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## Bibliometric Analysis of Climate Change Publications in Tanzania from 1964 to 2021

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### Abstract

*Climate change has affected lives of all human beings around the globe making it a growing area of research concern among scientists worldwide. Researchers have used bibliometrics to analyse research productivity and the impact of climate change research output. This study aimed at analysing the trends of research output on climate change in Tanzania from 1964 to 2021. Specifically, the study investigates the growth of publications and citation impact on climate change in Tanzania during the period under study. Data were searched, retrieved and analysed from Dimensions.ai. The results show that the trend of publications on climate change in Tanzania is growing with peak production in 2020 and 2021. Researchers in developed nations like USA, UK, and Germany have significantly contributed to the production of publications on the subject and so are their citations. Renowned public universities and research institutions in Tanzania have contributed more publications on the subject. Research outputs published in Open Access are increasingly contributing to climate change scholarly research output. Researchers from developed countries are highly cited compared to local researchers. Comparing the productivity of research institutions in Tanzania, the University of Dar es Salaam, Sokoine University of Agriculture, and the Nelson Mandela Institute of Science and Technology have a large share of publications and citations on climate change. Publications from high Impact Factor open-access journals are highly cited. This study recommends further studies on climate change using bibliometrics including assessing the impact of climate change publications on policy influence in the country.*

**Keywords:** climate change, publications, citations analysis, bibliometrics, Tanzania

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### Introduction

Climate change is referred to as changes that occur in a statistical distribution of weather patterns during an extended period of time (Haunschild, Bornmann, & Marx, 2016). Climate change has brought effects that are unevenly distributed among people of different social and economic levels and gender (Swai, Mbwambo, & Magayane, 2012). Africa is not isolated from the rest of the regions of the globe when it comes to variation in climatic conditions because climate change is not confined within territorial boundaries. In most African countries where farming is largely dependent on rainfall, the effects of climate change are vividly observed in rural livelihood, especially in semi-arid areas which are most vulnerable to changing weather conditions (Kangalawe & Lyimo, 2013). It has been noted that populations in Sub-Saharan Africa are vulnerable to climatic changes due to their high dependence on rain in farming and other livelihoods (Juana, Kahaka, & Okurut, 2013). In recent years, Tanzania has been experiencing weather extremes including an increase in temperature and rainfall pattern changes leading to increased drought, land degradation and floods (Swai et al., 2012). The effects of climate change are especially felt in semi-arid areas

in Tanzania, for example, the study by Swai et al., (2012) observed that semi-arid areas in Tanzania are witnessing a decrease in precipitation like it is for other parts of Africa, the situation that has a very negative effect in agricultural production.

Climate change has affected different sectors including agriculture, economy, business, health sector, Forestry, mineral, and energy (Shemsanga, Omambia, & Gu, 2010). This problem has attracted scholars to study the phenomena. In recent years, the negative impacts of climate change have attracted the attention of researchers in the fields related to environment and sustainable development to investigate the phenomenon (Wang, Pan, Ke, Wang, & Wei, 2014).

Tanzania is not isolated from the rest of the countries in the world when it comes to issues related to climate change. Climate change has negatively affected all walks of life making a topical issue and major area of research that needs much attention. This is the reason why the researcher took interest in studying the trend of climate change research output and their impact in terms of citation in Tanzania. Climate change research output has increased over the last several years (Santos & Bakhshoodeh, 2021). Studies on climate change have increasingly gained attention in natural science and so in social sciences as it was noted by Haunschild et al., (2016) that researchers from subfields of physics, chemistry, meteorology, and geosciences are interlinked in the study of the environment. Nalau & Verrall (2021) observed that research on climate change adaptation has increased in number and significance since the 1970s. The same was noted by Nabout et al., (2012) that the number of articles on climate change has increased over the years. Likewise, Harper et al., (2021) investigated the trends and gaps in climate change health-related research in North America to map the publication trends based on the Intergovernmental Panel on Climate Change (IPCC) 5th Assessment Report (2014) and found a significant increase of articles on climate change research.

This study investigated climate change research output (in terms of published articles) to ascertain the growth and citation impact in Tanzania. Limited studies on this topic in African continent has been noted and this can be explained by various factors such that noted by (Hendrix, 2017) who observed that most research on climate change are being biased due to factors such as cultural affinity and personal networks or languages, data availability and perceived permissibility and safety of conducting research in a particular country. This means there have been biases in studying climate change research leaving other areas under researched. It has been observed that “countries with greater exposure to the negative effects of climate change and countries with less adaptive capacity (including Africa) do not receive more scholarly attention” (Hendrix, 2017).

There are limited studies on this topic in Africa and Tanzania in particular. A study conducted by Lukwale and Sife (2017) assessed climate change research trends in Tanzania between 2006 to 2016 has also indicated an increase in research output produced from Tanzania. However, the level of increase of publication and citations on climate change research since Tanzania became a united republic in 1964 up to the period of this study (2021) is unknown hence the motive for conducting this study. Specifically, this study intended to analyse the trends of growth of publication output from Tanzania. This study aimed at analysing the trends of publications on climate change in Tanzania from 1964 to 2021. Specifically, the study intended to two objectives:

- i. The growth of publications (in terms of journal articles) on climate change in Tanzania during the period under study from 1964 to 2021
- ii. Citation impact of research output on climate change in Tanzania during the period of this study.

## **Research questions**

- i. What is the growth of climate change publications from Tanzania from 1964 to 2021.
- ii. What is the citation impact of climate change research output from Tanzania?

## **Literature review**

This section is arranged based on the objectives of the study. This study aimed at analysing the trends of publications on climate change in Tanzania from 1964 to 2021. Specifically, the study intended to investigate the growth of publications (in terms of journal articles) on climate change in Tanzania during the period under study from 1964 to 2021 and was to analyse the citation impact of research output on climate change in Tanzania during the period of this study.

## ***Introduction***

Research output emanating from climate change research helps in predicting future environmental effects that could lead to devising mechanisms for mitigating the challenges related to climate variations. Scholars have used bibliometrics studies to study the publication patterns of research output to ascertain the trends and coverage of specific subject field such as climate change. Bibliometrics studies provide useful indicators of the researcher's productivity, preferences, trends, and emphasis on research in various disciplines which are very useful in decision-making in the research management and planning (Jacobs & Pichappan, 2001). The results from bibliometrics studies are highly needed in decision-making in higher learning organizations, research organizations, government agencies and funding agencies. According to ESF, (2012). For example, funding agencies and organizations need bibliometrics reports to track the performance of research projects in a view to ensure their funds go to the right scientists who can demonstrate quality and reliable production research output to achieve value for money. For that case, bibliometrics studies are conducted to evaluate research productivity to inform on the progress of research and knowledge production in a specific field of research whereby the impacts of research organizations, research groups and individual researchers are evaluated.

