



## Countdown to The 2030 Global Goals: A Bibliometric Analysis of Research Trends on SDG 2 - Zero Hunger

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### Abstract

As we approach the deadline for achieving the United Nations' 17 Sustainable Development Goals (SDGs), which is less than a decade away, it is crucial for researchers and research institutions at both national and international levels to conduct rigorous scientific assessments of the progress made towards these goals. The assessment is of utmost importance as it will provide valuable insights and information to political leaders and other stakeholders, guiding their actions and efforts towards successfully attaining the SDGs by the year 2030. This study aimed at providing vivid descriptions of the SDG 2 – zero hunger-related research endeavour. It employed bibliometric analysis and geographical patterns of SDG 2-related publications extracted from Scopus database from 2015 to 2023. A total of 397 documents were extracted where *Sustainability* journal ranked 1<sup>st</sup> among the journal outlets of zero hunger-related publications. The publication of zero hunger-related documents grew from 1.5% in 2016 to 29.7% in 2022. Food and Agriculture Organisation (FAO) and Chinese Academy of Sciences were the top 2 institutions publishing zero hunger-related documents while the lead article was published by *Journal of Cleaner Production* with 128 citations. The funding sponsors of SDG 2-related publications were dominated by sponsors from developed countries (such as China, Belgium, United States, and United Kingdom) while no funding sponsors from developing countries were among the top 10. The United States and United Kingdom were the two most productive countries while only one African country (South Africa) made the list of top 10 countries publishing zero hunger-related documents. This study provided political leaders and key stakeholders with in-depth understanding of the SDG 2-related research activities and highlighted research funding and collaboration gaps facing the developing nations.



### Article History

Received: 23 August 2023

Accepted: 15 December 2023


### Keywords

Food Security;  
Developed Countries;  
Developing Countries;  
Food Access;  
Scientometrics.

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Doi: <https://dx.doi.org/10.12944/CRNFSJ.11.3.34>

## Introduction

With only 7 years remaining until the attainment of the seventeen United Nations (UN) Sustainable development goals (SDGs), the preliminary report of the UN General Assembly Economic and Social Council revealed that only 12% of 140 SDG targets are assessed to be on track, about 50% are off track, while 30% are either static or regressed below the 2015 measure.<sup>1</sup> Also, global hunger remained higher, with about 735 million people facing hunger in 2022, leading to an additional 122 million more people than in the 2019 pre-pandemic time.<sup>2</sup> From recent estimates, 2.4 billion people were found to be moderately/severely food insecure globally while 900 million of these people were found to be severely food insecure. It is also reported that 3.1 billion more people globally were unable to afford a high-quality diet in 2021.<sup>2</sup> Remarkable headway was achieved among Asia (except Western Asia) and Latin America in reducing hunger while Western Asia (10.8%), the Caribbean (16.3%), and all sub-regions of Africa (about 20%) are currently grappling with escalating hunger in 2022. Globally, about 148 million under-five children were stunted, 45 million were wasted, and 37 million were overweight in 2022. However, the ever-increasing urbanisation was reported to be driving substantial changes in agrifood systems across rural-urban spectrum. The changes offer both obstacles and opportunities to make sure everyone has unhindered access to low-cost healthy diets.<sup>2</sup>

The word "hunger", according to Merriam-Webster dictionary was first used before the 12th century, and defined as "a craving or urgent need for food or a specific nutrient or "an uneasy sensation occasioned by the lack of food" or "a weakened condition brought about by prolonged lack of food".<sup>3</sup> Also, The word "hunger" is defined by the UN as "the periods when people experience severe food insecurity – meaning that they go for the entire day without eating due to lack of money, access to food, or other resources".<sup>4</sup> Further, Food and Agriculture Organisation (FAO) also defined "hunger" as "an uncomfortable or painful physical sensation caused by insufficient consumption of dietary energy. It becomes chronic when the person does not consume a sufficient amount of calorie (dietary energy) on a regular basis to lead a normal, active and healthy life".<sup>2</sup>

The concern about food systems *Sustainability* was revealed in the Sustainable Development Goal 2 (SDG 2) also referred to as "zero hunger", which is one of the 17 SDGs adopted by the United Nations General Assembly (UNGA) in 2015. The SDG 2 - zero hunger aimed at encouraging all member countries to "end hunger, achieve food security and improved nutrition, and promote sustainable agriculture" by 2030.<sup>5</sup> The SDG 2 – zero hunger has five pivotal targets which include: "end hunger and ensure access to safe, nutritious, and sufficient food; end all forms of malnutrition; double the productivity and incomes of small-scale food producers; ensure sustainable food production systems and implementing resilient agricultural practices; maintain the genetic diversity of seeds, plants, and animals".<sup>5-7</sup>

Further, the global headway against hunger in recent time has been reported to be rather at a close stand still, with the 2022 global hunger index (GHI) score for the world found to be moderate (18.2), while showing slight decrease when compared with 2014 GHI score of 19.<sup>8</sup> The barrage of crises such as poverty, conflict events, climate change, inequality, corruption, economic implications of COVID-19 pandemic, and Russia-Ukraine war are recognised as significant drivers of global hunger in recent time. It is important that resources are deployed to respond to these emergencies while also revolutionising food systems so that they are more equitable, sustainable, inclusive, and resilient.<sup>8</sup>

The second SDG – zero hunger is regarded as one of the SDGs that have found relevance in all the 17 SDGs and is currently of great interest given the effect of the afore-mentioned global crises to worsening global hunger and food security in recent time. It has been established that researchers and academic members of higher institution of learning are leading actors in advancing sustainable development goals.<sup>9-11</sup> While the contributions of scientists in various disciplines are crucial in enlightening policy makers and enhancing important policy implementation. Some studies have conducted bibliometric analyses that centred on SDGs<sup>12-13</sup>; SDG 2 (but limited to the Pacific Alliance - Chile, Colombia, Peru, and Mexico) from 2015 to 2019,<sup>14</sup> and SDG 3.<sup>11, 15</sup> According to literature

search, this is the first bibliometric analysis on SDG 2 – zero hunger that accommodated all countries, region and territories from 2015 to 2023.

This study aimed at conducting a bibliometric analysis of literature reviews on SDG 2 - zero hunger from 2015 to 2023. The objectives of the study include (i) to explore the quantity of research publication trends during 2015-2023; (ii) to analyse the evolution of salient topics by exploring the keywords; and (iii) to explore the geographical distribution of top research institutions and countries bordering on the SDG 2. However, this study utilizes bibliometric data for year, countries, institutions, authors, citations, source, subject areas, and keywords. To accomplish these tasks, bibliometric database, mapping, and visualization software package was employed.

## Research Methodology

### Search Strategy

A bibliometric analysis of scientific literature was conducted by (i) searching the selected database (Scopus) on 7 July 2023 with search limit from 2015 to 2023 on July 7 (2023). For a robust bibliographic analysis, an extensive dataset that encompassed important advances within the evolution of the subject matter is of paramount importance. According to Rogers *et al.*,<sup>a</sup> bibliographic data size for robust bibliometric analysis should be above 200 publications. This study aligned with this proposition, having a sample size for bibliometric analysis on SDG 2 above 300. Scopus database is used for this study and it is arguably one of the most reliable databases with exhaustive collection of abstract and citation database linked to scholarly publications from various academic fields. In 2023, Scopus has more than 90 million content records,<sup>17</sup> million plus author profiles, above 1.8 billion cited references, and more than 7 thousand publishers across 240 disciplines.<sup>17</sup> Further, Scopus is a widely trusted source for reliable and quality bibliometric search.<sup>14, 18-19</sup>

The search strategy for the SDG 2 - zero hunger-related publications was conducted based on the search term query of Scopus database given as: (TITLE-ABS-KEY ("SDG" AND "Hunger") OR TITLE-ABS-KEY ("SDG" AND "Goals") OR TITLE-ABS-KEY ("SDG" AND "Zero hunger")) AND PUBYEAR > 2014 AND PUBYEAR < 2024.

