle and higher education (e.g., Kitamura, 2003), and (c) Application materials for original research in basic space science.

If these three implementation strategies are properly monitored and adhered to, developing countries will be at advantage of ensuring quality research activities, and by extension, good research publication outputs; as space science research assists countries, either directly or indirectly, to achieve societal goals. For instance, the study of the Sun and the planetary region have led to experimental procedures for the study of the Earth's environment to a larger perception from which to consider terrestrial environmental concerns like ozone depletion and the greenhouse effect (Haubold, 1999). In addition, space science provides human-centred, informative and technical contributions to the society at large, as it proffers modern answers to questions about humanity's place in the Universe, and immediate practicability in the industry, medicine and the understanding of the Earth's environment.

However, research in any field of study is not complete until it is communicated, either by product development, presentation, or publication (and by any other means). This work focused on the Publication feature of research dissemination on the global platform within Africa. There are however, different databases that curates research publications. Some of this include Scopus, Web of Science (WoS), CrossRef, and MEDLINE; which are searchable electronic collections of scholarly communications metadata. These databases are integral to the development of communicating publication outputs, as they foster the preservation, evaluation and the dissemination of research findings (Asubiaro & Onaolapo, 2023). These indexing databases are classified into two major categories based on their method of assessment of information gathering. First are those that curates all the sources that are available to them without any major instrument of assessment (e.g., Google scholar, Open Alex) and are more exhaustive but less authoritative (Martín-Martín et al., 2018). The second category laid down specific mechanisms for assessment (e.g., Scopus, WoS) and are globally authoritative. Both the Scopus and WoS contributes the key components to the current global research environment through the provision of data for global university rankings and bibliometric analysis for global research and assessments. The United Nations Educational, Scientific and Cultural Organization (UNESCO) annual science report and the Times Higher Education (THE) annual global institutional rankings are examples of global organizations that embrace the use of the Scopus and WoS indexing databases for their assessments (e.g., Asubiaro & Onaolapo, 2023).

In spite of the move to support African countries in the area of space science research, the African space sector has not appeared as a significant player in the global space community, and is largely due to government regulatory bottlenecks, inadequate financial provisions, paucity of human capital, and lack of an excellent curriculum that addresses the current challenges in STEM education, especially in the field of space science amongst others. These gaps have disrupted the quality of academic and technological research and output that plays a crucial role in educating, equipping, and maintaining a vibrant space workforce. Moreover, Africa has the least number of STEM professionals, despite having about 19% of the world population. According to Ama (2022, November), over 70,000 skilled African professionals, including those in space science related fields, have drifted to the other parts of the world; arising in the continent's seemingly brain drain tale.

Using the WoS database, the Clarivate Report (2024, July) specified that out of the many fields of research publications emanating from African authors between 2014 and 2023, the Space Science field recorded the lowest output of about 1%. The first five most prolific research fields based on the highest number of publications in descending order, according to the report, include Clinical Medicine, Engineering, Social Sciences—General, Chemistry as well as Plant and Animal Science. Similar scenario was observed in the extracted data for Nigerian Scholars who were listed among the 2024 top 2% Scientists in the World, published by Elsevier/Stanford University (Ioannidis, 2024). The report showed that of the 233 Nigerians on the list, 78 (33.5%) were from the Clinical Medicine/Biomedical Research field, 19 (8.2%) from Engineering, while Physics and Astronomy presented only 8 (3.4%) researchers, amongst other subject areas; thus, further validating the low publication volume from the space science field (a field that Astronomy belongs to) compared to the other fields. Further from the

Clarivate Report (2024, July), the Category Normalized Citation Impact—CNCI (a metric used to measure the impact of a country's scientific publication relative to the average) was also measured across all fields for publication outputs from Africa. Kenya leads with CNCI of 1.40 (1.00 being the world average impact). Uganda followed with 1.27, Ghana with 1.25, South-Africa, Egypt, Ethiopia and Nigeria respectively presents impact values of 1.23, 1.13, 1.13, and 1.00.

In another work (Baratoux et al., 2017) spanning 2000–2015, publication outputs in the field of Planetary and Space Science were obtained for African authors from four-Journals (Meteorites & Planetary Science, Icarus, Journal of Geophysical Research (JGR)—Planets, and JGR-Space Physics). It was found that the Africa-to-World output is less than 1%, and only six countries (including South-Africa, Nigeria, Egypt, Sudan, Morrocco, and Algeria in descending order) contributed publication output more than a single article. In the same way, the Clarivate Report (2017, May) used to identify the leading African countries (in all fields) spanning 2012–2016 revealed that South-Africa, Egypt, Tunisia, Algeria and Nigeria in descending order leads the countries in publication volumes. More recently, Adebesin et al. (2024) quantitatively investigated the publication contribution of African-affiliated authors to the AGU (American Geophysical Union) list of journals relative to the world output; using the SCOPUS database spanning 2019–2023. They reported that Africa contributed only 1.6% of the total AGU world volume, with South-Africa, Nigeria and Ethiopia/Egypt leading the list from Africa. In addition, of the 54 African countries, only 9 accounted for Publication outputs of 5 or more, representing 67% of the African output.

Many studies have discussed and present the results of the geographical coverage of journals in the global research publications, but such studies are most prominent among the developed regions and countries like Canada, United States, United Kingdom, Japan, etc. (Mongeon & Paul-Hus, 2016; Singh et al., 2021; Visser et al., 2021) with few in the African region. Other studies, even involving the African continent, had also concentrated on the assessment of publication metrics based on the general fields/specific fields not related to Space Science, or dealing with few Africa countries. (e.g., Arvanitis et al., 2000; Waast, 2002; Ingwersen & Jacobs, 2004; Pouris, 2005; Tijssen, 2007; Asubiaro, 2022). Consequently, the scope of this study is to have a scientometric assessment of Space Science Journals published by Africans relative to the world volume over a period of 10 years. The objectives are to (a) investigate the African publication output in the selected Space Science journals and compare with the world output, (b) obtain the citation statistics of the publications in (a), (c) highlight the views counts from (a), and (d) determine the Field-Weighted-citation-Impact of the publications. These objectives were carried out for the entire countries in Africa and for the selected journals. These, the authors believed will open up the rate of involvement of African publications in Space science in the global space and foster ways of improving same.

2. Data and Method

The data used are those of 28 randomly selected Journals in the Space Science field and spans 10 years covering 2014–2023. The data were obtained from the Scopus database at https://www.scopus.com and the raw data as downloaded are stored and accessible through the repository address https://eprints.lmu.edu.ng/id/eprint/5657. The algorithm for generating the data for each Journal considered is as shown in Figure 1. The data were automatically collected on the bases of the authors' affiliation with African countries publications in Scopus database regardless of the authorship position. The List of Journals considered with their corresponding Codes, Publisher names, Percentile scores, and Average Citation per Publication are presented in Table 1. It is worth mentioning that of the 28 Journals listed, 15 are in the Q1 Percentile (75%–100%) category, 8 in the Q2 (50%–74%) category, 3 in Q3 (25%–49%), and 2 in the Q4 (1%–24%) category. More journals were picked from the Q1 category on the assumption that researchers prefer to publish in that category of Journals, and as such will serve as a good representation of the actual outputs from researchers, including those from Africa. Though the study's reliance on 28 journals—of which 15 of them are from the Q1 (75%–100% percentile) may somewhat introduce potential bias by over representing high-impact publications, but this category notably represents the platform upon which most African scholars prefer to publish provided the most-common barriers (e.g., high Article Processing Charges (APCs), editorial bias, language barrier mostly against non-English speaking authors, limited research funding, digital divide, biases for not coming from prestigious institutions and lack of appropriate government policy on research) faced by African scholars in accessing top-tier journals are removed or relegated to the barest minimum. According to Mongeon and Paul-Hus (2016), what matters most when using bibliometric

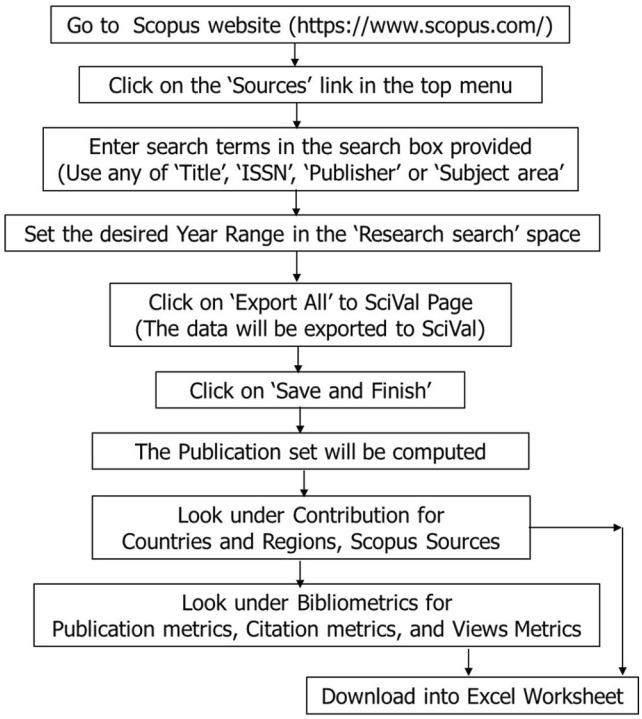

Figure 1. Algorithm for data collection from the Scopus database.

methods for research evaluation is the understanding of what each tool presents to offer and identifying its limitations toward choosing the right tool for the task.

3. Result and Discussion

3.1. Publication Output and Trends

Figure 2 depicts the Publication output from Africa both in volume and percentage. South-Africa leads with 40.9% (936) of the total volume from Africa. This is followed by Nigeria (14.3%) and Egypt (13.6%). These three countries contribute 68.8% of the total volume from Africa. The outputs of the other countries are as indicated. Djibouti, Gambia, Guinea, Liberia, Libya, Mauritania, Mozambique, and Togo (not presented on the Figure) had 1 scholarly output each. Other countries not listed are without any publication output during the study period. With this, only 1 country (South-Africa) presents publication volume greater than 500 in Space sciences covering 28 journals and spanning 2014–2023. Six countries presented above 100 volumes, 12 countries present between 10 and 50 publication volume, 15 countries generate between 2 and 9 outputs, 8 countries present only 1 output each, and the remaining 13 countries are without any publication output.