## ***The growth of publications on climate change***

The growth of research output on climate change has been recorded by several studies; "Research on climate change adaptation has increased in number and significance since the 1970s" (Nalau & Verrall, 2021) and so is the publications emanating from these research projects. In this study, publications refer to journal articles published, disseminated in digital format and they are discoverable by search engines and other indexing databases online. The increased number of publications is based on the fact that climate change is a global phenomenon and its mitigation needs a joint effort by researchers worldwide. In the study conducted by Nabout et al., (2012) using scientometric analysis using Thomson ISI database, they found an increased number of articles on the globe climate change research. Likewise, a recent study by Harper et al., (2021) investigated the trends and gaps in climate change health-related research in North America to map the publication trends based on the Intergovernmental Panel on Climate Change (IPCC) 5<sup>th</sup> Assessment Report (2014). Their results show that the number of climate change articles related to health has significantly increased over the years. Savage and Olejniczak, (2022) conducted a study to compare journal articles and books published in 2010 that were produced by 290 academic

institutions, it was observed that the production of journal articles had increased up to 64% between 2011 and 2019, this increase signifies a very high rate of the growth rate of research output.

Li, et al., (2020) investigated the trends of climate change and infectious diseases worldwide for two decades between 1999 to 2008, and 2009 to 2018, and found a rapid growth of the relevant publications on climate change. The same was observed by (Xue et al., 2021) who conducted a bibliometrics analysis of the trends of publications in the principal journal of Process Safety and Environmental Protection (PSEP) from 1990 to 2020, their result shows that the number of publications keeps growing over time. The growth of publications on climate change might have been attributed by the fact that many multinational campaigns were launched during the 1990s to mitigate climate changes around the globe. According to the research by Haunschild et al., (2016), in the period between 1991 to 2010, the number of papers published annually increased by a factor of ten and they suspected this rate of increase could have been influenced by the Intergovernmental Panel on Climate Change (IPCC) report in 1988. The report might have triggered the intergovernmental research initiatives that led to productivity on climate change publications. Einecker and Kirby, (2020) who conducted a bibliometrics study on climate change adaptation, mitigation, and resilience found that publications on climate change had increased steadily across the three decades from 1991 to 2019.

In Tanzania, locally published publications on climate change are collected, archived, preserved and disseminated in collaborative repositories which are hosted by collaborating institutions including the UDSM, Sokoine University, Ardhi University, and Tanzania Meteorological Authority (TMA) and other collaborating institutions from Norway under the coordination of the University of Life Sciences (UMB). It is in view of the background above, a bibliometrics study was conducted to analyse the patterns of climate change publication citations in Tanzania (Matovelo & Ellingsen, 2012). The study sought to establish the trends of publication on climate change from Tanzania from 1964 to 2021. This is to say that research on climate change is on progress, as noted by Weissbecker, (2011), researchers will continue to investigate different measures to adapt as well as mitigate the situation.

### ***Generated types publications on climate change***

The types of publications are categorized based on access whether they are Open Access (OA) or Closed Access (CA). Looking at the nature of production of these two categories, literature have indicated that OA publications have increased at a high pace since the 2000s when the OA movement was launched. The open access movement was officially launched in 2002 during the Budapest OA Initiative (BOAI) declaration this is where the first point of inflexion of the curve of OA publications started manifesting (Miguel, de Oliveira, & Grácio, 2016). In the study conducted to establish the trends of OA publishing in India by Nazim, Bhardwaj, Agrawal, and Bano, (2022) found that the number of OA journals has significantly increased from just a few OA journals in 2003 to 317 in 2021 that has constituted 40% of all Indian journals indexed in Scopus database. According to the report by the chair of the Universities of the UK Open Access coordination group, the Vice-Chancellor of the University of Sussex issued in 2018, it reports 31% of the publications were published in Gold Open Access (Tickell, 2018) let alone other aspects of OA such as Hybrid, Bronze, Green, and others. Also, Piwowar, Priem, and Orr, (2019) analysed the performance of Gold, Bronze, and Green publications, they found a rapid and proportional growth of up to 31% of all journals and they predicted a growth of up to 44% of all the journal article will be OA by

2025. The OA policy mandates that are reinforced by funders who require dissemination of research output into media that provide free access to the publications might be among the reasons for the rise of the OA publications (Wallach, Boyack, & Ioannidis, 2018).

## **Methodology**

This study used analysed publications (journal articles) on climate change using bibliometrics approach to ascertain the trends of publications and citations. Bibliometrics is an approach that uses mathematical and statistical techniques to quantify, classify and evaluate the publication pattern of titles, authorship, and citation (Tella & Aisha Olabooye, 2014). The bibliometrics analysis investigates publication count in terms of citation, usage of publications, institutional affiliation, author, co-authorship, and associated keywords (Ziegler, 2009). Bibliometric involves searching, retrieving and analysing content from various online databases depending on the choice of the researchers.

### ***Search Procedures***

Data were searched and retrieved from the Dimensions database which is known for its rich information as it is open and comprehensive data infrastructure that provides an opportunity for users to discover connections of data from a wide range of disciplines. Dimensions merge openly available data obtained from proprietary databases and enhance them using persistent identifiers and technological approaches (Hook, et al., 2021). Data analysis was conducted to provide the quantification of publications, types and citations. The search procedure included formulating the search terms, which was followed by the search process. Consideration of including related key terms to climate change was the key priority in the search process. During the search process, the term Tanzania was used to identify the geographical boundaries of the output of the search results. The search syntax was reviewed and refined using Boolean logic, phrases, parentheses, and wildcards.

The term “climate change” was the main theme for this study which was combined with related terms and Tanzania to obtain the desired results. “Tanzania” as a country name was officially recognized and used after Tanganyika and Zanzibar became united in 1964. Historically, Tanganyika became a member of the UN on 14<sup>th</sup> December 1961 and Zanzibar followed two years after in 1963. These two countries decided to unite and became the United Republic of Tanzania on 26<sup>th</sup> April 1964 and the term Tanzania became officially recognised by the united nations (United Nations, 2022).

The analysis focused on publications on climate change that were produced by researchers in Tanzania alone or in collaboration with foreign researchers abroad from 1964 (when Tanzania (the name) was recognized to 2021. This study started in march 2022 but data for this year were excluded to avoid taking partial data.

The search terms/keywords were identified and they were tested on several variations. Boolean operators “AND” and “OR” were used for two or more terms. In addition, double quotations were also used as well as wildcards. These search tools were used to combine the climate change as a central term with other terms keywords to attain the desired and accurate results. The search process started by formulating search terms that Hook et al., (2021) call it search strings, the dominant key terms were climate change and Tanzania which were tied up together using the Boolean operator “AND” to make a single string that is “climate change” AND Tanzania. Since the term “climate change” was coined by researchers, a lot of related disciplines have associated their research topics with climate research although they have

primarily been dealing with different topics (Haunschild et al., 2016). In order to accommodate the possible variations of the word “climate” and “change” a wildcard search was first used to test the outcome, this is *climate\* chang\* AND Tanzania* which aimed to include the words such as *climate/climatic, change/changes/changing*. However, the wildcard search did not bring the intended results as it was realized that Dimensions ignores wildcards search.