The search was conducted on July 7, 2023 and the search commenced from year 2015 being the commencement year of the UN SDGs and extended till July 7 2023, which is the most recent data available. The extracted documents were limited to peer-reviewed publications which include; articles, reviews, book chapters, conference papers, note, books, and other academic publications. At the end of the search, a total of 397 documents was included after careful inspection. From the Scopus search database, all the accompanying metadata such as abstract, keywords, funding sources, authors, authors' affiliation information, year of publication, thematic areas, document source among others were downloaded as a CSV file. In this study, the VOSviewer 1.6.19 software was employed mainly because of its impressive visualization features for bibliometric data while the software is also a freely available tool.<sup>13, 20-22</sup>

### Data Analysis

In order to explore the evolution of literature on SDG 2 - zero hunger, the bibliometric analysis procedure for the extracted 397 publications was conducted. The bibliographical data analysis was conducted through the use of freely downloadable software package called Visualization of Science viewer (VOSviewer). VOSviewer was developed by van Eck and Waltman<sup>20</sup> and its commonly used for bibliometric networks of different actors (such as authors, organizations and countries) through several network analysis methods such as co-authorship, co-occurrence, citation, co-citation, and bibliographic coupling resulting in network, overlay and density visualizations between documents with clearly specified clusters based on combined features as specified above.<sup>13, 20</sup>

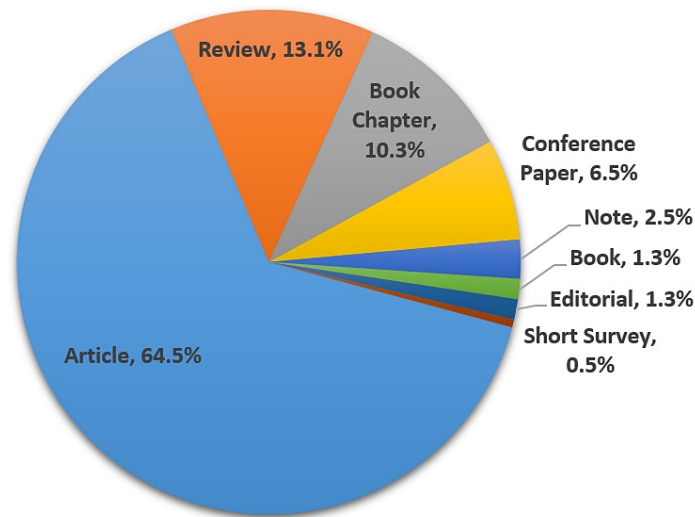
## Findings

### Overview of Sdg2 - Zero Hunger-Related Research Publications (2015-2023)

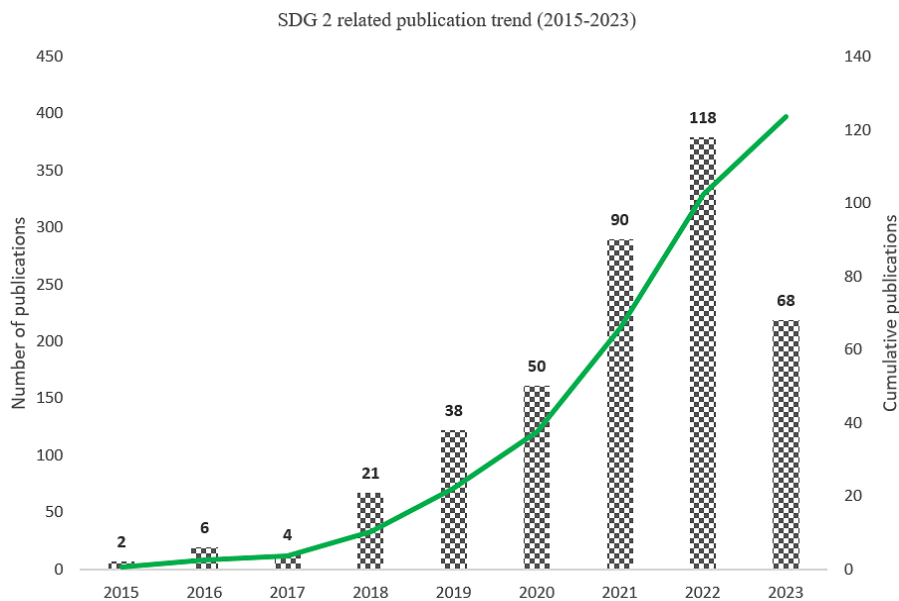
The search query from Scopus database extracted 397 documents of the zero hunger-related publications from 2015 to 7 July 2023. As shown in Figure 1, the 397 documents for this study included publication types such as articles (n = 256), review (n = 52), book chapter (n = 41), conference paper (n = 26), note (n = 10), book (n = 5), editorial (n = 5), and short survey (n = 2). In Figure 2, the total publications in 2015 was only 2 but progressed

steadily to a total of 397 in 2023 (as of 7 July 2023). It is worthy of note that publications on SDG 2 reached its highest in 2022 (n = 118) while it is believed that the number of publications in 2023 (n = 68) may surpass that of 2022 at the end of the present year because the stated value was achieved in 7 July 2023. The total publication collection resulted in a total of 4,551 citations, with an average citation per document of 11.46, average citation per document per year of 1.43, and the annual growth rate was 55.4% indicating an increasing research

publications focusing on the SDG 2. The percent citations also increased from 2 citations (0.07%) in 2015 to 8.1% (364 citations) in 2020 and later achieved 1721 citations (37.82%) in 2022. As of July 7, 2023, the citations has reached 1265 (27.8%) indicating the possibility of 2023 citations surpassing that of 2022. According to publication authorship, out of 1594 authors, 54 were authors of single-authored publications, indicating about 97% multiple authors in SDG 2-related research publications.



**Fig 1: SDG 2 zero hunger publication type (2015-2023)**



**Fig. 2: SDG 2 zero hunger related publication trend (2015-2023)**

Further, the 397 documents had h-index of 38, indicating that 38 of the publications have been cited at least 38 times. The major language of the publications was English (n =390; 98.2%) while others were Portuguese (n = 3; 0.75%), Spanish (n =2; 0.5%), and Chinese (n = 2; 0.5%). In terms of the subject areas of the SDG 2 publications in this study, there are 26 different subject areas

including Environmental Science, Social Sciences, Engineering, Energy, Medicine, Computer Science, Economic, Econometrics and Finance among others. However, Environmental Science was ranked 1st with 19.5% (n = 174), followed by Social Science (n = 143; 16%), Agricultural and Biological Sciences (n = 116; 13%), and Engineering (n = 73; 8.3%). Other subject areas are presented Figure 3.

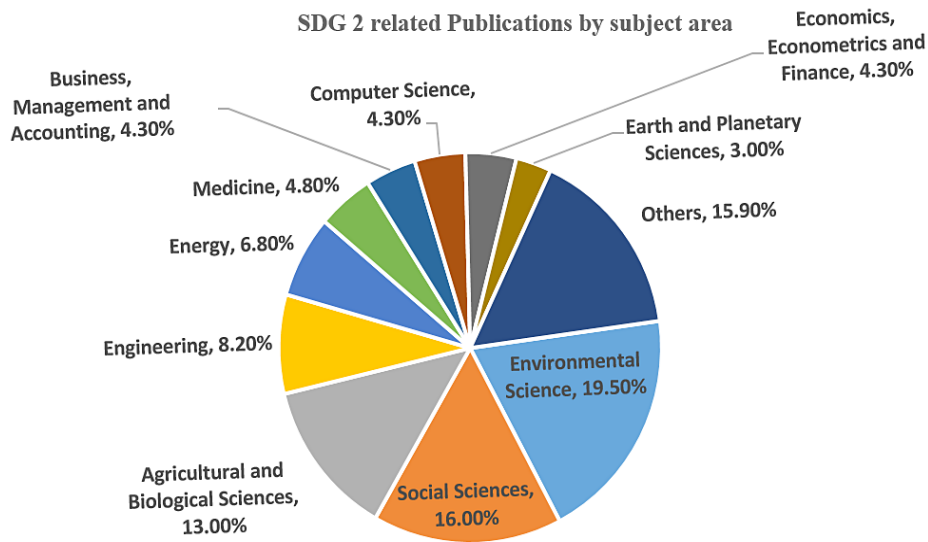


Fig. 3: SDG 2 related publications by subject areas (2015-2023)