In terms of regional output (Figure 3), Southern African recorded the highest publication volume from Africa with 42% output. Others include North Africa, West Africa, and East Africa with 25%, 18%, and 13% outputs respectively. The lowest (2%) was recorded from the Central Africa region. Of the six countries with the highest publication volumes (the labeled countries shown on the figure and the only ones above 3% volume of the overall coverage from Africa during the study period), three are from North Africa. In the Clarivate Report (2017, May), the African research publication output for all fields between 2007 and 2016 had the Northern and Southern Africa contributing 42% and 29% of the total volume respectively, yielding about 70% of the output. In the current work, a cumulative output of 67% was obtained from both the Southern and Northern African countries. The remaining 33% was shared between the other three regions.

The plot of Publication volume from African authors per Journal versus the Percentage output from Africa to World output is represented in Figure 4. The bar-chat, in descending order, reveals the Publication volume per Journal starting from ASR (with 413), ASS (298), AJL (212) and ending with TRANS (2). This suggests that ASR is more sought after among the list of Journals considered in this work. The first five leading African countries in publication output for this journal (ASR) are Nigeria, South-Africa, Egypt, Ethiopia and Algeria with 101, 86, 72, 44, and 35 research volumes respectively (see also Table 2 for the other Journals). In the same way, the ratio of the African output to the world output per journal was also calculated in percentage and is represented by the blue circled dots. From this, ASS recorded the highest percentage (11.3%), followed by IJRSP (9.3%), JASTP (8.2%) and then ASR (7.6%). The least was TRANS with 0.5%. Additionally, the Pearson correlation coefficient (r) between the publication output and the percentage African output to world output is 0.549 (and of positive trend), suggesting a moderate positive correlation between the two, such that as the African publication output increases, the percentage (%) African-output to world-output tends to increase as well. On the average, Africa contributes only 3.2% of the world publication output considering the 28 Journals in Space Science spanning 2014–2023.

Table 3 presents the summary statistics table for the observation in Figure 4, which provides a comprehensive overview of the data set, including the distribution and central tendencies of the African publication output and the % African output to world output. From the table, African output recorded 16.25, 47.0, and 113 for the first, second, and third quartile range respectively. This implies that 25% of the data fall below 16.25 volumes, 50% of the data fall below 47 outputs, and 75% of the data fall below 113 outputs corroborating the 80.93 mean (average) output. In the same way for the African-to-world output percentage, 25%, 50%, and 75% of the data falls below 1.45%, 2.6%, and 5.13% of the African-to-world output respectively; suggesting small rate. The F-statistic is used to assess the overall significance of the model created from the two variables. The value of 11.23 suggests that the model significantly explains the variance in the dependent variable. Also, the p-value used to explain the

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Table 1
List of Journals Used With Corresponding Codes, Publishers, Percentile Scores, and Average Citation per Publication

S/N	Journal name	Code[a]	Publisher	Highest percentile score (%)[b]	Ave. Journal citation per publication[c]
1	Advances in Space Research	ASR	Elsevier	78	12.0
2	Earth and Space Science	ESS	John Wiley	80	12.0
3	JGR—Space Physics	JGR-SP	John Wiley	79	16.6
4	Earth, Planets and Space	EPS	Springer Nature	83	14.6
5	Journal of Atmospheric & Solar Terrestrial Physics	JASTP	Elsevier	70	10.6
6	Physics of the Earth and Planetary Interiors	PEPI	Elsevier	77	14.2
7	Astrophysics & Space Science	ASS	Springer Nature	57	9.9
8	JGR-Atmospheres	JGR-Atm	John Wiley	90	17.6
9	Astronomical Journal	ANJ	American Astronomical Society	86	23.8
10	Earth & Planetary Science Letters	EPSL	Elsevier	97	32.6
11	Solar Physics	SOLAR	Springer Nature	68	14.9
12	Icarus	ICARUS	Elsevier	76	20.2
13	Planetary & Space Science	PSS	Elsevier	73	13.3
14	Astrophysical Journal Letters	AJL	American Astronomical Society	72	35.7
15	Astrophysical Journal: Supplement Series	APJ-SS	American Astronomical Society	93	41.4
16	JGR-Solid Earth	JGR-SE	John Wiley	90	24.0
17	Space Weather and Space Climate	SWSC	EDP Science	77	18.0
18	International Journal of Aeronautical & Space Science	IJASS	Korean Society for Aeronautical & Space Science	59	5.7
19	Journal of the Earth & Space Physics	JESP	Institute of Geophysics, Tehran University	13	1.1
20	JGR-Planets	JGR-Pl	John Wiley	92	21.0
21	Acta Astronautical	ACTA-A	Elsevier	31	4.2
22	Earth, Moon & Planet	MOON	Springer Nature	31	6.1
23	Transactions of the Japan Society for Aeronautical & Space Science	TRANS	Japan Society for Aeronautical & Space Science	36	3.9
24	Annales Geophysicae	ANNALES	Copernicus Publications	76	11.0
25	Radio Science	RADIO	John Wiley	63	10.5
26	Indian Journal of Radio & Space Science	IJRSP	National Inst. of Science Comm. & Policy Research	9[d]	2.5
27	Space Weather	SpaW	John Wiley	69	17.2
28	Space Policy	SPolicy	Elsevier	90	8.1

[a]Code is based on authors' choice and not that of the Journals. [b]2023 metrics (https://www.scopus.com/sources.uri). This percentile is used to evaluate the relative performance of journals based on their publication and citation data within similar fields/categories in the Scopus database. Accessed on 3 September 2024. [c]Journal World metrics for 2014–2023. (https://www.scival.com/overview/citations?uri). SciVal regularly presents Citations per Publication in a table with years. These years are the years in which items were published, and not the years in which citations were received. Accessed on 3 September 2024. [d]2023 metrics is not available (N/A). Hence, 2022 metrics was used.

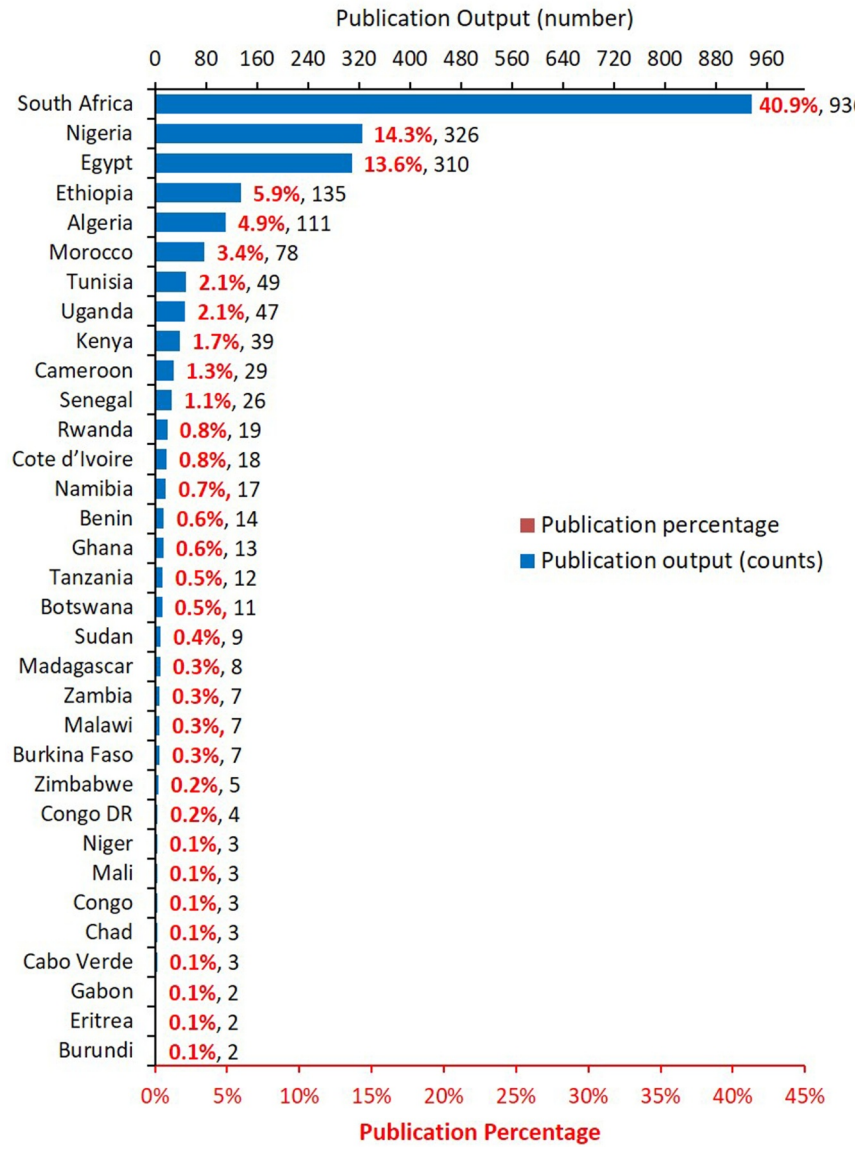

Figure 2. Publication output from Africa (countries with less than two publication output are not shown).

F-statistics at 0.00247 < 0.5 (at 2 degrees of freedom) suggests that the model relationship between the two variables is statistically significant. However, the *R*-squared value of 0.302 indicates that approximately 30.2% of the variance in the % African-to-world output can be explained by the African publication output. The remaining 69.8% of the variance cannot be explained by the model, implying the presence of other determinant factors of the African-to-world output percentage beyond the publication rate from Africa alone.