Furthermore, the first term was expanded to avoid the possibility of eliminating Zanzibar as it was realized that some of the publications appear to have Zanzibar without the term Tanzania. Therefore, Boolean operators “AND” and “OR” and parentheses were used to combine climate change, Tanzania and Zanzibar that is *“climate change” AND (Tanzania OR Zanzibar)*. The researcher looked for words or phrases that have similar meanings to “climate change”, terms such as “seasonal variability”, “environmental change” and “environmental variability” appeared to be commonly used. These terms were combined using the same search tools and the following search term was used: *(“climate change” OR “seasonal variability” OR “environmental change” OR “environmental variability” OR “global warming”) AND (Tanzania OR Zanzibar)* and this string was considered to accommodate relevant results.

The selected keywords on climate change and related terms were searched in the Dimensions <https://www.dimensions.ai/> database which was obtained through the research for life portal <https://www.research4life.org/>. Dimensions database houses metadata from millions of publications in different disciplines both closed and open access. The database is said to be more exhaustive in journal coverage compared to other aggregators such as Web of Science and Scopus (Singh, et al., 2021). Therefore, the researcher believed this database would provide adequate information as a basis for analysis. The search was conducted for one day only to avoid changes that would occur in the system as the number of publications keeps changing from day to day. The search process was conducted on 30<sup>th</sup> April 2022. The extracted data in .csv file format were saved on the computer as a basis for this analysis.

### ***Data analysis***

The search results from Dimensions were analysed by the system to attain the types of publications, the number of publications, and citations per country, organization, and researchers. Data were cleaned, filtered, and sorted using Ms-excel. The output of the data was presented in tables and figures. The analysis of publications and citations was filtered and limited from 1964 to 2021. Inclusion and exclusion were conducted to determine the type of publications to achieve the objectives of this study. The search criteria filtered articles, monographs, pre-prints, and proceeding in order to discriminate against non-research-based publications. A total of 79,495 publications were retrieved from the Dimension database based on the keywords and filters used during the search process

### **Results**

The findings of this study are based on the objectives of this study are presented. This study sought to investigate the growth of publications (in terms of journal articles) on climate change in Tanzania during the period under study and the citation impact of research output on climate change in Tanzania during the period of this study.

### ***Type of publications***

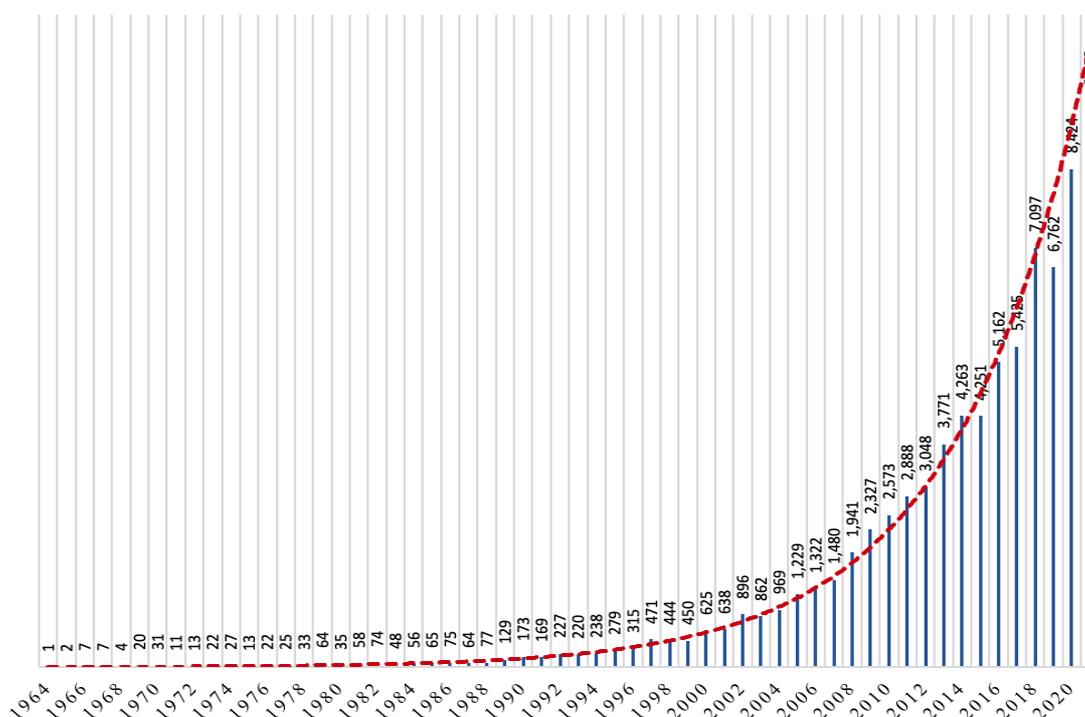
As highlighted earlier the types of preferred publications for this study were articles, monographs, pre-prints. Of a total of 79,495 publications, 67,334 (84%) were articles, 8,258 (10.4%) monographs, 3261 (4.1%) pre-prints, and 642 (0.8%) proceeding. Data show that, journal articles constituted a major portion of all publications during the period under study followed by other materials by far.

### ***Publications published in closed and Open Access model***

Data from dimensions show that 44,975(67%) publications were published in closed access journals while 34,642(43%) of publications were published in OA avenues of which 15,974(46%) were Gold Open Access, 4,783(14%) were published in Hybrid journals, and 4,682(14%) were published in Bronze journals while 9,203(26.5%) publications were categorized as Green Open Access. These data show how open-access publications are increasingly getting popularity in scholarly communication.

### ***Publication trends from 1964-2021***

The pace of increase in research and publications in Tanzania is evident in Figure 1 which shows a gradual growth of the curve from 1964 up to the 1990s when the curve began to rise rapidly. The strong rise in the number of publications on climate change in Tanzania in the 1990s suggests the presence and establishment of research activities during the time geared towards addressing the climate change problem in the country.