Table 1: Top 10 Journals that published SDG 2 - zero hunger publications

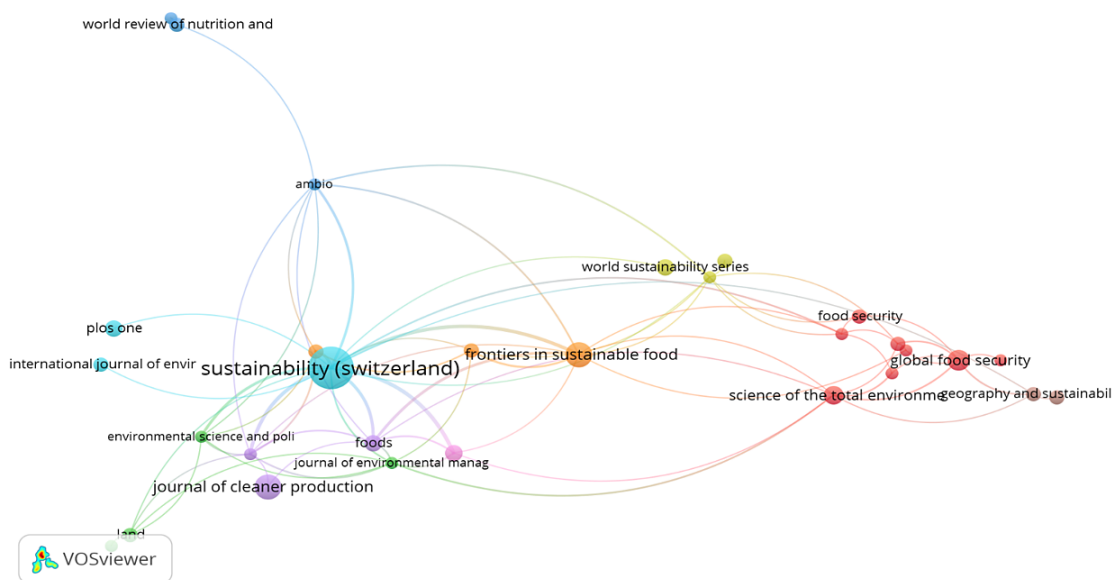
Rank*	Source	Publisher	P	% P	TC	ACP	IF	h-index	TLS
1	Sustainability (Switzerland)	MDPI	24	6.05	140	5.8	3.9	136	40
2	Frontiers in Sustainable Food Systems	Frontiers	9	2.27	42	4.7	4.7	41	1
2	Journal of Cleaner Production	Elsevier	9	2.27	470	52.2	11.1	268	18
4	International Journal of Speech-Language Pathology	Taylor & Francis Group	7	1.76	7	1.0	1.8	50	5
5	Global Food Security	Elsevier	6	1.51	150	25	8.9	69	7
6	Science of the Total Environment	Elsevier	5	1.26	125	25	9.8	317	7
7	Foods	MDPI	4	1.01	88	22	5.2	73	15
7	PLOS ONE	PLOS	4	1.01	84	21	3.8	404	1
7	Water (Switzerland)	MDPI	4	1.01	45	11.3	3.4	85	14
7	World Sustainability Series	Springer Nature	4	1.01	11	2.8	-	-	1

Note: Rank\* source with the same number of publications (P) are given the same rank; MDPI, Multidisciplinary Digital Publishing Institute; PLOS, Public Library of Science; TC, total citations; P, number of publications; ACP, average citation per publication; IF, impact factor; TLS, total link strength.

**Publication Sources**

This section centred on the most relevant journals with highest number of SDG 2 - zero hunger-related publications with corresponding citations as presented in Table 1. *Sustainability* published by multidisciplinary digital publishing institute (MDPI) had the highest number of documents (n = 24) on SDG 2. This was followed by two journals (*Frontiers in Sustainable Food Systems* and *Journal of Cleaner Production*) with 9 documents each. *Journal of Cleaner Production* (JCP) had the highest

total citations (470) and highest average citation per publication (ACP) (52.2) of SDG 2-related publications. Not surprising, JCP also had the highest 2022 impact factor (IF) of 11.1 with h-index of 268, followed by *Science of Total Environment* with IF of 9.8 (and having h-index of 317) among the top 10 journals publishing SDG 2-related publications from 2015 to 2023. The *Sustainability* journal had the highest total link strength (40) among the top 10 journals.



**Fig. 4 Network visualization of bibliographic coupling of sources (minimum of 2 documents, 10 citations per source), VOSviewer 1.6.19 (2023).**

Further, the network visualization analysis of bibliographic coupling of source (journals) with most documents and citations is presented in Fig. 4. Here, a minimum of 2 documents per source, and minimum of 10 citations per document were used as a limit, in order to achieve the top publication outlets with highest documents and citations. However, out of 37 items that met the threshold (from 274 sources), only 30 were sets of connected items forming 9 clusters with 73 links, and total link strength (TLS) of 135. Note that the colour of an item is determined by the cluster to which the item belongs while lines between items represent links. Here, the links between journals were not high enough as *Sustainability* had the highest TLS of 57, followed by *Frontiers in Sustainable Food Systems* with 24 TLS indicating stronger co-citation links between the journals as

presented by the lines. Some journals were far apart (such as *World Review of Nutrition and Dietetics and Ambio*), indicating lower level of relatedness in terms of co-citation links among them. Contrariwise, there was higher level of relatedness among journals in red colour (such as *Global Food Security, Food Security, Science of Total Environment, and Food policy*) influencing higher co-citation links among these journals publishing SDG 2-related publications from 2015 to 2023 (see Fig. 4).

**Publications (Documents) Related to SDG 2 - Zero Hunger**

One of the important ways of assessing scholarly publications is through the evaluation of its total citations received in a particular field over a specific period of time. The impact factor (IF), which is an



essential metric that determines the quality and relevance of scholarly publications in a field and its multidisciplinary nature is equally considered. Table 2 presented the top publications with minimum of 50 citations (27 out of 397 articles) as obtained by the bibliographic data extracted. The study by van der Waal and Thijssens,<sup>23</sup> was the most cited SDG 2-related article with the highest citation (Scopus) count of 128 and was published by JCP with the IF of 11.1 and h-index of 268. This was followed by Gil *et al.*<sup>24</sup> with total citation of 109 and published by *Ambio* (IF, 6.5; h-index, 141), while the article focused mainly on SDG 2, improving the targets and indicators for agriculture and food security. Another important articles in this selection is that of Blesh *et al*<sup>25</sup> titled “Development pathways toward “zero hunger”, published by *World Development* (IF, 6.9; h-index, 206). The paper reviewed literature on SDG 2 from a food systems perspective and

reiterated the fact that achieving SDG 2 required the attention to institutional capacities, ecosystem-based management, and high-quality diets. The work of Fanzo *et al*<sup>26</sup> on the importance of monitoring food system transformation in achieving the 2030 global goals, published by *Food Policy* (IF, 6.5; h-index, 126) received 59 citations within 2 years of its publication. The only article that received 50 citations was authored by Africans (South Africa) Mugambiwa and Tirivangasi<sup>27</sup> and published by *Jamba: Journal of Disaster Risk Studies*. The paper focused on the impact of climate change on the achievement of zero hunger in South Africa. It is worthy to note that African authors were under-represented in this collection of SDG 2-related articles. Out of the 27 articles in this category, only 4 authors (from three countries) were Africans (South Africa [2], Uganda [1], and Cameroon [1]) with 14.8%.

**Table 2: Top SDG 2-zero hunger related publications with minimum of 50 citations**

S/N	Title	Authors	Year	Journal title	Lead author's country	IF	TLS	TC
1	Corporate involvement in Sustainable Development Goals: Exploring the territory	<sup>23</sup>	2020	Journal of Cleaner Production	Netherlands	11.1	128	0
2	Sustainable development goal 2: Improved targets and indicators for agriculture and food security	<sup>24</sup>	2019	<i>Ambio</i>	Netherlands	6.5	109	17
3	On the sustainable perishable food supply chain network design: A dairy products case to achieve sustainable development goals	<sup>28</sup>	2021	Journal of Cleaner Production	Iran	11.1	105	0
4	Sustainable development goals in mining	<sup>29</sup>	2019	Journal of Cleaner Production	Brazil	11.1	103	0
5	Agroforestry Can Enhance Food Security While Meeting Other Sustainable Development Goals	<sup>30</sup>	2017	Tropical Conservation Science	Singapore	1.7	100	3
6	Global food security in the context of COVID-19: A scenario-based exploratory analysis	<sup>31</sup>	2020	Progress in Disaster Science	Thailand	6.3	99	2

7	Women's and men's reports of past-year prevalence of intimate partner violence and rape and women's risk factors for intimate partner violence: A multi-country cross-sectional study in Asia and the Pacific	<sup>32</sup>	2017	PLOS Medicine	South Africa	11.6	97	0
8	From goals to joules: A quantitative approach of interlinkages between energy and the Sustainable Development Goals	<sup>33</sup>	2019	Energy Research and Social Science	Indonesia	6.7	97	6
9	The global nutrition report 2014: Actions and accountability to accelerate the world's progress on nutrition	<sup>34</sup>	2015	Journal of Nutrition	United States	4.7	96	0
10	Gender equality, food security and the sustainable development goals	<sup>35</sup>	2018	Current Opinion in Environmental Sustainability	India	7.2	85	0
11	Shifting states, shifting services: Linking regime shifts to changes in ecosystem services of shallow lakes	<sup>36</sup>	2021	Freshwater Biology	Netherlands	3.538*	81	2
12	Soil organic carbon stock as an indicator for monitoring land and soil degradation in relation to United Nations' Sustainable Development Goals	<sup>37</sup>	2019	Land Degradation and Development	United States	4.7	79	4
13	Impacts of the Russia-Ukraine War on Global Food Security: Towards More Sustainable and Resilient Food Systems?	<sup>38</sup>	2022	Foods	Qatar	5.2	75	5
14	Towards sustainable palm oil production: The positive and negative impacts on ecosystem services and human wellbeing	<sup>39</sup>	2021	Journal of Cleaner Production	Cameroon	11.1	75	0
15	Soils and sustainable development goals of the United Nations: An International Union of Soil Sciences perspective	<sup>40</sup>	2021	Geoderma Regional	United States	4.1	74	4
16	Agricultural land systems importance for supporting food security and susta-	<sup>41</sup>	2022	Science of the Total Environment	Portugal	9.8	70	4