Remarkably, it was also observed, on the average, that Journals that had the highest publication outputs from African authors are Journals with high percentile scores and high Journal Citation per Publication while those with the lowest Publication rate are those with seemingly low percentile scores and low Journal citation per Publication. This is evident from Table 4. The table (extracted from a combination of the fifth and sixth columns of Table 1 and the publication output of Figure 4) highlights the six highest/lowest Journals in each category of publication volume (i.e. high—Category A, moderate—Category B, and low—Category C) with their corresponding Percentile score and Journal Citation per Publication. The Category A, B, and C Journals presents an average Percentile score of 77%, 69%, and 56% as well as an average Journal Citation per Publication count of 20.8, 12.3, and 8.9 respectively. This statistic suggests that African authors had more publication preference in Journals with high percentile score and high Journal citation per publication.

Figure 3. Publication output by region. Only countries with the highest publication volumes above 3% were labeled.

3.2. Citation Counts of African Authors

Citations per Publication in SciVal specifies the average citation impact of each of an entity's publications, and is useful in benchmarking the average citation impact of publications. The country-by-country citation volume is depicted in Figure 5. South-Africa led the other African countries with 46,460 citation metrics, accounting for 64% of the total volume from Africa during the study period. This is followed by Morocco (6.8%), Egypt (5.5%), Namibia (4.8%), Nigeria (4.4%), Algeria (3.5%), and Ethiopia (2.4%). Only these seven countries presented citation metrics above 1% of the total volume. Additionally, only countries with citation percentage ≥0.2% are shown on the figure. Inset on the Figure is the African map highlighting the number of Journals in which each country appears for the Citation count. For instance, of the entire 28 Journals considered, South-Africa had citation presence in 25, Egypt in 23, Nigeria in 21, etc. Only the 11 countries with presence in 10 or more journals are labeled on the map. The number of appearances obviously presents a positive influence on the citation metrics, as these 11 countries with appearance in ≥10 Journals are among the first 15 countries with the highest citation metrics.

In the same way, the citation impact per journal from African authors (represented by the bar-chart of Figure 6) based on the 28 journals considered reveals AJL having the highest citation metrics. This is followed by EPSL, JGR-SE, and JGR-SP in the second, third and fourth positions respectively. The least cited journal was IJRSP. The citation percentage ratio of the African output to the world output per journal, represented by the blue triangles from the same figure revealed ASS having the highest percentage (14%), followed by APJ-SS (13%), IJRSP (11%) and then AJL/SWSC (10%). It is worth noting that ASS (Astrophysics and Space Science) also presented the highest percentage ratio of Africa publication to world output of 11.3% (from Figure 4). On the average, Africa contributes only 5.0% of the world citation volume relative to the 28 Journals spanning 2014–2023.

3.3. Views Counts of Publications From African Authors

The Views Count of a publication projects the overall usage impact of such publication. In this section, the Views Counts in SciVal are generated from usage data in Scopus. The metric is the sum of abstract views and clicks on the link to view the full-text at the publisher's website. The Views Counts has the advantage of immediately

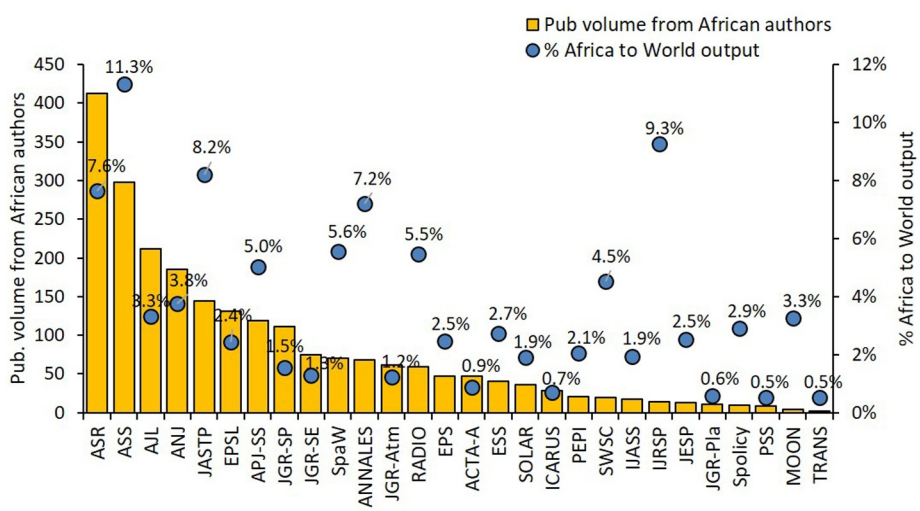

Figure 4. Plot of Publication volume from African authors (bar-chart) per Journal versus Percentage Africa-to-World output (blue dots).

Table 2
Journals List With Corresponding First Three Leading Countries in Publication Output

S/N	Journal name	Code[a]	Three leading countries in publication per journal
1	Advances in Space Research	ASR	Nigeria (101); South-Africa (86); Egypt (72)
2	Earth and Space Science	ESS	Nigeria (9); South-Africa (7); Egypt (4)
3	JGR-Space Physics	JGR-SP	South-Africa (42); Nigeria (32); Egypt (11)
4	Earth, Planets and Space	EPS	South-Africa (15); Egypt (8); Algeria (5)
5	Journal of Atm. & Solar Terrestrial Physics	JASTP	Nigeria (43); South-Africa (30); Ethiopia (17)
6	Physics of the Earth and Planetary Interiors	PEPI	Nigeria (6); Algeria/Egypt (3)
7	Astrophysics & Space Science	ASS	Egypt (114); South-Africa (52); Nigeria (46)
8	JGR-Atmospheres	JGR-Atm	South-Africa (17); Tunisia (8); Senegal (6)
9	Astronomical Journal	ANJ	South-Africa (144); Morrocco (19), Egypt (9)
10	Earth & Planetary Science Letters	EPSL	South-Africa (82); Ethiopia (11); Egypt (8)
11	Solar Physics	SOLAR	South-Africa (15); Algeria (9); Egypt (6)
12	Icarus	ICARUS	South-Africa (20); Senegal (3); Namibia (2)
13	Planetary & Space Science	PSS	Tunisia (4)[b]
14	Astrophysical Journal Letters	AJL	South-Africa (174); Morrocco (14); Namibia (10)
15	Astrophysical Journal: Supplement Series	APJ-SS	South-Africa (109); Morrocco (4)[b]
16	JGR-Solid Earth	JGR-SE	Egypt (20); South-Africa (14); Ethiopia (9)
17	Space Weather and Space Climate	SWSC	South-Africa (9); Algeria (3); Egypt/Ethiopia (2)
18	Int'l Journal of Aeronautical & Space Science	IJASS	Egypt (8); Algeria (4); South-Africa (2)
19	Journal of the Earth & Space Physics	JESP	Nigeria (7); Egypt/Kenya/Uganda (2)
20	JGR-Planets	JGR-Pl	South-Africa (4); Morrocco (3); Senegal (2)
21	Acta Astronautical	ACTA-A	South-Africa (16); Egypt/Nigeria (7)
22	Earth, Moon & Planet	MOON	[b]
23	Transactions of the Japan Society for Aeronautical & Space Science	TRANS	[b]
24	Annales Geophysicae	ANNALES	South-Africa (29); Nigeria (12); Ethiopia (6)
25	Radio Science	RADIO	South-Africa (19); Ethiopia (13); Nigeria (10)
26	Indian Journal of Radio & Space Science	IJRSP	Nigeria (10); Uganda (2)[b]
27	Space Weather	SpaW	South-Africa (37); Nigeria (19); Egypt (3)
28	Space Policy	SPolicy	South-Africa (8); Nigeria (2)

[a]Code is based on authors' choice and not that of the Journals. [b]For three or more Countries with only one publication each.

accumulating as soon as publication output is available online, and are more immediate than citation activities. They also reflect the interest of the whole research community, including students and researchers working in the corporate sector, who tend not to publish and cite and who are "unseen" from citation-based metrics.

The Views Counts of Publications of African Authors, by country, based on the 28 Journals considered are presented in Figure 7a. South Africa recorded 29,038 views of the entire 63,282 views between 2014 and 2023, accounting for 46%. This is followed by Morocco (10%), Egypt (9%), Namibia (7%) and Nigeria (7%), being the only five (5) countries with View counts of above 4,000. Additionally, 47 of the countries are with publication count views of less than 1,000. Similarly, Figure 7b revealed that AJL (Astrophysical Journal Letters) projects the highest publication count views with respect to the entire 28 journals considered. The least three with views counts include TRANS (with 26 counts), MOON (76) and IJRSP (126).

3.4. Field Weighted Citation Impact of African Authors (by Country) in Space Science

The Field-Weighted Citation Impact (FWCI) in SciVal defines the extent to which the number of citations received by a Journal's publications compares with the average number of citations received by all other similar

Table 3
Statistics Table of African Publication Output and African-To-World Output Percentage

Statistics	African publication output[a]	African output to world output (%)[a]
Mean	80.93	3.6
Std	96.59	2.89
Min.	2	0.5
25%	16.25	1.45
50%	47	2.6
75%	113	5.13
Max.	413	11.3
F-statistic	11.23	
Prob (F-statistic)	0.00247	
R-squared	0.302	

[a]All statistics are based on Figure 4.

publications in the data universe. In essence, it relates how the citations received by a journal's publications compare with the world average. Numerically, a FWCI = 1.00 indicates that the entity's publications have been cited exactly as would be expected based on the global average for similar publications; the FWCI of "World", or the entire Scopus database, is 1.00. A FWCI > 1.00 indicates above the global average for similar publications; for example, 1.11 means 11% more than the world average. Also, a FWCI < 1.00 indicates below the global average for similar publications; for example, 0.66 means 24% less than the world average.

By definition, similar publications imply the publications in the Scopus database that have same publication type, publication year, and discipline, as represented by the Scopus journal classification system. SciVal often displays FWCI in a table with years. These years are always the years in which the articles were published, and do not refer to the years in which citations were received. The citations received in the year in which an item was published, and the following 3 years, are counted for this metric (https://www.scival.com/overview/citations?uri). FWCI is useful for Benchmark entities like the geographical region of publication interest and countries within such region, regardless of differences in their size, disciplinary profile, and age in the publication business.