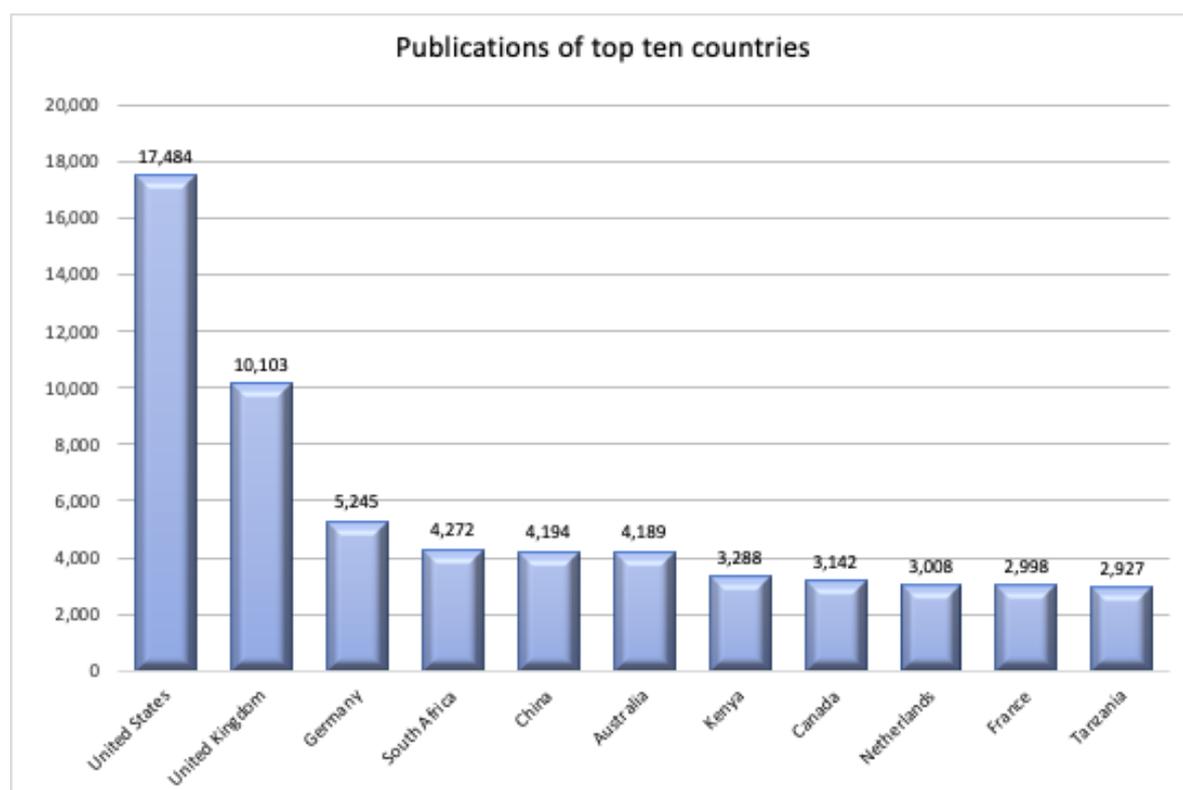


**Figure 1:** Growth of climate change publications in Tanzania from 1964-to 2021

As it can be observed in the Figure-1, research on climate change gradually increased the number of publications from one digit between 1964 and 1968 to two digits from 1969 to 1988 making a total of 833 with an average of 42 publications per year, it also increased to three digits from 1989 to 2004 making a total of 7,105 publications with an average of 444 publications per year. From the year 2005 until 2021 the trend of publications jumped to four digits making a total of 71,536 publications with an average of 4,208 publications per year. Generally, in the past 17 years, there has been a significant increase in climate change publications on Tanzania, this is especially evident in 2018 with an exception of 2019 when the number of publications dropped from 7,097 to 6,762 then it rose to 8,424 and 9,573 in the subsequent years.

### ***Publication productivity***

The number of publications is the determinant of the research productivity of academic and research organizations and countries. One of the objectives of this study was to find out the number of publications from individual researcher level, organization, and country. Countries were ranked based on the number of publications they had produced during the period. Figure 2 shows the top countries from around the globe.



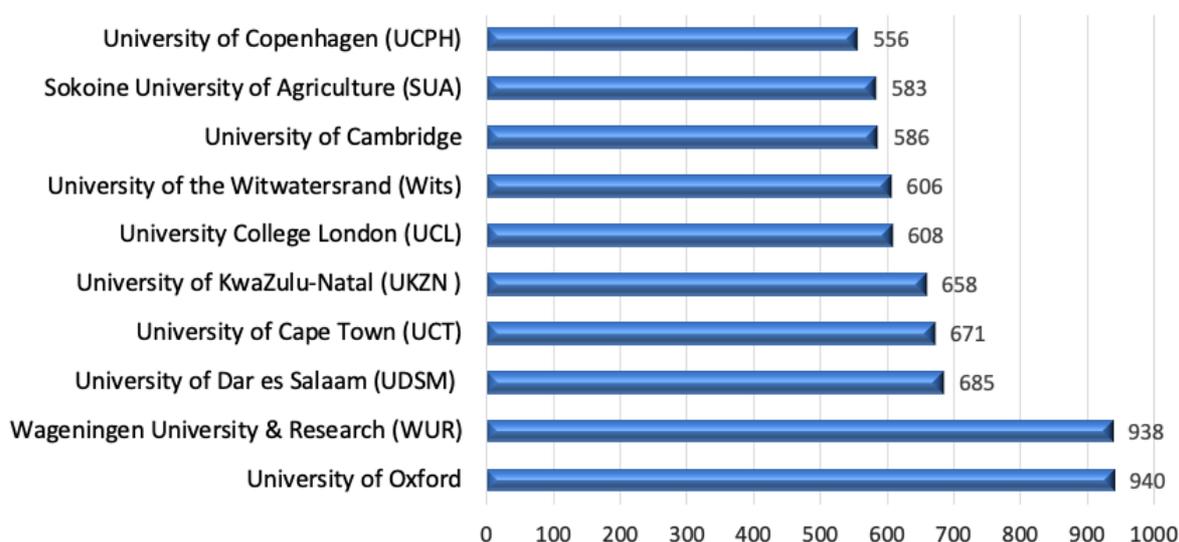
**Figure 2.** Top ten country share

Results in Figure 2 indicate that the USA has contributed 17,484(22.%) publications of the global share followed by the United Kingdom with 10,103(12.7%) publications, while Germany has contributed 5,245(6.6%), publications, China has 4,194(5.3%) South Africa has 4,272(5.4%) publications while Australia produced 4,189(5.3%) followed by Kenya that has produced 3,288(4.1%) publications. In addition, Canada has 3,142(4.0%), the Netherlands

has 3,008(3.8%), France had produced 2,998 (3.8%), and Tanzania where the research is being conducted had produced 2,927(3.7%) publications.