	inable development goals: A systematic review							
17	The imbalance of food and biofuel markets amid Ukraine-Russia crisis: A systems thinking perspective	<sup>42</sup>	2022	Biofuel Research Journal	Italy	13.0	68	0
18	Development pathways toward “zero hunger”	<sup>25</sup>	2019	World Development	United States	6.9	68	11
19	Coastal and marine conservation strategy for Bangladesh in the context of achieving blue growth and sustainable development goals (SDGs)	<sup>43</sup>	2018	Environmental Science and Policy	Bangladesh	6.0	65	11
20	Animal Welfare and the United Nations Sustainable Development Goals	<sup>44</sup>	2019	Frontiers in Veterinary Science	Sweden	3.2	62	14
21	The centrality of water resources to the realization of Sustainable Development Goals (SDG). A review of potentials and constraints on the African continent	<sup>45</sup>	2016	International Soil and Water Conservation Research	Uganda	6.4	62	0
22	Viewpoint: Rigorous monitoring is necessary to guide food system transformation in the countdown to the 2030 global goals	<sup>26</sup>	2021	Food Policy	United States	6.5	59	5
23	Implementing Sustainable Development Goals with Digital Government – Aspiration-capacity gap	<sup>46</sup>	2016	Government Information Quarterly	Poland	7.8	56	0
24	The importance of achieving foundational Sustainable Development Goals in reducing global risk	<sup>47</sup>	2020	Futures	Australia	3.0	54	3
25	The challenge for the soil science community to contribute to the implementation of the UN Sustainable Development Goals	<sup>48</sup>	2019	Soil Use and Management	Netherlands	3.8	54	14
26	To Achieve a Sustainable Blue Future, Progress Assessments Must Include Interdependencies between the	<sup>49</sup>	2020	One Earth	Australia	16.2	53	16

Sustainable Development Goals						
27	Climate change: A threat towards achieving 'sustainable development goal number two' (end hunger, achieve food security and improved nutrition and promote sustainable agriculture) in South Africa	2017	Jamba: Journal of Disaster Risk Studies	South Africa	0.498*	50 0

\*Impact factor is for Clarivate Analytics, 2021; TC: total citations; IF: impact factor; TLS: total link strength.

This revealed that publications that focused on monitoring the progress towards the achievement of SDG 2 - zero hunger and its interconnectedness among SDGs especially in low-and middle-income countries (LMICs) are pivotal towards the actualization of SDG 2 and its associated SDGs. Further, the network and density analyses of bibliographic coupling of documents that have received high citations are presented in Fig. 5a & 5b. A minimum of 10 citations from each document was set as the limit in order to achieve top cited documents. However, 113 documents met the set threshold but only 63 documents had the largest of connected items which formed 11 clusters, with 152 links and 176 total link strength (TLS). In Fig. 5a, the weight of the coloured circles represents the number of citations of the item (article). The bigger the circle, the higher the citation count of such document. Also, the closer the distance between the lines linking the journals, the higher the relatedness of the journals in terms of co-citation links. From cluster 1 (red),<sup>38</sup> had the highest citations (75) out of 9 items but with only 5 links and 5 TLS, while Nash *et al*<sup>49</sup> with 53 citations had the highest links in the cluster with 14 links and 16 TLS, indicating higher relatedness in terms of co-citation links. In cluster 2 (green, with 7 items),<sup>43</sup> had the highest citations (65) in this cluster with 10 links and 11.

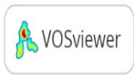
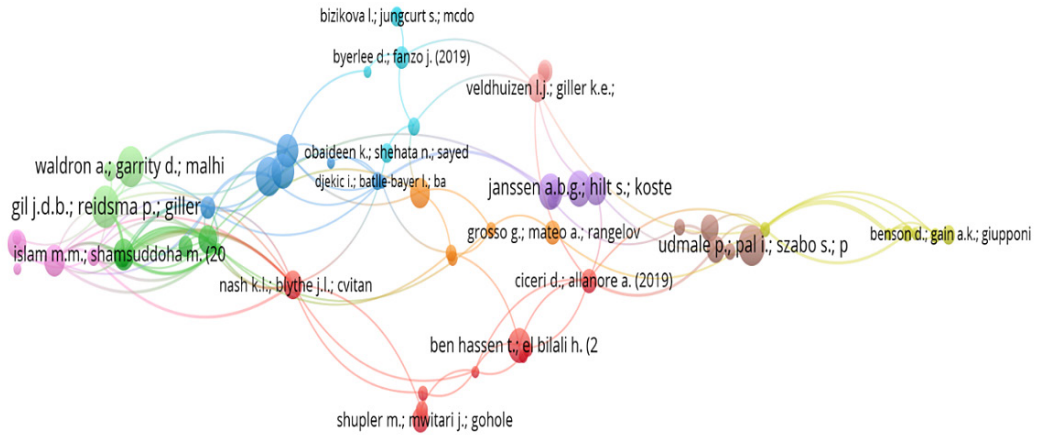
However, Atukunda *et al*<sup>50</sup> had the highest TLS (23) within the cluster and in the entire 11 clusters even though it had only 10 citations. It indicated that<sup>50</sup> had the best co-citations links among other journals. This was influenced because of the importance of the review paper that focused on unlocking the potential for the achievement of the UN SDG 2-zero hunger in

Africa. In cluster 3 (blue, with 7 items), Santika *et al*,<sup>51</sup> had the highest total link strength (17) with 17 links and 21 citations. This high co-citation links reflected the importance of the paper to SDGs. This was followed by Blesh *et al*<sup>25</sup> with 5 links, 11 TLS and 58 citations. Blesh *et al*'s<sup>25</sup> article is one of the important publications that explored the progress, challenges and opportunities towards SDG 2 attainment as we move closer to 2030. In cluster 11 (light green, 3 items), Gil *et al*<sup>24</sup> had both highest TLS (17) and total citations (109) among the three articles in the cluster. Gil *et al*<sup>24</sup> focused on improving the SDG 2 targets and indicators for sustainable agriculture and food security, and has produced a better co-citation links among other articles in cluster 11.

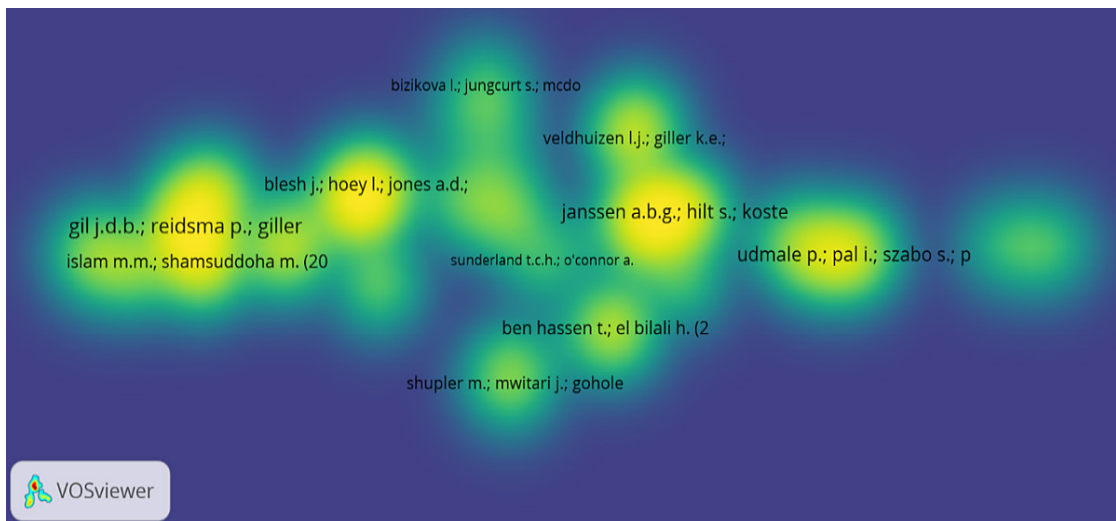
From Fig. 5b, the item density visualization of the bibliographic coupling of documents and their co-citation links are presented. As indicated in the network visualization analysis, the items' properties are the same but each point in the item density visualization has a colour that indicates the density of items at that point. According to,<sup>20</sup> the colour range from blue to green to yellow. The larger the number of items around a point, coupled with higher weights of the items, the closer is the colour of the point to yellow. The number of citations is represented by the intensity of the colour while the bibliographic coupling through the distance among documents. The yellow colour of the documents was prominent around items such as,<sup>24</sup>, <sup>43</sup> and <sup>30</sup> at the far left side of Fig. 5b (though <sup>30</sup> was not quite visible) revealing the co-citation links among the items. In the top most point in Fig. 5b, Bizikova *et al*<sup>52</sup> had a light shade of green while the weight of the item in a point is

smaller when compared to those in the far left as mentioned above. It indicated lower citation count

of the document when compared to other items with higher intensity of yellow colour.