The average FWCI of African Authors per country across the 28 Space Science Journals are shown in Figure 8. This was achieved by bringing together the cumulative FWCI values across the entire journals per country and

Table 4
Classes of Journals List Based on Publication Output With Corresponding Average Journal Citation per Publication and Journal Percentile

Six leading journals by publication (category A)			Six middle journals by publication (category B)			Six lowest journals by publication (category C)		
Journal (output)	Percentile (%)	Ave. Journal citation per publication	Journal (output)	Percentile (%)	Ave. Journal citation per publication	Journal (output)	Percentile (%)	Ave. Journal citation per publication
ASR (413)	78	12.0	JGR-Atm (61)	90	17.6	TRANS (2)	36	3.9
ASS (298)	57	9.9	RADIO (59)	63	10.5	MOON (4)	31	6.1
AJL (212)	72	35.7	EPS (47)	83	14.6	PSS (9)	73	13.3
ANJ (185)	86	23.8	ACTA-A (47)	31	4.2	SPolicy (10)	90	8.1
JASTP (144)	70	10.6	ESS (41)	80	12.0	JGR-Pla (11)	92	21.0
EPSL (131)	97	32.5	SOLAR (36)	68	14.9	JESP (13)	13	1.1
Range	57–97	9.9–35.7		31–90	4.2–17.6		31–92	1.1–21.0
Average	77	20.8		69	12.3		56	8.9

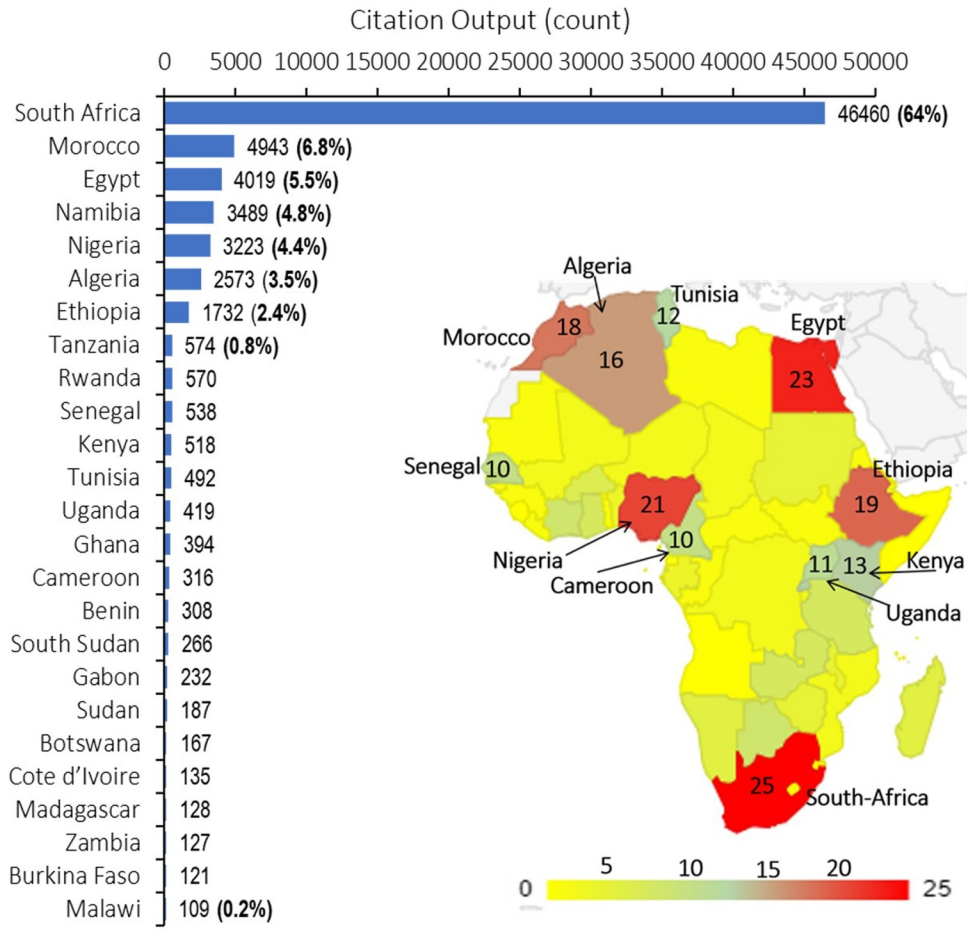

Figure 5. Citation output from Africa (countries with less than 100 or less than 0.2% Citation volume are not shown). Inset: African map showing the number of Journals in which each country appears for the Citation count.

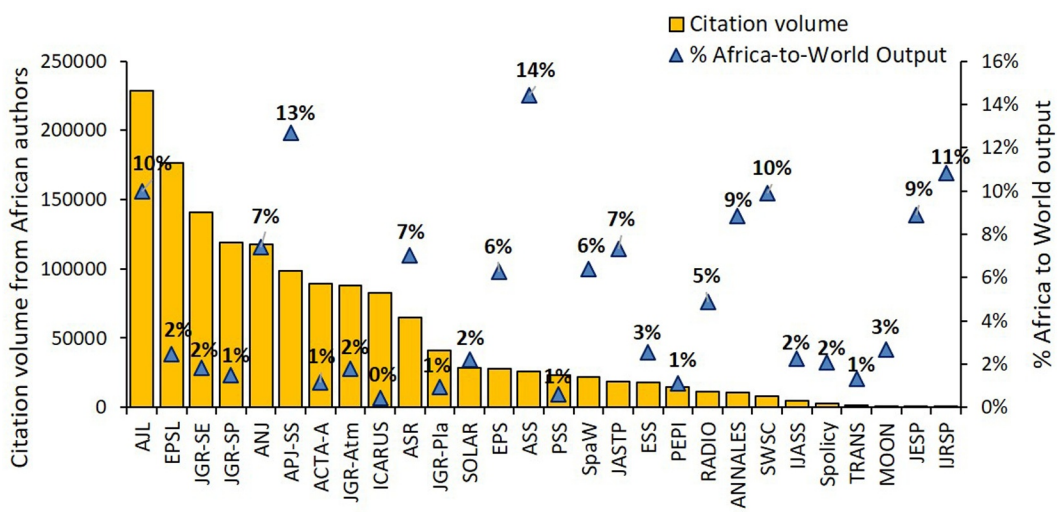

Figure 6. Citation volume from African authors (bar-chart) per Journal versus Percentage Africa-to-World output (blue triangles).

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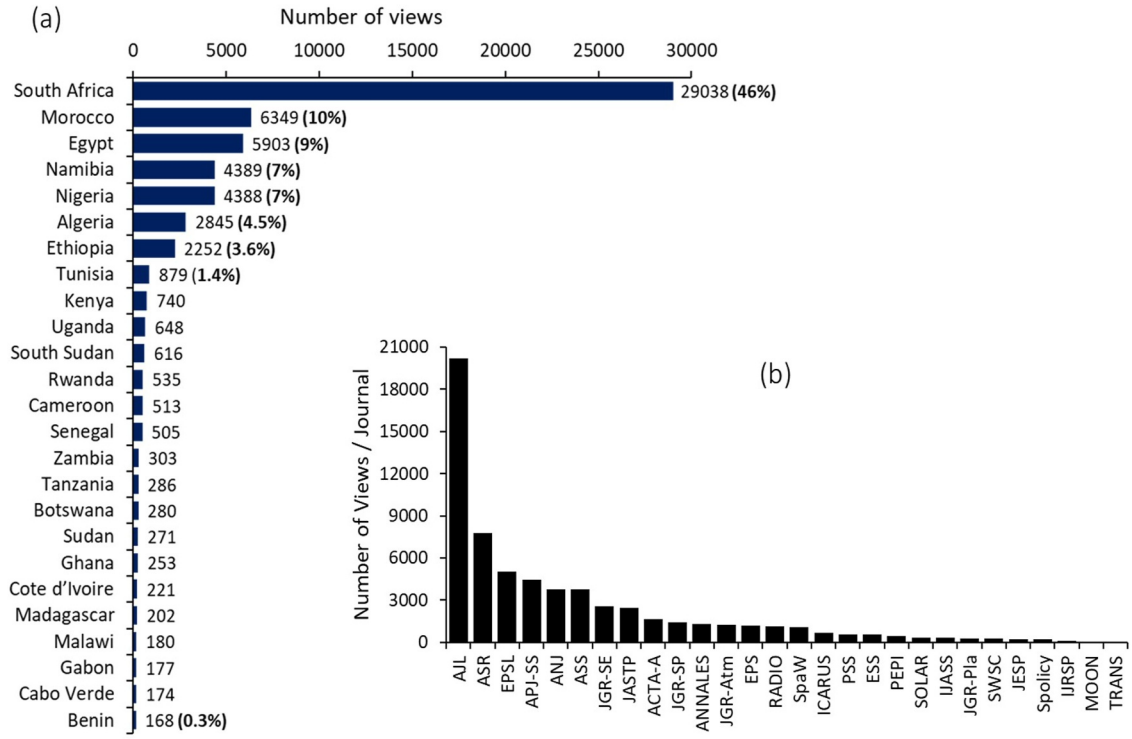

Figure 7. Views Count of Publications of African Authors (a) by country (countries with less than 150 count rates are not shown), (b) by Journal.

averaging the values. Only countries without any FWCI value are not shown. Ethiopia led the countries with a FWCI of 1.47. This is closely followed by South-Africa with FWCI = 1.25. This implies that for the entire 28 journals bin together for each country, only these two countries present publications that have been cited above the global average of 1.00. The interpretation of these is that both Ethiopia and South-Africa respectively have 47% and 25% FWCI more than the world average for similar works, whereas Nigeria's FWCI = 0.44 implies Nigerian papers receive 56% fewer citations than the global average. Morocco, Egypt, Algeria, and Namibia had FWCI values below 1 but greater than 0.50. All other countries stating from Ghana and Nigeria in descending order had FWCI < 0.50, showing that the scientific publications of this countries have a significantly lower impact than the world average.