### *Leading organizations in terms of publications*

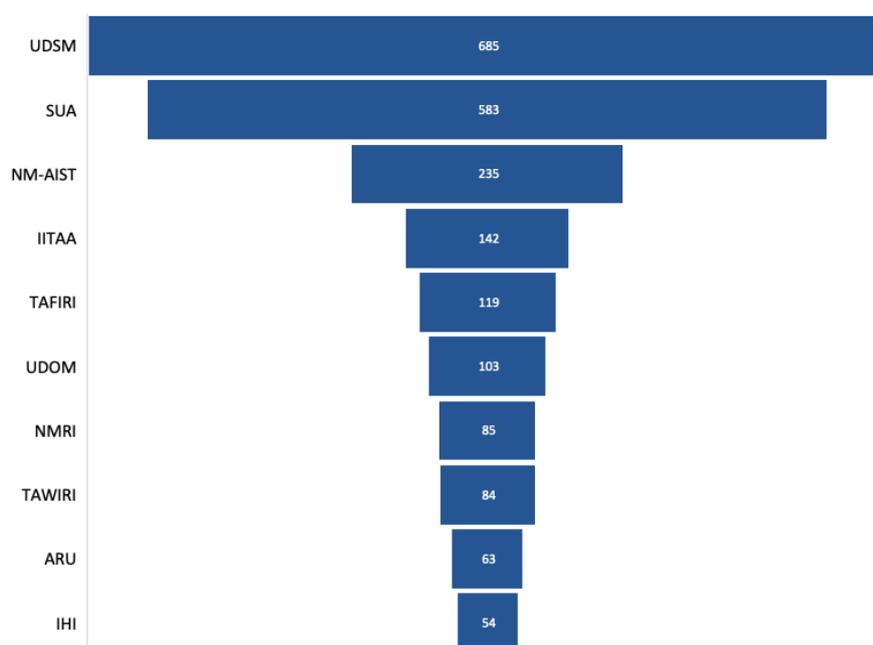
Results show the University of Oxford is at the top of the list with 940 publications followed by Wageningen University & Research (WUR) which had produced 938 publications, while the UDSM holds the third position with 685 publications see Figure 3. Of the top ten countries with the largest number of publications, five African Universities, two are from Tanzania that is University of Dar es Salaam (UDSM) and Sokoine University of Agriculture (SUA) while three are from South Africa University of Cape Town (UCT), the University of KwaZulu-Natal (UKZN), and the University of the Witwatersrand (Wits).



**Figure 3:** Number of publications by top organizations globally

### *Publications by organizations in Tanzania*

The performance of organizations in Tanzania was examined based on the number of publications they produced during the period under study. Figure 4 shows the three public universities on the top ten organizations, these are UDSM, SUA, and Nelson Mandela African Institute of Science and Technology (NM-AIST). Other public Universities listed in Figure 4 are the University of Dodoma (UDOM) and Ardhi University making five organizations. There are also five research organizations that include the International Institute of Tropical Agriculture (IITA), the National Institute of Medical Research (NMRI), the Tanzania Fisheries Research Institute (FAFIRI), the Tanzania Wildlife Research Institute (TAWIRI), and the Ifakara Health Institute (IHI) see Figure 4.



**Figure 4:** Publications share of top ten organizations in Tanzania

***Citation counts of countries, organizations and researchers***

The performance of countries, organizations, and individual researchers both globally and in Tanzania was analysed to rank the extent to which the publications of the groups were cited. It was observed that publications from USA and EU organizations were highly cited than organizations from other regions. African organizations are lagging behind in this regard, with the exception of some academic and research organizations from South Africa.

At a global level, the most cited organizations are the University of Oxford in the United Kingdom which has produced 940 publications that have been cited 54,607 times, the second on the top list is Wageningen University and Research from the Netherlands with 938 publications that have been cited 50,949 times while the University of Washington from the United States had produced 337 publications that have been cited 34,599 times, the University College London from the United Kingdom have 608 publications with a citation count of 33,477 while the Harvard University from the United States has 483 publications that have been cited 32,767 times. Table 1 shows the top twenty-five organizations that have been cited many times. Data in Table 1 shows that the US and UK have seven organizations each, while Netherlands Canada and Australia have two each, and Denmark and Sweden have one organization each.

The list indicates that only three organizations are from Africa of which two are from South Africa; the University of Cape Town (UCT) which holds the sixth position with 671 publications that has been cited 31,802 times, and the University of the Witwatersrand (Wits) that holds 17<sup>th</sup> position with 606 publications which have been cited 23,327 times, and UDSM from Tanzania that holds 22<sup>nd</sup> position with 685 publications which have been cited 21,030 times.

**Table-1: Top 25 Organization by Citation globally**

Academic/Research Institution	Country	Publications	Citation	Citation mean
1. University of Oxford	United Kingdom	940	54,607	58.09
2. Wageningen University & Research (WUR),	Netherlands	938	50,949	54.32
3. University of Washington (UW)	United States	337	34,599	102.67
4. University College London (UCL)	United Kingdom	608	33,477	55.06
5. Harvard University	United States	483	32,767	67.84
6. University of Cape Town (UCT)	<b>South Africa</b>	671	31,802	47.39
7. University of Cambridge	United Kingdom	586	31,236	53.3
8. University of East Anglia (UEA)	United Kingdom	300	30,097	100.32
9. University of British Columbia (UBC)	Canada	384	27,326	71.16
10. University of Queensland (UQ)	Australia	552	27,259	49.38
11. Stockholm University	Sweden	417	26,841	64.37
12. Stanford University (SU)	United States	313	26,756	85.48
13. University of Florida (UF)	United States	488	25,136	51.51
14. University of Leeds	United Kingdom	457	24,922	54.53
15. University of Copenhagen (UCPH)	Denmark	556	24,597	44.24
16. University of California, Berkeley (UCB)	United States	382	23,840	62.41
17. University of the Witwatersrand (Wits)	South Africa	606	23,327	38.49
18. Australian National University (ANU)	Australia	346	22,498	65.02
19. Imperial College London	United Kingdom	315	22,198	70.47
20. University of California, Davis (UCD)	United States	317	22,171	69.94
21. Cornell University (CU)	United States	384	22,085	57.51
22. University of Dar es Salaam (UDSM)	Tanzania	685	21,030	30.7
23. Utrecht University	Netherlands	350	20,573	58.78
24. McGill University	Canada	312	20,224	64.82
25. London School of Hygiene & Tropical Medicine (LSHTM)	United Kingdom	352	19,811	56.28

As seen in Table 1, Publications from African Universities seem to be less cited as compared with non-African organizations, for example, SUA has produced 583 publications that have been cited 11,316 times with a citation mean of 19.4 while the UCPH next to it has 556 publications which have been cited 24,597 times with a citation mean of 44.24, this citation is as twice as much the citation of SUA. It has also been observed that the University of East Anglia (UEA) has produced only 300 publications that have been cited 30,097 times with a citation mean of 100. In this list of top 25 organizations, the UCAS from China has produced 409 publications that have been cited 7,315 times and has a citation mean of 18 which is the lowest compared with other non-African Universities see Table 1.

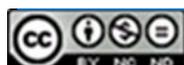
### ***Citation by Organizations in Tanzania***

UDSM has published 685 publications that have been cited 21030 times, SUA has 583 publications with a total citation of 11301, IITA has 142 publications with a total citation of 2926 publications, while TAWIRI has 84 publications that have been cited 2697 times and the fifth is NM-AIST that has produced 235 publications with a citation of 2675 see Table 2.