**Fig. 5a: Network visualization of bibliographic coupling of documents (minimum of 10 citations per document), VOSviewer 1.6.19 (2023)**



**Fig. 5b: Item density visualization of bibliographic coupling of documents (minimum of 10 citations per document), VOSviewer 1.6.19 (2023)**

**Country Representation of SDG 2 - Zero Hunger-Related Publications**

From the extracted 397 publications on SDG 2 - zero hunger, a total of 100 countries were represented based on corresponding author’s affiliations country. This shows the place of the scientific research production as analysed by country and presented

in Table 3. The Table 3 indicated countries with minimum of 10 SDG 2-related publications, with their corresponding total citations, average citation per publication, total link strength, and 2022 Global Food Security Index ranks (which indicated each country’s progress towards SDG 2). The United States was the most productive country with 71 publications,

1586 citations, 22.3 average citation per publication (ACP), and ranked 13<sup>th</sup> in the latest 2022 GFSI. The United Kingdom ranked 2<sup>nd</sup> with 64 publications and 1403 citations while India, Australia, and Germany were 3<sup>rd</sup> (52 publications, 414 citations), 4<sup>th</sup> (40 publications, 812 citations), and 5<sup>th</sup> (34 publications, 587 citations) respectively. The United Kingdom had the highest total link strength of 169 among all the countries, the Netherlands had the highest ACP of 44.2, while France was ranked

highest (4<sup>th</sup>) in the 2022 GFSI. In terms of African region representation, South Africa (7<sup>th</sup>) was the only country in the top 10 ranking, having 29 publications, 385 citations, 59 total link strength, and ranked 59<sup>th</sup> in the 2022 GFSI. Other African countries making the list of minimum of 10 publications include; Nigeria (16 publications, 118 citations, 17 TLS), Ghana (13 publications, 212 citations, 35 TLS), and Kenya (10 publications, 304 citations, 39 TLS).

**Table 3: Top countries with minimum of 10 SDG 2 - zero hunger related publications**

Rank*	country	Publication	% Publication	TC	ACP	TLS	GFSI 2022 rank
1	United States	71	8.99	1586	22.3	142	13
2	United Kingdom	64	8.10	1403	21.9	169	9
3	India	52	6.58	414	8.0	46	68
4	Australia	40	5.06	812	20.3	75	22
5	Germany	34	4.30	587	17.3	81	19
6	Italy	33	4.18	567	17.2	85	27
7	South Africa	29	3.67	385	13.3	59	59
8	China	27	3.42	425	15.7	49	25
9	Canada	22	2.78	437	19.9	60	7
10	Spain	21	2.66	180	8.6	43	20
11	Netherlands	19	2.41	840	44.2	66	5
12	Brazil	18	2.28	236	13.1	31	51
13	Nigeria	16	2.03	118	7.4	17	107
13	Sweden	16	2.03	258	16.1	61	7
15	Ghana	13	1.65	212	16.3	35	83
15	Indonesia	13	1.65	298	22.9	31	63
15	Thailand	13	1.65	259	19.9	34	64
18	Bangladesh	10	1.27	244	24.4	22	30
18	France	10	1.27	256	25.6	55	4
18	Kenya	10	1.27	304	30.4	39	82

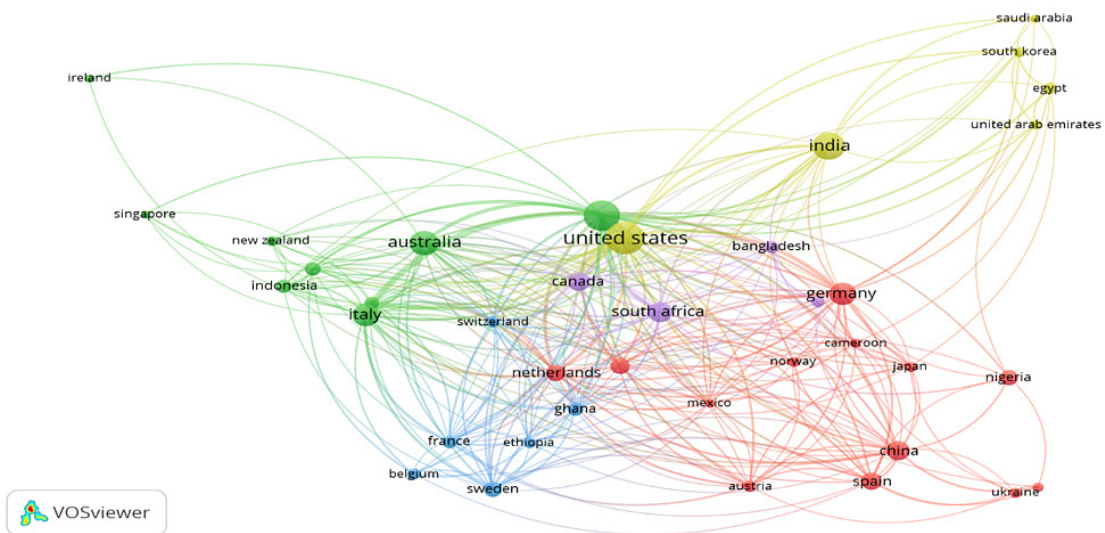
Note: Rank\*, countries with the same number of publications (P) are given the same rank; TC, Total Citations; ACP, average citation per publication; TLS, total link strength.

However, in order to have a better understanding of the international collaborations among countries, the mapping of co-authorship of countries with regards to authors' affiliations was presented in Fig. 6. Thirty-eight (items) countries met the threshold of 5 publications per country resulting in a total of 321 links and 691 TLS. In respect to African region, Cluster 1 (red; 9 items) had only two African countries (Nigeria and Cameroon) with only 22 publications, 286 total citations, and 32 TLS. As presented in Table 4, Cluster 1 had a total of 3,312

citations, and 398 TLS. Germany had the highest TLS (72) among the countries in the cluster, followed by Netherlands with 62 TLS. These indicated higher interrelatedness of the items (Germany and Australia) in terms of co-citation links. In cluster 2 (green, 9 items), United Kingdom had the highest number of publications (64), citations (1403), and TLS (155) within the cluster and also among all the 38 countries selected. In cluster 3 (blue, 6 items), Switzerland had the highest TC of 320 and 39 TLS but Sweden had the highest TLS of 51 within the

cluster. Only one African country (Kenya) was found in Cluster 2 while two (Ethiopia and Ghana) were found in Cluster 3. Among the 38 countries that merited the co-authorship bibliographic analysis, only 7 African countries (Nigeria, South Africa, Kenya, Cameroon, Ghana, Ethiopia, and Egypt) were included with 18% representation. However, South Africa had the highest number of documents (29), citations (385), and TLS (51) among the African countries in this category. In general, stronger co-citation links (research collaborations) existed

among countries at the centre of the map while countries like Ireland, Saudi Arabia and Egypt (at the extreme of the co-authorship map) indicated least research collaborations. Both United States and United Kingdom had the highest citations, number of publications, and TLS when compared to other countries in all 5 clusters, and it is indicative of the fact that the two countries had stronger collaborations among other countries with higher co-citation links that are linked to zero hunger-related publications.



**Fig. 6: Network visualization map of international research collaboration among countries with minimum of SDG 2 – zero hunger related publications, VOSviewer 1.6.19 (2023)**

**Table 4: Citation features of co-authorship clusters according to countries**

Cluster	item	Countries	P	TC	ACP	TLS
1 (red)	13	Austria, Brazil, Cameroon, China, Germany, Japan, Lithuania, Mexico, Netherlands, Nigeria, Norway, Spain, and Ukraine	183	3312	19.11±10.75	498
2 (green)	9	Australia, Indonesia, Ireland, Italy, Kenya, New Zealand, Singapore, Thailand, and United Kingdom	190	3821	18.35±8.13	420
3 (blue)	6	Belgium, Ethiopia, France, Ghana, Sweden, and Switzerland	65	1250	19.68±8.72	204
4 (yellow)	6	Egypt, India, Saudi Arabia, South Korea, United Arab Emirates, and United States	150	2228	15.79±8.40	227
5 (purple)	4	Bangladesh, Canada, Malaysia, and South Africa	70	1078	14.72±8.68	133

P, number of publications; TC, total citations; ACP, average citation of country per publication; TLS, total link strength.