While the reason behind Ethiopia's high FWCI (1.47) despite low publication volume (5.9% of Africa's output) in comparison with the high publication volume, lower-FWCI countries (e.g., Nigeria, FWCI = 0.44) could not be immediately established, the implication is that Ethiopia has much higher global impact while a country like Nigeria presents lower global impact. However, the likely explanation is that Ethiopia may have developed strong expertise in a few specialized, high-impact research areas that attract global attention as specialized fields often have smaller communities and higher citation rates, especially if the work contributes to global research frontiers. It may also be possible that Ethiopian researchers may be engaged in internationally co-authored projects with leading universities or global institutions, as international collaborations tend to produce papers with higher visibility and more citations, because they are published in high-impact journals and accessed by wider audiences. This FWCI comparison between Ethiopia and Nigeria could therefore involve analyzing (a) Research field distributions (which subjects they publish in), (b) degree of international collaboration, (c) journal impact factors, (d) research funding sources, and (e) Institutional or policy frameworks. It is expected that such analysis could reveal practical strategies that countries with high volume but low impact could adopt to improve their global research visibility and citation performance. It is believed that such analysis could help identify how to optimize research impact and visibility across Africa.

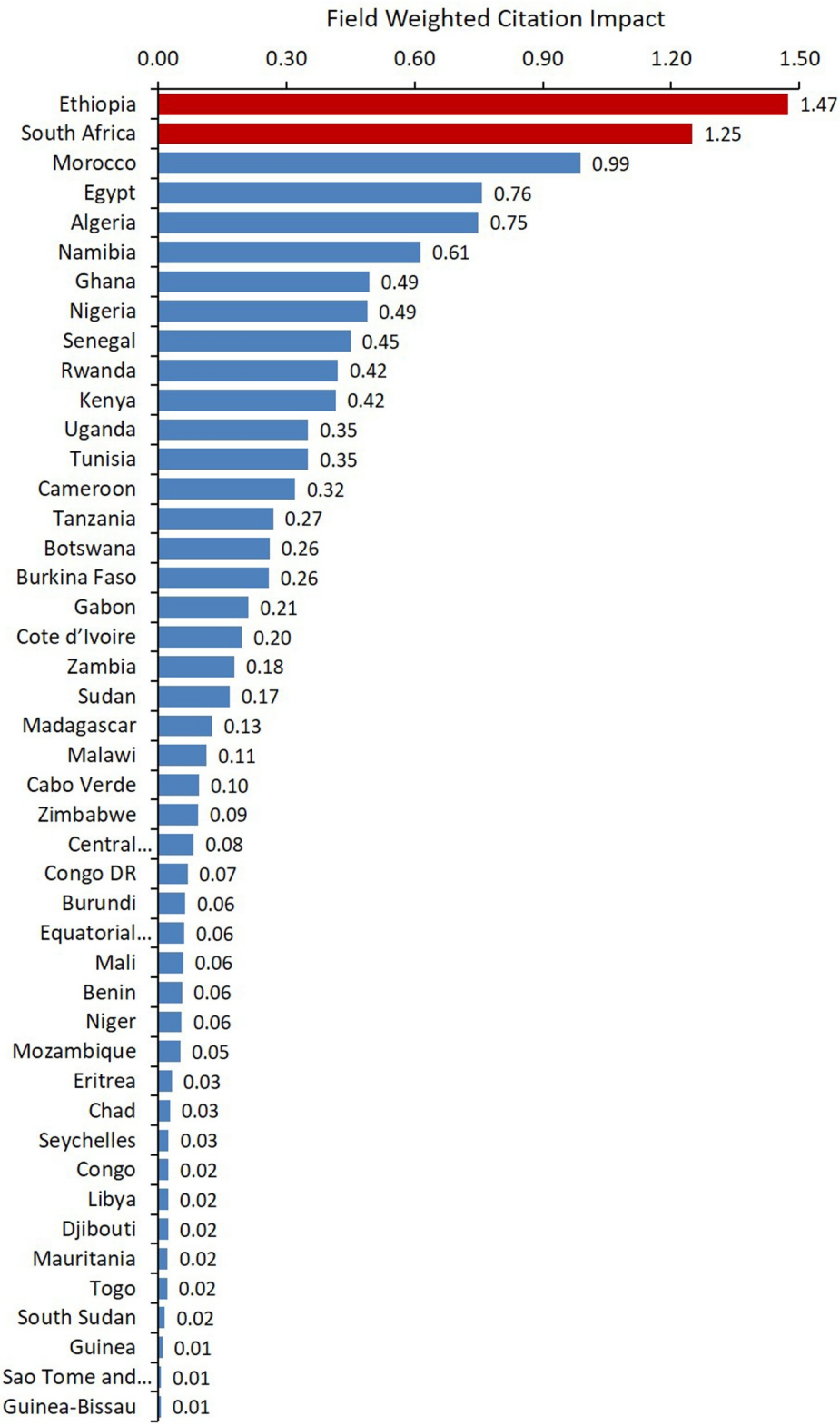

Figure 8. The Field-Weighted Citation Impact of African authors in space science journals.

Table 5
List of the Top 10 African Countries in Research Publications, Citations, Views Counts, and Citation Impact in the Current Work and Comparison With Other Related Works

S/N	Top 10 countries by publication (this work) space science field 2014–2023 (A)	Top 10 countries by citations (this work) space science field 2014–2023 (B)	Top 10 countries by views count (this work) space science field 2014–2023 (C)	Top 10 countries by impact—FWCI[a] (this work) space science field 2014–2023 (D)	Top 10 countries by publication (Clarivate Report, 2024) all fields 2014–2023 (E)	Top 10 countries by impact—CNCI[b] (Clarivate Report, 2024) all fields 2014–2023 (F)	Top 10 countries by impact—CNCI[c] (Clarivate Report, 2017) all fields 2012–2016 (G)
1	South-Africa	South-Africa	South-Africa	Ethiopia	South-Africa	Kenya	South-Africa
2	Nigeria	Morrocco	Morrocco	South-Africa	Egypt	Uganda	Egypt
3	Egypt	Egypt	Egypt	Morrocco	Nigeria	Ghana	Tunisia
4	Ethiopia	Namibia	Namibia	Egypt	Tunisia	South-Africa	Algeria
5	Algeria	Nigeria	Nigeria	Algeria	Algeria	Egypt	Nigeria
6	Morrocco	Algeria	Algeria	Namibia	Morocco	Ethiopia	Morocco
7	Tunisia	Ethiopia	Ethiopia	Ghana	Ethiopia	Nigeria	Kenya
8	Uganda	Tanzania	Tunisia	Nigeria	Kenya	Morocco	Ethiopia
9	Kenya	Rwanda	Kenya	Senegal	Ghana	Algeria	Uganda
10	Cameroon	Senegal	Uganda	Rwanda	Uganda	Tunisia	Ghana

[a]The Field-Weighted Citation Impact (FWCI) defines the extent to which the number of citations received by a Journal's publications compares with the average number of citations from similar publications globally. FWCI = 1.00 indicates the world average. [b]Category Normalized Citation Impact (CNCI) is a metric used to measure the impact of a country's scientific publications relative to the world average. A CNCI = 1.0 indicates world average impact (Clarivate Report, 2024, July). [c]Category Normalized Citation Impact (Clarivate Report, 2017, May).

3.5. Comparison of Result With Related Literature

Table 5 highlights the list of the top 10 African countries in research publications, citations, views counts and citation impact in the current work (for only Space Science field) and that obtained from Clarivate Report (2024, July) and Clarivate Report (2017, May) for all fields. From the Table, a comparison in the Scopus database result of the top 10 African countries with respect to Publication outputs for only the Space Science Field/Journals, spanning 2014–2014 [column **A**] and the Web-of-Science database result of the top 10 African countries with respect to All-Fields, spanning 2014–2014 [column **E**] showed same 9 countries listed on each column out of the 10 countries listed on each column. The only country on column A/column E not listed on column E/column A was Cameroon/Ghana. This 90% similarity (though not necessarily in similar order of appearance) between the Scopus and WoS databases results further affirms their uniqueness and global acceptance as mechanisms for assessment of the research environment and for bibliometric analysis for global research. Though, there are other concerns about the Scopus and WoS databases despite their global credibility (Tennant, 2020). Part of the concerns according to Asubiaro (2022) and Vera-Baceta et al. (2019) is that the two databases are systematically biased against research publications from non-Western countries, non-English language journals, and researches from the arts and humanities. Though this is not the interest of the current work.

In the same way, the list of the top 10 countries with citation impact—FWCI (column **D**) for the Space Science Field only reveals that 7 of these countries also reflect among the top 10 countries with citation impact—CNCI (column **F**) for all fields spanning 2014–2023 and column **G**, for all fields spanning 2012–2016. This suggests a consistency in the African countries' citation impact metrics irrespective of the observation field of interest. It should be noted that both the Field-Weighted-Citation-Impact (used by Scopus) and the Category-Normalized-Citation-Impact (used by Web-of-Science) measure same metric/entity.

In terms of regional appearance of countries on the top 10 lists from the Table, with respect to columns A—D, the North African countries dominated the Publication list with 40% appearance, East Africa with 30%, and 10% each for West Africa, Southern Africa, and Central Africa. For the Citation list, both the North and East Africa showed higher presence of 30% each, while the West and Southern Africa presents 20% presence apiece. In terms of views counts, both the North and West African countries led with 30% presence each, while the Southern and East Africa recorded 20% appearance each. Lastly for the citation impact, both the North and West Africa recorded the 30% highest apiece while Southern and East Africa presents 20% representation on the top 10 list. The Central

Table 6
Number of African Universities in the Times Higher Education (THE) Top 1,000 World Universities in the Subject Area of "Physics and Astronomy" Spanning 2014–2024

S/N	Top 10 countries by publication (this work)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	Total
1	South-Africa	0	0	0	0	5	9	10	11	11	13[a]	11[a]	70
2	Nigeria	0	0	0	0	0	2	3	1[a]	2[a]	6[a]	4[a]	18
3	Egypt	0	0	0	0	1	15	18	20	18[a]	21[a]	24	117
4	Ethiopia	0	0	0	0	0	0	0	0	1	1	0[a]	2
5	Algeria	0	0	0	0	0	5	8	4[a]	2[a]	3[a]	3[a]	25
6	Morrocco	0	0	0	0	0	4	5	3[a]	3[a]	3[a]	6[a]	24
7	Tunisia	0	0	0	0	0	3	5	4[a]	2[a]	2[a]	3[a]	19
8	Uganda	0	0	0	0	0	0	0	1	1	1	1	4
9	Kenya	0	0	0	0	0	0	0	0	0[a]	0[a]	0[a]	0
10	Cameroon	0	0	0	0	0	0	0	0	0	0	0	0

[a]Additional Universities per country on the *THE* list but not in the top 1,000 for the year under consideration.