**Table-2: Most cited organizations from Tanzania**

S/N	Academic/Research Institution	Publications	Citation
1	University of Dar es Salaam (UDSM)	685	21030
2	Sokoine University of Agriculture (SUA)	583	11301
3	International Institute of Tropical Agriculture (IITA)	142	2926
4	Tanzania Wildlife Research Institute (TAWIRI)	84	2697
5	Nelson Mandela African Institution of Science and Technology (NM-AIST)	235	2675
6	St. John's University of Tanzania (SJUT)	7	2555
7	National Institute for Medical Research (NIMR)	85	2406
8	Tanzania Fisheries Research Institute (TAFIRI)	119	2048
9	Ifakara Health Institute (IHI)	54	1686
10	Ministry of Natural Resources and Tourism Tanzania	31	1313
11	College of African Wildlife Management (CAWM)	30	1241
12	Aarhus University (AU)	25	1038
13	Ministry of Health and Social Welfare, Tanzania	19	1037
14	University of Dodoma (UDOM)	103	990
15	Ardhi University (ARU)	63	987
16	Mikocheni Agricultural Research Institute (MARI)	33	924
17	Tanzania National Parks (TANAPA)	30	830
18	Muhimbili University of Health and Allied Sciences (MUHAS)	49	720
19	Tanzania Meteorological Agency (TMA)	25	701
20	Ministry of Water and Irrigation	8	697
21	Tumaini University (TUMA)	39	618
22	Tropical Pesticides Research Institute (TPRI)	43	597
23	Open University of Tanzania (OUT)	25	511
24	Tanzania Commission for Science and Technology (COSTECH)	12	475
25	Tanzania Forestry Research Institute (TAFORI)	26	469
26	State University of Zanzibar (SUZA)	28	415
27	Institute of Finance Management (IFM)	7	316
28	Catholic University of Health and Allied Sciences (CUHAS)	30	303
29	Kilimanjaro Christian Medical Centre	17	209
30	Western Indian Ocean Marine Science Association (WIOMSA)	8	159
31	Western Indian Ocean Marine Science Association (WIOMSA)	8	159
32	Mzumbe University (MU)	24	155
33	Dar es Salaam Institute of Technology (DIT)	19	132
34	The Jane Goodall Institute (JGI)	7	93
35	Mbeya University of Science and Technology (MUST)	21	83
36	College of Business Education (CBE)	8	72
37	Moshi Co-operative University (MoCU)	12	41

It has been observed that publications produced by research-based organizations (non-training organizations) were highly cited compared with those published by academic institutions such as universities. For example, the IITA has produced 142 publications that have been cited 2,926 times and has a citation mean of 20.6 more than some Universities such as SUA which has produced 583 publications (four times that of IITA), it has a total citation of 11,301 with a citation mean of 19. This is to say, IITA has produced fewer publications but on average has been cited many times. The Ifakara Health Institute (IHI) which ranks 9<sup>th</sup> has produced only 54 publications that have been cited 1,686 times with a citation mean of 31.22 slightly higher than that of the UDSM which has produced publications that are almost 12 times that of IHI. Surprisingly, even small colleges such as the College of African Wildlife Management (CAWM) which has produced only 30 publications that have been cited 1,241 times with a citation mean of 41.37 which is actually higher than all the universities in the country. Also, the government agencies and ministries have



produced publications that are highly cited for example Ministry of Health and Social Welfare, Tanzania has produced 19 which have been cited 1037 times with a citation mean of 54.58, Tanzania Commission for Science and Technology (COSTECH) has produced 12 publications which have been cited 475 times with a citation mean of 39.6, and the Ministry of Water and Irrigation has produced 8 publications which have a total of 697 citations which has an average of 87.13 citations.

**Table-3:** Organizations in Tanzania with the highest citation average

Organization	Publications	Citation	Citation mean
1. St. John's University of Tanzania (SJUT)	7	2555	365
2. Ministry of Water and Irrigation	8	697	87
3. Ministry of Health and Social Welfare, Tanzania	19	1037	55
4. Institute of Finance Management (IFM)	7	316	45
5. Ministry of Natural Resources and Tourism Tanzania	31	1313	42
6. Aarhus University (AU)	25	1038	42
7. College of African Wildlife Management (CAWM)	30	1241	41
8. Tanzania Commission for Science and Technology (COSTECH)	12	475	40
9. Tanzania Wildlife Research Institute (TAWIRI)	84	2697	32
10. Ifakara Health Institute (IHI)	54	1686	31
11. University of Dar es Salaam (UDSM)	685	21011	31

Data in Table 3 shows that, St. John's University of Tanzania (SJUT) has only 7 publications that have been cited 2,555 times with a citation mean of 365 followed by the Ministry of Water and Irrigation which has 8 publications that have been cited 697 times with a citation mean of 87 and the Ministry of Health and Social Welfare, Tanzania has 19 publications with citation of 1037 with a citation mean of 55, and the Institute of Finance Management (IFM) has 7 publications that have been cited 316 times with a citation mean 45. The UDSM, which actually has many publications compared with other organizations in Tanzania, has a citation mean of 31 which holds the eleventh position on the list.

### ***Researchers' productivity and citations***

Data were analysed to rank the performance of researchers in terms of the number of publications they had produced, Data in Table 4 show the researcher with the highest number of publications is from the University of York in the UK. Further analysis shows that USA, UK, and Germany are represented by two researchers. Other countries are Switzerland, Belgium, and Cameroon from Africa see Table 4. In terms of citation, Simon Iain Hay from the USA who had produced 60 publications with a citation of 28,531 citations, this is the most cited author, followed by Jurg Utzinger from Swiss-TPH Switzerland who has published 56 with 5,455 citations while and Neil David Burgess from the World Conservation Monitoring Centre, in the UK had produced 69 publications that have been cited 4,353 times see Table 4.

**Table 4:** Researchers' productivity world-wide

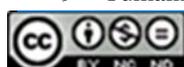
S/N	Organization, Country	Country	Publications	Citations
1	Rob Marchant	University of York, United Kingdom	82	2,045
2	Simplice Anutechia Asongu	African Governance and Development Institute, Cameroon	79	1,502
3	Dirk Verschuren	Ghent University, Belgium	77	3,117
4	Stefan Sieber	Leibniz Centre for Agricultural Landscape Research, Germany	71	1,074
5	Neil David Burgess Lindsay Carman	World Conservation Monitoring Centre, United Kingdom	69	4,353
6	Stringer	University of York, United Kingdom	68	2,565
7	Andreas Hemp	University of Bayreuth, Germany	66	2,535
8	Andrew S Cohen	University of Arizona, United States	63	2,696
9	Simon Iain Hay	University of Washington, United States	60	28,531
10	Jürg Utzinger	Swiss Tropical and Public Health Institute, Switzerland	56	5,455

### *Researchers' productivity per organization in Tanzania*

The number of researchers in all contributing institutions was examined in the top hundred researchers in Tanzania. The contributing organizations include four public universities with a large number of researchers, six research institutes, three ministries, two colleges, and one private University see Table 5. Data shows the top three organizations which have a large number of researchers include SUA which has 28 researchers who have contributed a total publication (TP) of 420 that have been cited 9,438 times, and the UDSM has 27 researchers who have produced 373 total publications that have been cited 8,678 times followed by the NM-AIST which has 12 researchers who have made 220 total publications which have been cited 2,663 times as shown in Table 5.