### Institutions, Authors and Funding Sponsors of Sdg 2-Related Publications

The 397 extracted publications on SDG 2 had authors (the corresponding authors) from more than 90 countries. The geographical distribution of institutions (affiliations) of authors that have contributed immensely to the literature related to SDG 2 – zero hunger is presented in Table 5. These institutions are regarded as most productive in terms of the number of publications. From this study, Food and Agriculture Organization of the United Nations (FAO) was the leading institution in SDG 2 – zero hunger-related publications (9), followed by Chinese Academy of Sciences, The Ohio State University, Wageningen University & Research, Cornell University, and University of Pretoria with 7 publications each (Table 5). Seven institutions (mostly from Africa) produced 4 publications each. Institutions from Ghana and South Africa (University of Pretoria [7], University of KwaZulu-Natal [6], University of Ghana [6], and University of Cape Town [5]) were the only African institutions that produced minimum of 5 SDG 2-related publications. Other African institutions produced 4-5 publications such as Makerere University (4), Federal University of

Agriculture, Abeokuta (4), Covenant University (4), Kwame Nkrumah University of Science and Technology (3), Minia University (3), and North-West University (3). This finding is linked to the fact that most productive countries in terms of SDG 2 related publications were from developed countries, led by United States and United Kingdom. Further, in Table 6, the top 10 funding sponsors with highest number of SDG 2-related publications is presented. It revealed that all the top 10 funding sponsors of SDG 2 related research outputs were from the developed countries, led by National Natural Science Foundation of China (12 publications), European Commission (8 publications), and Horizon 2020 Framework Programme (7 publications). It is surprising that no African-based funding sponsors made the top 10 list. This showed the level of research funding in developing countries especially in the African region which is the worst hit in terms of prevalence of hunger globally in recent time.<sup>2</sup> It is important to note that African institutions were among the top 10 institutions with highest SDG 2-related publications but no African countries were among the most productive funding sponsors of SDG 2-research publications.

**Table 5: Top institutions of authors of the SDG 2 - zero hunger publications**

Rank*	Institutions	Country	Publications
1	Food and Agriculture Organization of the United Nations	Italy	9
2	Chinese Academy of Sciences	China	8
3	The Ohio State University	United States	7
3	Wageningen University & Research	Netherlands	7
3	Cornell University	United States	7
3	University of Pretoria	South Africa	7
7	University of KwaZulu-Natal	South Africa	6
7	University of Ghana	Ghana	6
7	Indian Council of Agricultural Research	India	6
10	University of Cape Town	South Africa	5
11	Federal University of Agriculture, Abeokuta	Nigeria	4
11	Makerere University	Uganda	4
11	Covenant University	Nigeria	4
14	University of South Africa	South Africa	3
14	Minia University	Egypt	3
14	University of the Witwatersrand	South Africa	3
14	North-West University	South Africa	3
14	Kwame Nkrumah University of Science and Technology	Ghana	3
14	Landmark University	Nigeria	3

Note: \*Rank, Institutions with the same number of publications are given the same rank.



**Table 6: Top 10 Funding sponsors of SDG2 - zero hunger publications**

Rank	Funding Sponsors	Country	publications
1	National Natural Science Foundation of China	China	12
2	European Commission	Belgium	8
3	Horizon 2020 Framework Programme	Belgium	7
4	Chinese Academy of Sciences	China	6
4	UK Research and Innovation	United Kingdom	6
6	Bill and Melinda Gates Foundation	United States	5
6	Consortium of International Agricultural Research Centers	France	5
6	Economic and Social Research Council	United Kingdom	5
9	Fundação de Amparo à Pesquisa do Estado de São Paulo	Portugal	4
9	National Institutes of Health	United States	4

Note: Rank\*, funding sponsors with the same number of publications are given the same rank.

**Table 7: Authors with minimum of 3 SDG 2 - zero hunger publications**

Rank*	Authors	Country	No of papers	TC	h-index
1	Lal, R <sup>54</sup>	United States	5	79,182	132
2	Bouma, J <sup>56</sup>	Netherlands	4	11,904	55
2	Goethals, P <sup>57</sup>	Belgium	4	6,481	44
2	Pereira, P <sup>58</sup>	Lithuania	4	6,394	43
5	Abdelkareem, M.A <sup>63</sup>	United Arab Emirates	3	11,727	63
5	Choubey, V.K <sup>64</sup>	India	3	75	5
5	Cluver, L <sup>65</sup>	United Kingdom	3	11,307	58
5	Fanzo, J <sup>66</sup>	United States	3	21,738	44
5	Kumar, M <sup>67</sup>	India	3	66	5
5	Mabhaudhi, T <sup>61</sup>	South Africa	3	3,232	31
5	Olabi, A.G <sup>68</sup>	United Arab Emirates	3	23,451	85
5	Osabohien, R <sup>59</sup>	Nigeria	3	1,035	18
5	Otekunrin, O.A <sup>60</sup>	Nigeria	3	131	8
5	Sayed, E.T <sup>62</sup>	Egypt	3	6,934	47
5	Sherr, L <sup>69</sup>	United Kingdom	3	11,307	58
5	von Braun, J <sup>70</sup>	Germany	3	4,841	31

Note: \*Rank, authors with the same number of publications are given the same rank; TC, total citations.

Further, the top prolific authors of SDG 2-related publications from 2015 to 2023 is presented in Table 7. The number of publications of 16 authors with total of 53 articles accounted for 13.4% of overall publications in this period of time. Table 7 revealed the number of SDG 2-related publications of top authors, with their total citations (TC), country of affiliation, and h-index (provided through Scopus database). The author with the highest number of publications (5), TC (79,182), and h-index (132)

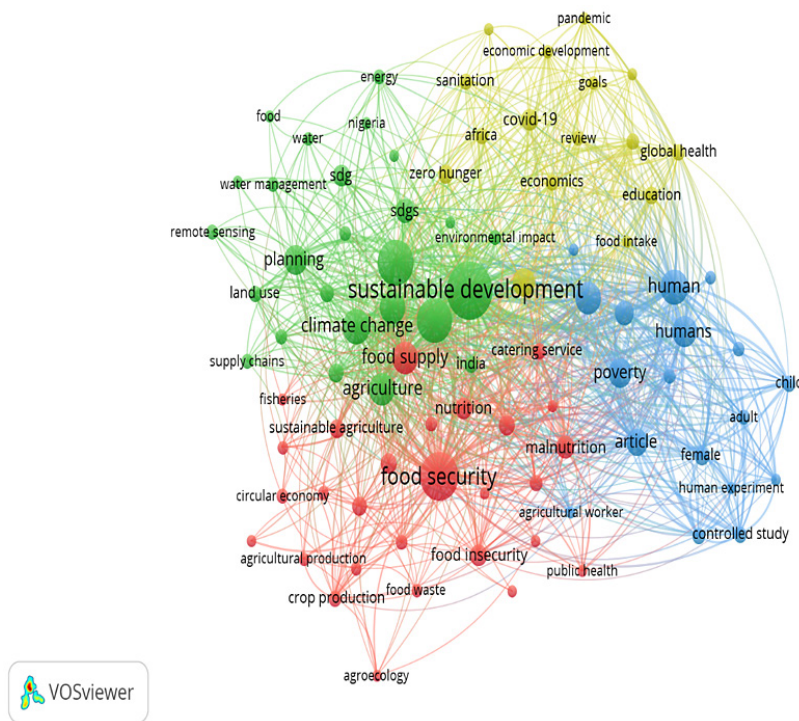
was Lal, Rattan.<sup>53</sup> He is affiliated to Ohio State University, Columbus, USA and has published in the field of sustainable soil management for global food security and mitigation of climate change. One of Lal, Rattan recent publications is "Food security impacts of the "4 per Thousand" initiative" which centred on the 2 pivotal elements of the "4 per Thousand" campaign<sup>54</sup> which was orchestrated by sequestration of soil organic carbon (SOC) are (i) abatement of climate change (from SDG 13) and

attainment of food security (from SDG 2 – zero hunger) which are both central to the SDGs.<sup>55</sup> Other authors with 4 publications include; Bouma Johan <sup>56</sup> (TC, 11,904; h-index, 55), Goethal Peter <sup>57</sup> (TC, 6,481; h-index, 44), and Pereira, Paulo <sup>58</sup> (TC, 6,394; h-index, 43). It is worthy to note that 12 of the authors published 3 papers each. However, from the 16 authors in this category, only 4 authors represented 3 countries from the African region which accounted for 27.3% of the top authors of zero hunger-related publications (2015-2023) viz; Nigeria (Osabohien, Romanus<sup>59</sup> and Otegunrin, Olutosin <sup>60</sup>), South Africa (Mabhaudhi, Tafadzwanashe <sup>61</sup>), and Egypt (Sayed, E.T <sup>62</sup>). Out of 16 authors' countries represented in this category, 10 authors are from 7 developed countries (Germany, Netherlands, United Arab Emirates, United States, Lithuania, Belgium, and United Kingdom) which accounted for 62.5% of the total authors and revealed that developed countries (ranked through Human Development Index 2021 [HDI]) are in the forefront of SDG 2 – zero hunger-related research globally. There is a need for researchers from LMICs to intensify research

collaborations in areas of zero hunger especially research works in the African region (FAO *et al.* 2023).