African region had no representation in the top 10 countries with citation metrics, counts views, and citation impact. On the average, the North Africa countries dominated the list (column A–D), followed by East Africa, Southern Africa, and then West Africa. The least represented region on the list was Central Africa. While North Africa leads in terms of appearance, the Southern Africa region leads in terms of volume.

In a recent ranking of African Universities, based on their research performance in the field of Astrophysics and Astronomy, a count of 1.26 million citations from 96,500 research articles was made by 218 African Universities to rate their publications (https://edurank.org/physics/astrophysics/af/—accessed 19 November 2024). Of the 218 institutions listed, 54 are in Nigeria, 36 in Egypt, 24 in South-Africa, 22 in Algeria, 11 each in Ethiopia and Tunisia, 6 each in Morocco, Kenya, Cameroon, and Ghana. Other countries presented less than 4 Universities. Incidentally, 9 of the 10 countries with the highest number of universities with high publication volume in Astrophysics and Astronomy (South-Africa, Nigeria, Egypt, Algeria, Ethiopia, Tunisia, Morocco, Kenya and Camerron) are also among the top 10 observed with the highest publication volume in this work (see Table 5—column A). This further revealed that with the involvement of more institutions in the teaching of Basic Space Science, more researches will be done and leading to more research output. It is also worth mentioning that from the eduRank.org statistics that the number of South-African Universities in the first 20 African Universities, based on their research performance in the field of Astrophysics and Astronomy was 11, Egypt took 7 of the first 20 slots, while the remaining 2 slots were occupied by Tunisia. Invariably, these figures demonstrate the commitment of each country toward positioning itself in the space research environment. One is then not surprised with the leading pace of South-Africa in the publication output and citation volume and impact in this work, given the quality in Basic Space science education and operations in its universities, compared to other African countries. The clarion call is therefore for the other African countries to improve on their curricula and adjust toward research-oriented programmes in all areas of Basic space science as highlighted earlier in the introduction section.

Additionally, from the Times Higher Education (*THE*) World University "Subject Ranking" (timeshighereducation.com/world-university-ranking/by-subject—accessed 19 November 2024), the number of the top 1,000 World Universities in the subject area of "Physics and Astronomy" were extracted for the African countries that comes in the top 10 publication in this work. The "Physics and Astronomy" subject field was used because it was the closest field in the *THE* Subject Ranking to the Space Science field considered in this work. Table 6 highlights the numbers of African Universities in the *THE* top 1,000 World Universities in the subject area of "Physics and Astronomy" spanning 2014–2024. Only Universities within the first 1,000 list were extracted, as all other Universities with ranking beyond the 1,000th position were not included, but were noted on the Table with an asterisk. For instance, the 18 +*/0 +* recorded for Egypt/Kenya in 2022 implies that 18/0 Universities from Egypt/Kenya were on the list in 2022 and are within the first 1,000 list but still contain other universities whose ranking are beyond the 1,000th position (and whose count is not our concern in this work). Those ranking beyond the 1,000th position presented on the Table are represented by the plus asterisks sign (+*). There was no African university on

the list between 2014 and 2017. Only South-Africa and Egypt appeared first on the list in 2018. However, effective from 2019 through 2024, more of the other countries have joined the list. In total, there are more Universities from Egypt appearing on the list with 117 entries. This is followed by South-African Universities with 70 entries, then Algeria (25), Morocco (24), Tunisia (19), Nigeria (18) and Uganda (4). Both Kenya and Camerron do not present any University, though Kenya had other universities but beyond the 1,000th threshold position considered. The Table therefore suggests that more of Egypt universities are involved in publication in the Space science/Astronomy related field compared to the other countries listed. From these, it may be assumed that a good number of the publication volumes emanating from this current work from South-Africa and Nigeria (that toped the publication list—Table 5, column A) may have been from Research institutions/agencies rather than from the Universities (since their respective University contributions on the *THE* list is low compared to that of Egypt, especially the case of Nigeria with only 18 entries); though this notion may only be held tentatively. Regionally, the North African countries present the highest number of THE World universities in the top 10 African countries by Publication output, occupying the first, third, fourth and fifth of 10 positions, while conceding the second position to South-Africa.

3.6. Collaborative Pattern of Journals Used and Effects on Percentile Score and Average Journal Citation per Publication

Collaboration of Scholarly (publication) output of Journals on the Scopus platform (for authors, institutions and countries) are often presented in four modes viz: international collaboration, national collaboration, institutional collaboration, and no collaboration. In this section, we explore the trend in each category of collaboration based on the 28 journals used for this study, and report their probable link or effect on Journals percentile score (Table 1—fifth column) and average journal citation per publication (Table 1—sixth column). The Journal percentile score is a metric on the Scopus database to evaluate the performance of a journal relative to others in the same field, and is used by authors to evaluate journal quality and make informed decisions on where to publish their work. Figure 9 presents the bar charts of each Journal's type of collaboration percentage. (a) Is for international collaboration percentage, with a mean value of 38% when averaged across all the 28 Journals, (b) is the representation for national collaboration (with an average value of 33%), (c) is for institutional collaboration (with 20%), and (d) for no collaboration with 9% average. The first inference from this is that the 28 journals used for our analyses in this work have more of international collaboration in the scholarly outputs they generate; and the least are those with no-collaboration.

For the international collaboration, APJ-SS leads with 65%, closely followed by AJL (64%), and then by EPS (63%) and ANJ (58%). JGR-Pl, JGR-SP and ANNALES each have 54%. Of this first top seven with the highest percentage of international collaboration, 5 (AJL, ANJ, EPSL, APJ-SS, JGR-SP) among them were part of the first top eight in Publication output (see Figure 4) and 5 also (AJL, EPSL, APJ-SS, ANJ, JGR-SP) among them were part of the first top six citation volume journals (see Figure 6). In the same manner, the Journals with the least percentage in international collaboration from Figure 9a, for example JESP—5%, TRANS—7%, IJRSP—7%, IJASS—9%, and SPolicy—15% were ranked 23rd, 28th, 22nd, 21st, and 25th respectively on the publication volume from Figure 4, revealing bottom positions on the publication ranking with respect to others. This in a way points to the fact that the higher the engagement of a Journal's scholarly output in international collaboration, the more the likelihood of enhancing high publication and citation outputs. Similarly, the lower the turnout of a Journal's scholarly output in "no collaboration," the more likely higher its publication and citation outputs. The national and institutional collaborations of the Journals are as presented on Figures 9b and 9c respectively.

For the "no collaboration" bar chart on Figure 9d, the less the percentage the better for a Journal. For instance, among the first top Journals with the highest percentage of international collaboration, six of them are in the list of Journals with the least percentage in "no collaboration" raging from 2% to 5%. These six Journals include EPSL (2%), JGR-SP (2%), JGR-SE (3%), AJL (4%), APJ-SS (4%), and ANJ (5%). We also observed from Figure 9d that Journals with the highest percentage of "no collaboration" are among the Journals with the least set of publication volume from African authors in Figure 4.

The effect of collaboration type on a Journal's percentile score and the average citation per publication was also observed, using the two extreme cases of "International collaboration" and "no-collaboration" percentage scores of journals. Table 7 highlights this. The Table was divided into four segments showing a(i) the Top 8 Journals with the highest "international collaboration" percentage, based on the 28 Journals considered, a(ii) the Top 5