**Table 5:** Organizations in Tanzania and Researchers' productivity

S/N	Organization	Researchers	TP	TC
1	Sokoine University of Agriculture,	28	420	9,438
2	University of Dar es Salaam	27	373	8,678
3	Nelson Mandela African Institution of Science and Technology, Tanzania	12	220	2,663
4	International Institute of Tropical Agriculture	6	92	2,904
5	Fisheries Research Institute	6	61	771
6	National Institute for Medical Research	4	52	1,235
7	Wildlife Research Institute	3	30	763
8	College of African Wildlife Management	2	27	1,953
9	Tumaini University,	2	24	363



10	University of Dodoma,	2	15	142
11	Tropical Pesticides Research Institute	1	24	381
12	Ministry of Agriculture, Food and Cooperatives	1	20	304
13	AVRDC - The World Vegetable Center	1	14	185
14	Ministry of Natural Resources and Tourism	1	11	183
15	Catholic University of Health and Allied Sciences	1	10	143
16	Institute of Rural Development Planning,	1	7	119
17	Ministry of Livestock Development and Fisheries	1	9	171

### ***Most productive Researchers from Tanzania***

The most productive researchers had published 35 publications while the researcher who have produced less among top has 19 publications. The highest climbers are Narriman Saleh Jiddawi from UDSM and Patrick Alois Ndakidemi from NM-AIST who had both produced 35 publications followed by Linus Kassian Munishi from NM-AIST who had published 30 publications. SUA and NM-AIST appear to have many researchers in the top twenty list of productive researchers followed by IITA and UDSM respectively. Other organizations are NIMR, TPRI and the Ministry of Food and Agriculture. See Table 6.

**Table 6:** Most productive Researchers from Tanzania

	Researcher	Institution affiliation	Publications
1	Patrick Alois Ndakidemi	NM-AIST	35
2	Narriman Saleh Jiddawi	UDSM	35
3	Linus Kasian Munishi	NM-AIST	30
4	Anna Christina Treydte	NM-AIST	26
5	James Peter Legg	IITA, Tanzania	25
6	Audax Z P Mabulla	UDSM,	25
7	Eliakimu Mnkondo Zahabu	SUA	25
8	Karoli Nicholas Njau	NM-AIST	24
9	Khamaldin Daud Mutabazi	SUA	24
10	Eliningaya John Kweka	IITA, Tanzania	24
11	Rogers Ernest Malimbwi Alfred Nzibavuga Nyarubakula	SUA	22
12	Muzuka	NM-AIST	21
13	Japhet Joel Kashaigili	SUA	21
14	Siza Donald Tumbo	Ministry of Agriculture, Food and Cooperatives, Tanzania	20
15	Pantaleo Kirari Munishi	SUA	20
16	Mateete A Bekunda	IITA, Tanzania	20
17	Gerald M Misinzo	SUA	19
18	Victor M Manyong	IITA, Tanzania	19
19	Amos Enock Majule	UDSM	19
20	Susan Fred Rumisha	National Institute for Medical Research, Tanzania	19

### ***Most cited researchers from Tanzania***

The author whose publications have been cited many times is Emanuel H Martin from the College of African Wildlife Management who had produced 13 publications which have cited 1,568 times with a citation mean of 121 followed by Audax Z P Mabulla from the UDSM who had produced 25 publications which have gained a total of 1,491 citations with citation mean of 60, the third position is held by Narriman Saleh Jiddawi from the UDSM, Tanzania who had published 35 which have gained a total of 1202 citations with citation mean of 34. The SUA has five researchers on the top list, while UDSM has three researchers while CAWM and IITA have one researcher each see Table 7.

**Table 7:** Most cited researchers from Tanzania

Researcher	Institution	Publications	Citation	Citation mean
1. Emanuel H Martin	CAWM	13	1568	121
2. Audax Z P Mabulla	UDSM	25	1491	60
3. Narriman Saleh Jiddawi	UDSM	35	1202	34
4. James Peter Legg	IITA	25	986	39
5. Boniface P Mbilinyi	SUA	17	986	58
6. Kim M Howell	UDSM	14	844	60
7. Khamaldin Daud Mutabazi	SUA	24	739	31
8. Eliakimu Mnkondo Zahabu	SUA	25	726	29
9. Yonika Mathew Ngaga	SUA	17	696	41
10. Rogers Ernest Malimbwi	SUA	22	642	29

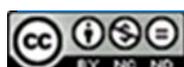
## **Discussion**

### ***Types of publications***

In this study, both closed-access (CA) and open-access (OA) publications were retrieved and analyzed. The findings have indicated that journal articles have largely dominated the amount of publications on the subject during the period under investigation. This is in line with Savage and Olejniczak, (2022) who observed that journal articles had increased compared with other type of published materials. The findings have indicated that most of the Open Access research output is published in Gold followed by Hybrid, bronze OA journals. Among the analysed OA publications, slightly quarter-percent is disseminated through green Open Access. The same observation was noted by (Nazim et al., 2022; Piwowar et al., 2019; Wallach et al., 2018) who observed a steady increase in OA publications on climate change on different online platforms. Therefore, the rate of increase of OA articles shared online including reputable databases indicates a gradual increase of OA research output that may probably surpass the traditional model of scholarly communication.

### ***The trends of growth of publications on climate change in Tanzania***

Research output in Tanzania is on the rise as indicated in Figure 1. The last two years (2020 and 2021) have marked the peak of publications on climate change in all years since 1964. This is an indication that research on climate change is increasingly being conducted in Tanzania. This implies that climate change is a research area of great concern like other areas that need to be tackled through research. This is true in the study conducted by Li, et al.,



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(2020) on the trends of climate change and infectious diseases conducted for two decades worldwide between 1999 to 2008, and 2009 to 2018. They found a rapid growth of publications on climate change research output. Likewise, a study conducted by Xue et al., (2021) analysed publications using bibliometrics to ascertain the trends of publication in the journal of Process Safety and Environmental Protection (PSEP) from 1990 to 2022 and found that the number of publications on the topic keeps growing over time. The growth of publications on climate change might have been attributed to the fact that many multinational campaigns were launched during the 1990s to mitigate climate change around the globe. According to the research by Haunschild et al., (2016), in the period between 1991 to 2010, the number of papers published annually increased by a factor of ten and they predicted that the rate of increase could have been influenced by the Intergovernmental Panel on Climate Change (IPCC) report in 1988. The report might have triggered the intergovernmental research initiatives that led to productivity in climate change publications only after a few years. This is supported by Einecker and Kirby, (2020) who conducted a bibliometrics study on climate change adaptation, mitigation, and resilience and found that publications on climate change increased steadily across the three decades from 1991 to 2019. Despite the observed minor fluctuations in the number of publications that were observed in Figure 1, the trends indicate a significant increase in the number of publications on the subject year after year. This implies that research on climate change is increasingly conducted in Tanzania by local researchers and collaborating partners from abroad.