**Keywords Analysis**

The evaluation of the relationship between keywords are pivotal in revealing and identifying scholarly contents in various fields of endeavour 12, 71. Keywords analysis are usually conducted via co-occurrence mapping that indicates the links between specialized terminologies used in scholarly publications 15. It is common for any research publications to have five keywords or more which are mostly linked to the scholarly contents. The most occurring keywords were commonly used in exploring the conceptual framework of the SDG literature appraisals to specify the overarching themes.<sup>12, 72</sup> Further, in this study, all keywords (2,707) were examined, while only 88 keywords that appeared at least 7 times in all the 397 scholarly publications were captured. The co-occurrence analysis of the selected keywords are presented in Figure 7a & 7b and Table 8 & 9.



**Fig. 7a: Network visualization map of keywords (4 clusters) with minimum of 7 SDG 2 – zero hunger related publication keywords. The size of the circle indicated the research trends in the SDG 2 - zero hunger, VOSviewer 1.6.19. (2023)**

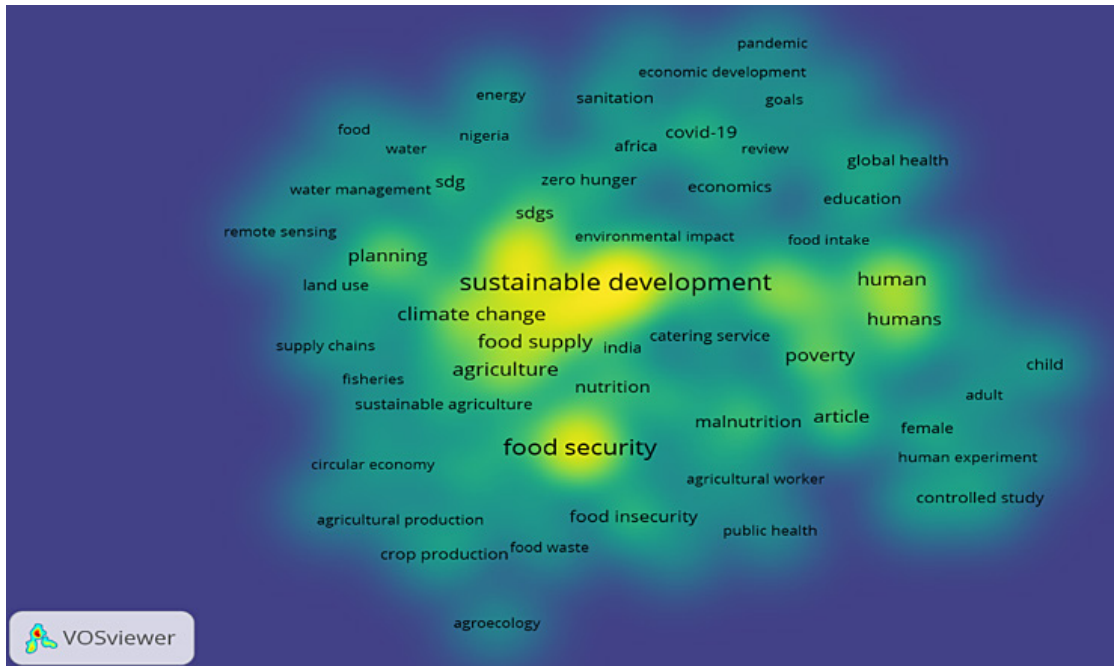


Fig. 7b: Item density visualization of SDG 2 – zero hunger related publications' keywords (minimum of 7 occurrences), VOSviewer 1.6.19 (2023)

Table 8: Top 10 occurring keywords in the SDG 2 - zero hunger related publications

Rank	Keyword	Cluster	Occurrences	Links	Total link strength
1	Sustainable Development	2	137	87	856
2	Food Security	1	99	83	515
3	Sustainable Development Goals	2	89	78	323
4	Sustainable Development Goal	2	85	84	531
5	Human	3	51	74	531
6	Climate Change	2	50	74	284
7	Hunger	3	46	73	411
8	Sustainability	2	45	66	212
9	Food Supply	1	44	80	330
10	Agriculture	2	43	68	254

Further, Table 8 revealed the top 10 keywords of SDG 2-related publications with minimum number of 40 occurrences. The map revealed the 88 keywords that met the limit with 4 clusters, 1959 links, and TLS of 5,880 which indicated the interconnectivity of the keywords. As specified above, the size and boldness of the circle and text showed the strength of co-occurrence (usually as weights) of individual keyword with other keywords in the data collection. The 4 clusters are displayed in four colours namely;

red, green, blue, and yellow respectively. The interval between the items and lines showed the closeness and connections of the keywords.

The cluster 1 (red) had the keyword “*food security*” as the keyword with the highest number of occurrences (99), links (83), and TLS (515) and accounting for 30% of the all publications. Out of the 28 keywords (see Table 8), other keyword include “*food supply*” (occurrence, 44; links, 80;

330, TLS), “*malnutrition*” (occurrence, 23; links, 61; TLS, 198), “*food insecurity*” (occurrence, 21; links, 55; TLS, 131), and “*SDG 2*” (occurrence, 17; links, 28; TLS, 60). The cluster 1 is mainly associated with the themes which centred on “*food (in) security, malnutrition and SDG 2*”. From Table 9, cluster 1 (28 items) had a total keywords occurrences of 430 and total link strength of 2772.

The cluster 2 (green), having 26 items focused on issues of sustainable development, sustainable development goals (SDGs), climate change, *Sustainability*, and planning. The keyword “*sustainable development*” had the highest number of occurrences (137), links (87), and TLS (856). The keyword “*sustainable development*” had the highest number of occurrences in all the 397 scholarly publications used in this study accounting for 34.5% of all the keywords in the entire publications. The keywords “*sustainable development*” had the highest weight and largest yellow area (Figure 7b). Other keyword include “*sustainable development goals*” (occurrence, 89; links, 78; TLS, 323), “*sustainable development goal*” (occurrence, 85; links, 84; TLS, 531), “*climate change*” (occurrence, 50; links, 74; 284, TLS), “*Sustainability*” (occurrence, 45; links, 66; TLS, 212), and “*agriculture*” (occurrence, 43; links, 68; TLS, 254). Cluster 2 had a total keywords occurrences of 690 and total link strength of 3894. With the inclusion of two developing countries (India and Nigeria) and belonging to LMICs in cluster 2, the central theme of cluster 2 focused on “*sustainable development goals in developing countries*”. Keywords that revealed the central issues in this cluster include; biodiversity, planning, land use, environmental impact, water management, decision making, food, and supply chain.

Cluster 3 (blue) has 18 items with the keyword “*human*” having the highest number of occurrences (51), links (74), and TLS of 531. The cluster focused on “*humans and hunger*” issues with special interests among keywords such as “*child*”, “*female*”, “*male*”, “*adult*”, “*zero hunger (SDG 2)*”. Other central keywords in cluster 3 include; “*hunger*” (occurrence, 46; links, 73; TLS, 411), “*humans*” (occurrence, 40; links, 72; TLS, 409), “*poverty*” (occurrence, 36; links, 69; TLS, 325), and “*sustainable development goals (SDGs)*” (occurrence, 26; links, 44; TLS, 89). Summarily, in Table 9, cluster 3 has keywords total occurrences (TO) of 345 and TLS of 3341 which

are crucial to the issues of human hunger especially among developing countries.

The fourth cluster (cluster 4), represented by items (16 keywords) in yellow featured the most prominent keyword in the cluster is “*united nations*”, with highest number of occurrences (35), links (73), and TLS (257) which also signifies the UN Agenda 2030 (SDG 2030). Other notable keywords in this cluster are “*COVID-19*” (occurrence, 20; links, 46; TLS, 108), “*zero hunger*” (occurrence, 16; links, 44; TLS, 98), “*education*” (occurrence, 14; links, 51; TLS, 138), “*global health*” (occurrence, 12; links, 48; TLS, 135) and “*Africa*” (occurrence, 11; links, 45; TLS, 94). In all the clusters (1-4), it is only in cluster 4 that keywords that are synonymous to COVID-19 pandemic featured, such as “*COVID-19*”, “*global health*”, and “*pandemic*”. This cluster is location-specific, having “*Africa*” as the only region represented. The central theme of this cluster is quite distinct because of the emergence of COVID-19 pandemic that has exacerbated the prevalence of hunger and worsening food insecurity situation in almost all countries where the African region was regarded as the worst hit region globally. The theme of cluster could be referred to as “*Zero hunger and COVID-19 in Africa*”. From Figure 7b (density visualization mapping), items such as *sustainable development, food security, humans, food supply, poverty, agriculture, and zero hunger* had greater intensity of the colour from green to yellow.