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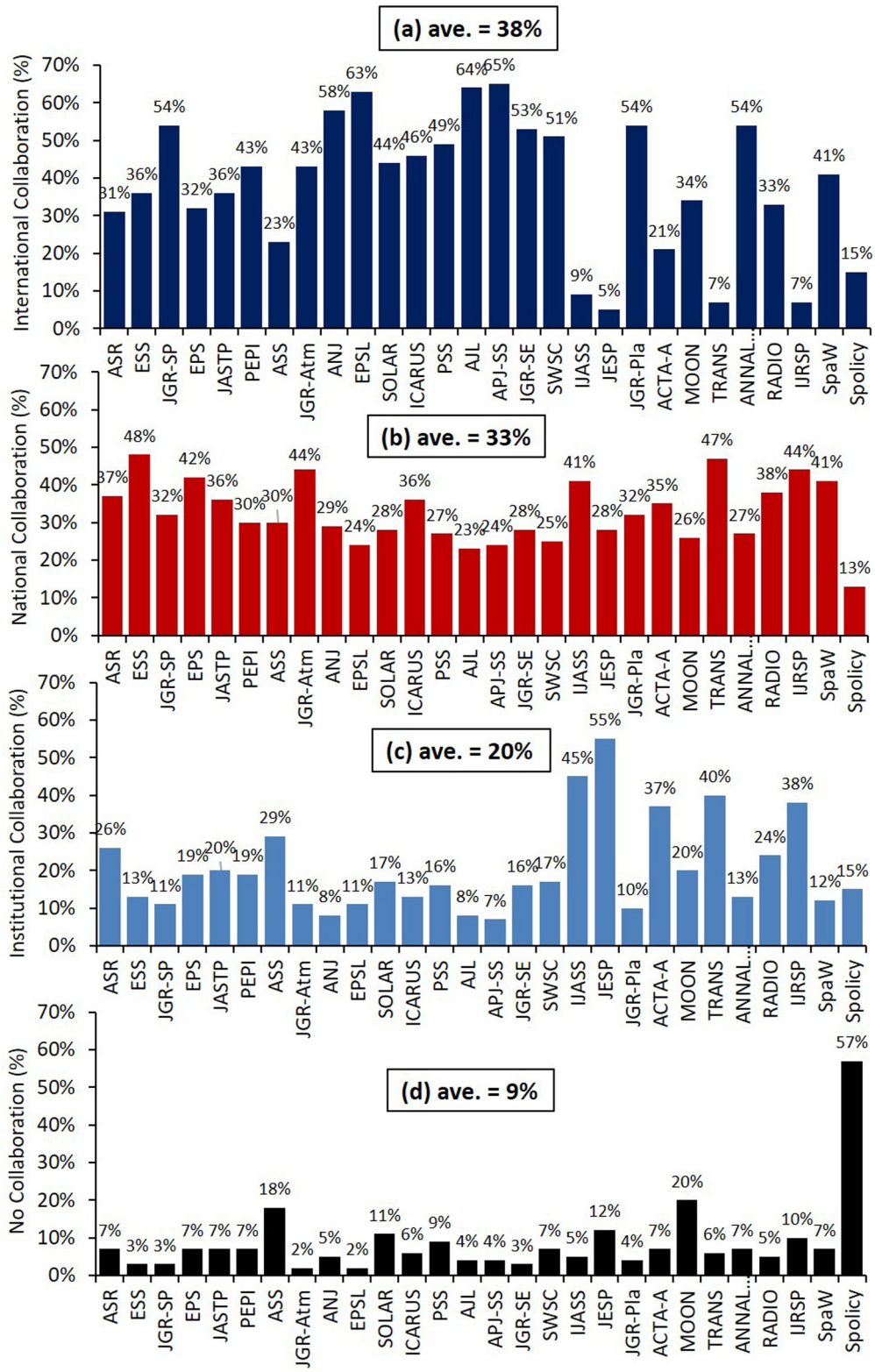

Figure 9. Bar charts of individual Journal's type of collaboration percentage. (a) Is for international collaboration percentage, with a mean value of 38%, (b) is the representation for national collaboration (with an average value of 33%), (c) is for institutional collaboration (with 20%), and (d) for no collaboration with 9% average.

Table 7
Comparison Between High-Ranked and Low Ranked Journals With International Collaboration and No-Collaboration as Related to Percentile Score and Average Citation per Publication

	International collaboration				No collaboration			
S/N	Journal name	Collaboration %	[a]Percentile score (%)	[a]Average journal citation per publication	Journal name	Collaboration %	[a]Percentile score (%)	[a]Average journal citation per publication
	a (i): Top 8 with the Highest International Collaboration Percentage				b (i): Top 8 with the Least No-Collaboration Percentage			
1	APJ-SS	65%	93%	41.4	JGR-Atm	2%	90%	17.6
2	AJL	64%	72%	35.7	EPSL	2%	97%	32.6
3	EPSL	63%	97%	32.6	ESS	3%	80%	12.0
4	ANJ	58%	86%	23.8	JGR-SP	3%	79%	16.6
5	JGR-Pl	54%	92%	21.0	JGR-SE	3%	90%	24.0
6	JGR-SP	54%	79%	16.6	AJL	4%	72%	35.7
7	ANNALES	54%	76%	11.0	APJ-SS	4%	93%	41.4
8	JGR-SE	53%	90%	24.0	ANJ	5%	86%	23.8
MEDIAN		56%	88%	23.9	MEDIAN	3%	88%	23.9
	a (ii): Top 5 with the Least International Collaboration Percentage				b (ii): Top 5 with the Highest No-Collaboration Percentage			
1	JESP	5%	13%	1.1	SPolicy	57%	90%	8.1
2	TRANS	7%	36%	3.9	MOON	20%	31%	6.1
3	IJRSP	7%	9%	2.5	ASS	18%	57%	9.9
4	IJASS	9%	59%	5.7	JESP	12%	13%	1.1
5	ACTA-A	31%	31%	4.2	SOLAR	11%	68%	14.1
MEDIAN		7%	31%	3.9	MEDIAN	18%	57%	8.1

[a]As presented in Table 1.

Journals with the least "international collaboration" percentage, b(i) the Top 8 Journals with the least "no collaboration" percentage, and b(ii) the Top 5 Journals with the highest "no collaboration" percentage. Visibly, category a(i) revealed that the journals with the highest percentage (with a range of 53%–65%) in international collaboration are characterized by high percentile scores (72%–97%) and high citation per publication (11.0–41.4). For b(i), Journals with the least "no-collaboration" percentage (2%–5%) also presents high journal percentile score (72%–97%) and high citation per publication (12.0–41.4). The observation from a(ii) showed that Journals with low percentage (5%–31%) of international collaboration are characterized by low percentile score (9%–59%) and low citation per publication (1.1–5.7). The same is the condition in category b(ii) in which journals with the highest "no-collaboration" percentage (11%–57%) are conditioned with low percentile score (13%–68% outside the 90% that was recorded for SPolicy) and low citation per publication (1.1–14.1). From the average (median) values across the segments, it may be argued that Journals with high "international collaboration" percentage of above 50%, and with low "no collaboration" percentage of less than 5% are most likely to be Q1 (first-percentile Journals—whose percentile ranges from 75% to 100%) having a citation per publication rate of ≥20. Though this may be taken as a tentative statement because of limited data size.

Q1 journals refer to the top 25% of journals in a specific field based on impact factor or other ranking metrics. International collaboration often enhances a journal's visibility, reputation, and citation rates, which in turn influence its quartile ranking. Research indicates that international collaboration tends to increase a journal's citation metrics, making it more likely to fall within the Q1 percentile. For example, a study by Gurses and Ilhan (2020) found that internationally co-authored articles tend to receive higher citations, which can elevate the journal's quartile position.

To further affirm the assertion that journals with high international collaboration (%) yield higher citations, an Analysis of Variance treatment was performed and presented in a tabular form (Table 8) to determine the

Table 8
Regression Analysis of International Collaboration in Research Versus Citation Impact

Analysis of variance				
Source	DF	Adj. SS (sum of squares)	*F*-value	*p*-value
Regression	1	148.04	25.50	0.002
Citation	1	148.04	25.50	0.002
Model summary				
S	Regression	Regression (adjusted)	Correlation	Correlation (adjusted)
2.4094	80.95%	77.78%	89.97%	88.19%
Coefficients				
Term	Coefficient	SE (standard error) coeff.	*p*-value	
Constant	46.46	2.46	0.000	
Citation	0.4530	0.0897	0.002	

Note. DF is the degree of freedom.

regression and the significance level of the *p*-value between international collaboration in research and citation impact. From the Table, the *p*-value was set at a threshold value of 0.05 (or at 5%), but here, the *p*-value for the international collaboration/citation relationship was 0.002, which is less than the threshold 0.05. Hence, the assertion that journals with high international collaboration (%) yield higher citations is statistically accepted, coupled with the correlation score of 89.97% and correlation score after error removal in the data (Correlation adjusted) of 88.19%. An example is the Astrophysical Journal Letters (64% international collaboration, 35.7 avg. citations) and Acta Astronautica (31%, 4.2 avg. citations).

However, the international collaboration on its own had its challenges with respect to time and cost, as collaborators may need to make trip to some precise research facilities for specific or dedicated equipment, and through that, may encounter issues with understanding and integrating with collaborators (Wang et al., 2024 and the reference therein). Franceschet and Costantini (2010) posited that limited funding, nationalistic biases, and differences in academic standards are the other conditions that can further engender international collaborations. Consequently, one of the major benefits that compensate for all the challenges inherent to international collaborations is an increase in citations. In addition, two major school of thought were recognized as fundamental factors assisting the impact of international collaboration (or co-authored) publications (Franceschet & Costantini, 2010). These include (a) a qualitative factor—the fundamental worth of an article with respect to significance, originality, clarity, and completeness. It captures the scientific credit by which the article merits commendation; and (b) an advertising factor—steady with the view of collaboration as a social connection (access to greater social connect the co-publication can allow).

3.7. Effect of Population and Gross Domestic Product on Publication Output Among African Countries

To further investigate the possibility of other probable factors that could be responsible for the pattern observed in the publication output from African countries based on the 28 selected journals (see Figure 2), the statistics of countries' Population count and their Gross Domestic Product (GDP) were also compared with their publication outputs. Both the population and GDP data are readily available at the World Bank Open Data website www.data.worldbank.org. While the data for the population can be accessed directly through https://data.worldbank.org/indicator/SP.POP.TOTL, that of the GDP was extracted from https://data.worldbank.org/indicator/NY.GDP.MKTP.CD, and both accessed on 9 October 2025. While Population is the total number of people in a specific location (e.g., country), the GDP is a key indicator of a country's economic performance, representing the total value of all goods and services produced within its borders over a specific period and it encompasses consumption, investment, government spending and net exports. While GDP reflects economic capacity; population reflects human capital aspects.