### **Countries share of climate change publications**

Despite the fact that research on climate change was conducted in Tanzania, researchers from developed countries including the United States, the United Kingdom, and Germany have a large share of all generated publications on climate change on Tanzania. The only African countries that have contributed are South African, Kenya and Tanzania itself which have been featured in the top eleven as indicated in Figure 2. The findings are in line with an analysis which was conducted by Yang, et al., (2012) who conducted a systematic review and meta-analysis to establish scientific publications of the English literature from 2001 to 2010, they found that the USA was leading in terms of publications of articles in high impact journals followed by Germany, France, Japan and the UK respectively. An analysis of the G20 countries on research production that was conducted by Lin, Hu, and Hou, (2018) also found that the USA leads in terms of publication count followed by China, the UK, Germany, Japan and France respectively. According to the research conducted to assess the performance of G8 countries in terms of research and development expenditure, the research found that USA, EU, Japan, German and UK respectively have invested significantly in research and they hold the economic and scientific wealth for the world (King, 2004). The related literature above is in line with the findings of this study that has portrayed a large share of publications on climate change in Tanzania being generated by developed nations. Therefore, it is evident that developed countries produce a significant amount of research output compared with developing countries.

### ***Contribution of organizations in Tanzania***

It is not surprising to see that large universities and research-based organizations are leading in terms of publications on climate change in Tanzania. Results have indicated in Figure 4 that UDSM and SUA have a large share followed by NM-AIST and IITA. The UDSM and

SUA are known for their long-standing academic and research track records in Tanzania. The UDSM offers multidisciplinary degrees and research in various subject areas and it was established in the 1970s as the first and only University in the country until the 1990s when other Universities started operating in the country. The SUA provides academic and research-intensive studies and it is a national focal point for agricultural information in Tanzania. The two Universities are characterized by having a large number of researchers, experiences, and multidisciplinary. Furthermore, research groups from the two Universities have been jointly collaborating in conducting research projects on Climate Change Impact, Adaptation and Mitigation (CCIAM) under the support of the Royal Norwegian Government (Lwoga, 2013). The project has facilitated the establishment of a common repository that collects, archive, preserve, and disseminates locally published materials on climate change produced in Tanzania (Matovelo & Ellingsen, 2012). The joint research project which was initiated in 2010 Tanzania spearheaded research and publication on climate change in Tanzania as the publication rate rose immediately after 2010 as indicated in Figure-1. On the other hand, the NM-AIST is a research-intensive organization that offers research-based postgraduate studies in the areas of science and technology, it has significantly contributed in terms of publications despite the fact that it was established a decade ago. Also, the IITA is a research-based organization operating in Tanzania that conducts research on agriculture and poverty reduction, and it has also contributed significantly to research on climate change in Tanzania.

### ***Researchers' productivity***

The reputation of any researcher can be evaluated based on the amount of research output they produce (Surulinathi et al., 2020). Evaluation of researchers' productivity is conducted for job recruitment, retention, career advancement, and assist funders in awarding research projects (Abramo et al., 2013). One of the important measures of productivity is the number of publications the researcher has produced. The results in Table 4 have indicated that researchers from developed countries have contributed more publications than their counterparts from developing countries including Tanzania. Researchers' productivity from developed countries is directly proportional to the number of publications that developed countries have produced as indicated in Figure-2. In Tanzania, researchers from the UDSM, SUA, and the NM-AIST have produced more publications than other institutions in Tanzania as seen in Table-6. The reason for this performance is partly contributed by the outstanding research profile of these institutions.

### ***Citations impacts***

The impact of publications is measured by the rate at which the publication is utilized by other scholars through citations. Results in Table 1 have indicated that organizations from developed countries have been cited many times. The University of Washington (UW) in the USA and the University of East Anglia (UEA) in the UK have publications that have an average of over 100 citations that makes them stand at the top. Generally, publications from Africa are less cited compared with non-African countries. When it comes to citation counts in Tanzania, organizations which have a high number of citations include UDSM, SUA, IITA, TAWIRI and NM-AIST respectively. It has been observed that publications from non-university organizations such as research centres, government agencies, institutes, and others have a high citation mean compared with organizations such as Universities, colleges, schools etc. For example, the findings in Table 3 show that publications from the Ministry of

Water and Irrigations have 8 publications with a citation mean of 87 Ministry of Health and Social Welfare has 19 publications with a citation mean of 55, the Institute of Finance Management has 7 publications with a citation mean of 45, Ministry of Natural Resources and Tourism has 31 publications with citation mean of 42, College of African Wildlife Management (CAWM) has 30 publications with citation mean of 41, Tanzania Commission for Science and Technology (COSTECH) has 12 publications with citation mean of 40, Tanzania Wildlife Research Institute (TAWIRI) has 84 publications with citation mean of 32 and Ifakara Health Institute (IHI) has 54 publications with citation mean of 31. These organizations have actually a citation average higher although they had produced a very minimal number of publications compared with for example the Universities of Dar es Salaam which has 685 publications with a citation mean of 31. It has been observed that articles published in high-impact prestigious Open Access journals are more highly cited than those published in closed-access mode. Articles published in these media tend to have high visibility and citation compared to other media. For example, the article that was published by a group of scientists affiliated with St. John's University was cited 2,500 times see a paper with this DOI [https://doi.org/10.1016/S1473-3099\(13\)70318-9](https://doi.org/10.1016/S1473-3099(13)70318-9) that was published by The Lancet Infectious Diseases which has an Impact Factor of 25.071 and is the world-leading infectious diseases journal (Nag, 2021). This is among journals with a high Impact Factor and it is Open Access, making it more visible and highly cited. A study conducted by Lawrence, (2001) reveals that the articles published in open-access journals are cited on an average of 336% if they are published online compared to offline articles published in the same venue. Online articles that are published in open-access avenues are likely to be read widely. The easier accessibility might be among the significant motivating factor for citing articles published in OA journals more frequently.

## Conclusion

This study investigated the growth of publications (in terms of journal articles) on climate change in Tanzania as well as its citation impact during the period under study. It has been revealed that the growth of publications on the subject is constantly growing with peak production in 2020 and 2021. The developed countries have made a significant contribution in terms of publications on climate change on the subject while the renowned public university and research institutions in Tanzania are leading in terms of the production of climate change publications. This study has also revealed a remarkable growth in open-access publications with evidence of being highly cited. Thus, the gap between closed and open-access publications is quickly narrowing. Generally, bibliometrics studies like the current ones provide indicators of performance and research gaps in various areas of study. This kind of analysis is highly needed for decision-making and planning including climate change research intervention. A deep analysis needs to be conducted to ascertain the impact of climate change research on policy influence in the country.

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