Presented in Figure 10a are the Bar chart of the average Gross Domestic Product (GDP) across the entire African countries; and Figure 10b the population count of African countries. While the GDP value for a country was

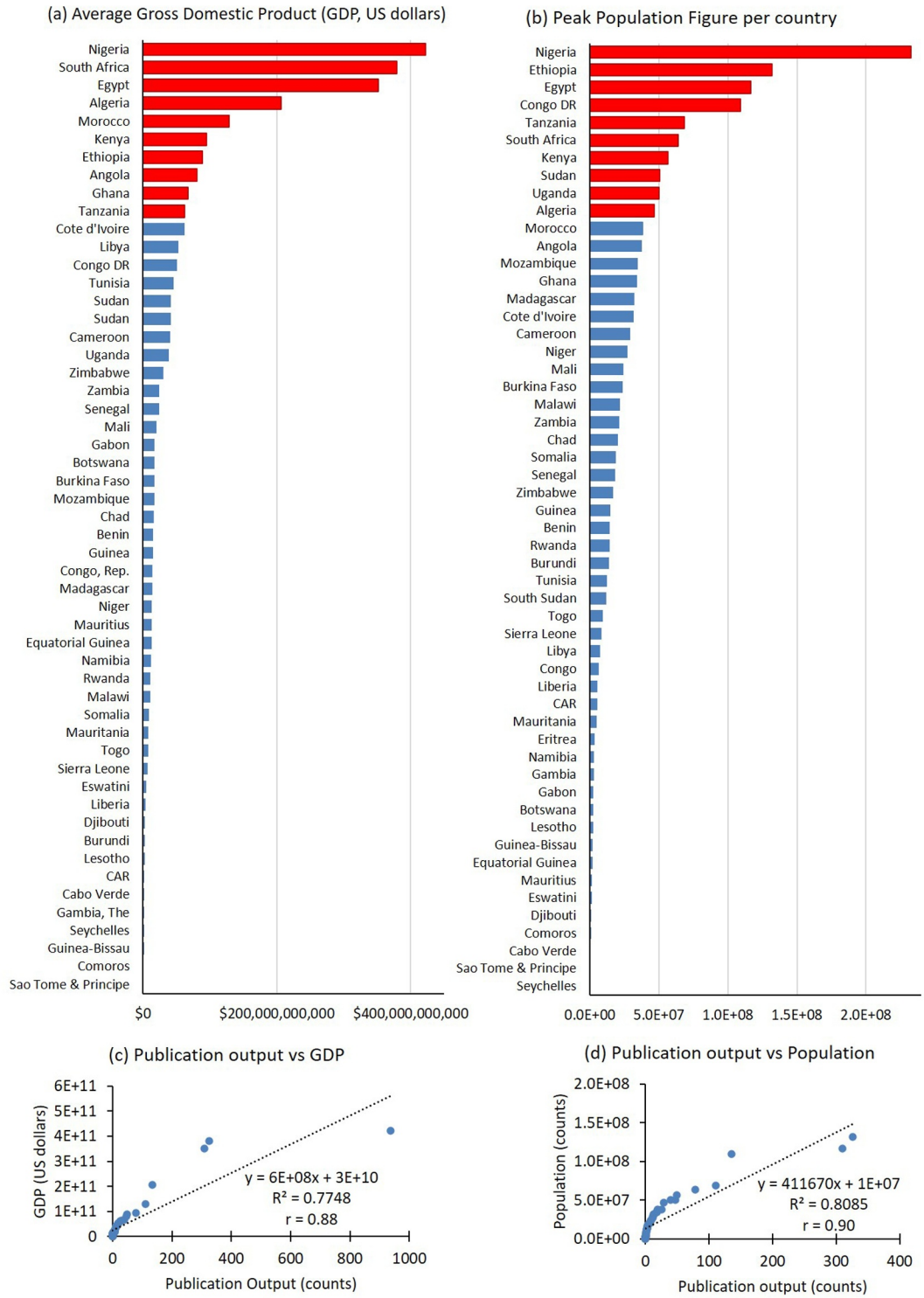

Figure 10. (a) Bar charts of the average Gross Domestic Product (GDP) across the entire African countries; (b) population count between 2014 and 2023 (c) Correlation plot of GDP versus Publication output; and (d) Correlation plot of Peak population versus Publication output.

obtained from the average value of entries between 2014 and 2023 (the study period), population was obtained from the largest (mode) count for each country between the same year range of observations. In essence, the highest population value per country between 2014 and 2023 was picked for each country on the plot. The red

highlighted bars on each figure presents the first 10 countries with the highest observations in each case. Interestingly, it was observed that the first 7 African countries with the highest GDP in Africa between 2014 and 2023 (Nigeria, South-Africa, Egypt, Algeria, Morrocco, Kenya and Ethiopia) were among the first 9 countries with the highest publication outputs (comparison of Figures 2 and 10a). In the same way, another seven of the African countries that are most populated (Nigeria, Ethiopia, Egypt, South-Africa, Kenya, Uganda, and Algeria) were also among the first 9 countries with the highest publication output (comparison of Figures 2 and 10b). This suggests that both the Population count and GDP of a country had effects on their research activities, and by extension the publication output.

Figures 10c and 10d highlights the correlation plots of GDP versus Publication output and population versus Publication output respectively. While the GDP versus Publication output presented an 88% correlation percentage, the population versus Publication output pair showed 90% relationship. A strong 88% correlation from Figure 10c, presents a statistical inference of association—as GDP increases, publication output tends to increase. This could be interpreted on the assumption that (a) countries with higher GDP might invest more in research, thus boosting publications, (b) economic development and research link might reflect development enabling scientific output, and (c) other factors like education, policy and technology access may also influence the relationship. Similarly, the 90% correlation percentage with population revealed that population and publication output tend to increase together. This is because larger populations might have more researchers and institutions contributing to publications.

3.8. Rising up to the Publication Output by African Scholars

The general low publication output stemming from African scholars relative to the world output was explained by Tijssen (2007) that majority of African science journals are left out from the major international publication databases or often processed selectively. African scholars should therefore, begin to promote their international visibility and prominence. This is because most of Africa's journals are naturally limited to local/regional purposes characterized by fairly low circulations, except for few among them. However, in spite of the presence of mostly locally published journals in the African continent, they still have vast advantages of publishing in them, as they serve as pivotal platforms of circulating indigenous research and outputs marked as "concealed discoveries." Unfortunately, many of such journals concentrating on regional issues in the African continent are not readily available on automated databases, and for this reason, are often unnoticed in the African science evaluation.

4. Summary and Conclusion

This work had espoused the publication contribution of African researchers to the global research environment in the area of Space science as related to the United Nations key areas of Solar-terrestrial interaction and its influence on terrestrial climate, Fundamental space physics, Astronomy and astrophysics, Planetary and atmospheric studies, and the Origin of life and exo-biology. The work reported the African Publication trends, Citation Analysis and Collaborative Patterns using data obtained from the Scopus database spanning 2014–2023.

The following results were reported:

(a) African continent contributes only 3.2% of the world publication output and 5.0% of the world citation volume in Basic Space Science.
(b) South-Africa leads in the African research publication output with 40.9%, followed by Nigeria and Egypt with 14.3% and 13.6% volumes respectively; accounting for approximately 70% of the total volume from Africa.
(c) South-Africa accounted for about 64% of the total citation volume from Africa, and only 7 countries present citation metrics above 1% of the total volume during the study period. These include South-Africa (64%), Morocco (6.8%), Egypt (5.5%), Namibia (4.8%), Nigeria (4.4%), Algeria (3.5%), and Ethiopia (2.4%).
(d) In terms of views counts, South Africa (46%), Morocco (10%), Egypt (9%), Namibia (7%) and Nigeria (7%) are the only five countries with publication View counts of above 4,000.
(e) Ethiopia and South Africa are the only two countries with Field-Weighted-Citation-Impact of above world average (of 1.00) with 1.47 and 1.25 respectively.
(f) The Northern African countries showed higher dominance of the 10 top countries in publication, citation, counts views and Citation Impact, and followed closely by East Africa countries. However, the Southern

Africa region (majorly represented by South-Africa and supported by Namibia) leads in volume of all the metrics considered;

(g) The Northern African countries present the highest number of *THE* World universities in the top 10 African countries by Publication output, occupying the first (Egypt), third (Algeria), fourth (Morocco) and fifth (Tunisia) of 10 positions, while conceding the second position to South-Africa. Nigeria came sixth.

(h) Higher engagement of a Journal scholarly output in international collaboration and lesser in "no collaboration" enhances high publication and citation outputs.

(i) The work suggested that Journals with high "international collaboration" percentage of above 50%, and with low "no collaboration" percentage of less than 5% are most likely to be Q1 (first-percentile Journals)—whose percentile ranges from 75% to 100% having a citation per publication rate of ≥20. Though this may be taken as a tentative statement because of limited data size.

(j) Both the GDP—reflecting a country's economic capacity, and population—reflecting a country's human capital aspects projected strong relationship with the publication output yielding correlation of 0.88 and 0.90 respectively for the GDP/Publication output and Population/Publication output pairs.

By way of recommendation, African educational policy makers across countries should begin to increase efforts geared toward developing more robust curriculum that addresses the current challenges in STEM education, especially relating to the field of space technology. With this in place, there will be a spark and curiosity on the part of students, thereby increasing the involvement in space science studies, research and research dissemination. Finally, for the African space science environment to thrive, research collaborations must be strengthened and partnership with international space programmes must be encouraged. For example, South Africa's dominance (of 40.9% publication output) aligns with its space agency (South African National Space Agency—SANSA) initiative and their partnership with NASA/ESA. SANSA's initiative, for instance, includes provision of Earth observation data to support environmental management and disaster management, as well as space weather monitoring, and conducting outreach programs toward enhancing the teaching of STEM. Same for Nigeria with the National Space Research Development Agency (NASRDA), and the Egyptian Space Agency for Egypt and partnering with the Italian Space Agency, as well as hosting the African Space Agency (AfSA) headquarters. However, the Central (Middle) Africa's absence in the first 25 countries with the highest publication output (besides Camerron on number 10 and Congo DR on number 25) reflects some levels of infrastructural gaps. There should therefore be a form of funding mandates for the North-South research consortia (e.g., EU Horizon Africa grants); as well as Incentives for Q1 journals to waive APCs for African authors (like this current work in which the APC charge was entirely waived).

Conflict of Interest

The authors declare no conflicts of interest relevant to this study.

Data Availability Statement

The Scopus database used for the analysis is available and accessible online at https://www.scopus.com. The method of extracting the data for each publishing journal is as indicated in Figure 1 of this manuscript, and the raw data as downloaded are stored and accessible through the repository address https://eprints.lmu.edu.ng/id/eprint/5657. Additionally, both the population and GDP data used are available at the World Bank Open Data website www.data.worldbank.org. While the data for the population can be accessed directly through https://data.worldbank.org/indicator/SP.POP.TOTL, the GDP data was extracted from https://data.worldbank.org/indicator/NY.GDP.MKTP.CD.

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