## Discussion

In order to assess the contributions and distribution of SDG 2 – zero hunger-related publications from 2015 to 2023, bibliometric analysis of 397 publications was conducted using Scopus database. The results of this study revealed the increasing trends of SDG 2-related publications from just 2 articles (0.5%) in 2015 to 29.7% (118 publications) in 2022 which was the highest while as of July 7, 2023, the percent publication has reached 17.1% (68 publications), indicating that by the end of 2023, the number of SDG 2-related publications may surpass that of 2022. Also, this study revealed the potential of SDG 2-related publications attracting more citations (increasing citations from 2 in 2015 to 3286 citations in 2022) in coming years as we move closer to the 2030 Agenda deadline. This finding is contrary to a bibliometric analysis on SDG 3 – health where

a downward trends in publication growth rate was reported.<sup>15</sup>

Further, according to top 10 journal outlets that published SDG 2 – zero hunger publications from 2015 to 2023, this study indicated that *Sustainability* by the publisher, MDPI had the highest number of publications (24) which is based in Basel, Switzerland. It is revealed that all the publishing outlets of the highest number of SDG 2 related publications were all based in the developed countries (Frontiers, Switzerland; PLOS ONE, United States; Springer Nature, United Kingdom; Elsevier, Netherlands). Most of the top journal outlets of SDG 2-related publications had very high impact factor (IF), indicating that the SDG 2-related articles attracted the attention of most journal administrators.<sup>11</sup> It is noteworthy that no journal outlets in developing nations were among the top journals of zero hunger-related publications from 2015 to 2023. The results were corroborated by<sup>11</sup> who reported that 100% of the journal outlets of SDG 3-related publications were based in Europe or North America, and also found *Sustainability* as the top (1<sup>st</sup>) ranked journal of SDG 3 – good health publications. However, the findings revealed publishing outlet gap of quality SDG 2-related articles in developing countries especially in Africa.

In addition, this study found that African researchers are under-represented, based on the SDG 2-related publications that are ranked among the most-cited publications and most-cited authors. From Table 2, the two most-cited publications were from,<sup>23</sup> and<sup>24</sup> with 128 and 109 citations respectively. The work of van der Waal and Thijssens<sup>23</sup> centred on the corporate involvement in SDGs while that of Gil *et al*<sup>24</sup> focused on SDG 2 – zero hunger, delving deeper into the gains from improved targets and indicators for agriculture and food security. However, while more than 70% of the leading authors were from developed countries, only four authors of African origin were among the 27 leading authors in this category with only one African publisher (*Jamba: Journal of Disaster Risk Studies*) making the list of top publishers from 2015 to 2023. The study found that some valuable publications by African and other researchers were not published in Scopus/Web of Science indexed journals which made it impossible to be included in this kind of bibliometric analysis that used Scopus/Web of Science databases for

their publications extraction.<sup>5, 73-78</sup> There is a need for researchers and publishing outfits especially those from LMICs to establish quality and trusted journal outlets for the publications of their SDG 2 and other SDGs-related research outputs that will be indexed in Scopus/Web of Science databases while encouraging interdisciplinary collaborative research with researchers from developed nations.

This study revealed that United States was the most productive country in terms of SDG 2-related publications while developed countries accounted for 80% of top 10 productive countries. Only South Africa was ranked among the top 10 countries in this category (Table 3). This showed that countries from African region were ranked among the lowest contributing regions to SDG 2-related publications from 2015 to 2023. The finding was similar to that of<sup>11</sup> and<sup>15</sup> that equally found African region among the lowest contributors to SDG 3 – good health related publications.

In terms of authors' institutions or affiliation, FAO, Chinese Academy of Sciences and The Ohio State University were ranked 1<sup>st</sup>, 2<sup>nd</sup>, and 3<sup>rd</sup> institutions of authors of SDG 2-related publications respectively. It is worthy to note that institutions from Africa were well represented but most of them had lower number of publications (less than 5), only University of Pretoria, University of Ghana, and University of Cape Town had at least 5 SDG 2-related publications. The low-level of funding for tertiary education research in most developing countries' universities and research institutions may be responsible for the low level of SDG 2-related research publications indexed in Scopus and Web of Science databases and was also reported as a stumbling block to actualization of SDG 2 and other SDGs in the region.<sup>15, 79</sup> Similar findings were found in the SDG 3 – good health related research in among African authors and institutions.<sup>11, 15</sup>

In addition, this study also revealed the absence of funding sponsors from developing countries among the top 10 SDG 2-related publications in Table 6. All the funding sponsors were based in developed countries (United States, United Kingdom, China, France, Belgium, and Portugal), implying a serious research funding and collaboration gaps in these countries especially Africa. Other similar studies have reported poor funding and collaborations (in



relation to SDG research) among African and Asian countries<sup>11, 13, 80</sup> However, healthy research funding and collaborations with researchers from developing countries is advocated as it was reported as a potential impetus for quality scholarly publications, promoted collaboration driving impactful scientific advancements, and wider recognition of research outputs.<sup>11, 81-85</sup>

From the major keywords forming different themes for each of the four identified SDG 2-related publications clusters in this study, it found that cluster 2 (28 items) had the highest total occurrences (690) and total link strength of 3,894 while the highest occurring keywords (sustainable development, 137 occurrences) in the entire 397 publications also belonged to cluster 2 (Table 9). Other theme-forming keywords in this cluster are; *climate change*, issues around *Sustainability, agriculture, land use, and planning*. However, cluster 1 (red) centred on SDG 2 related issues, having the top 5 keywords – *food security, food supply, malnutrition, food insecurity, and nutrition* which are pivotal to the core target of SDG 2. The food and nutrition security challenge was mainly a focus of the sub-Saharan Africa (SSA) sub region in this cluster, which was corroborated by the recent findings (2021-2022) where hunger prevalence was reported to be on the increase in all sub regions of Africa (FAO *et al.* 2023).

Cluster 3 (green, 26 items) had the keywords “*human*”, “*hunger*”, “*zero hunger*”, and “*poverty*” well projected in this group. Likewise, different human gender and age-groups such as “*female*”, “*male*”, “*adult*” and “*child*” were well represented among the keywords which suggested cluster theme such as “*zero hunger across gender and age-groups*”. The inclusion of *South Africa* among the keywords in this cluster, suggested that the populations of the SDG 2 related publications may cut across African region. From cluster 4 (yellow, 16 items), it is interesting to note the emergence of the important keyword -“*COVID-19*”, which did not feature in the previous three clusters (1-3). This reflected the influence of COVID-19 on the 2030 Agenda with a special focus on SDG 2 – zero hunger. The first three keywords are; “*United Nations*”, “*COVID-19*”, and “*zero hunger*”. Also the inclusion of *Africa, global health, and epidemiology* among the keywords in cluster 4 indicated that the cluster theme may likely focus on “*COVID-19, zero hunger, and global health*”. The

influence of COVID-19 on the global fight against hunger all forms of malnutrition revealed that the global hunger in 2022 (9.2% of world population) remained higher than the pre-COVID-19 estimate of 7.9% in 2019 2. In general, the central keywords like *SDG 2, food (in) security, Africa, sub-Saharan Africa, and sustainable development* revealed the importance of these keywords to the focus of the SDG 2 – zero hunger related publications in this study.

### Limitations of the Study

This SDG 2-related publications' bibliometric analysis contained some limitations worth mentioning. Firstly, this study did not capture publications outside of Scopus database, which adversely affected the total number of publications extracted for the purpose of bibliometric analysis. Secondly, this study did not include non-traditional publications (grey literature) such as government reports and publications, white papers, policy briefs, and non-profit organization reports where research or publications are not formally published in traditional commercial or scholarly journal outlets. Thirdly, other publication types other than original articles such as reviews, books, editorials, and notes were incorporated in this bibliometric analysis. Nevertheless, this study presented an in-depth snapshot of SDG 2-related scholarly output (from 2015 to 2023) and knowledge domains that are of interest to the global research community.

### Conclusion

This study explored the bibliometric analysis of SDG 2-related publications based on the Scopus database from 2015 to 2023. The study revealed the trends, evolving critical areas, and helps in gaining better understanding of the concept of SDG 2. The SDG 2-related publications have witnessed a positive growth (from 1.5% in 2016 to 29.7% in 2022) since the implementation of the 2030 global agenda in 2015. However, all the top 10 journals of zero hunger-related publications are based in developed countries while only one African based journal outlet was among the top publications with minimum of 50 citations. More than 80% of the lead authors of the highly cited SDG 2-related documents were from developed countries while developing countries especially Africa were grossly under-represented. Developed countries, led by China, dominated the top 10 funding sponsors of SDG



2-related publications with no African based funding sponsors, revealing the research funding gap (especially SDGs-related research) in the region. The United States was the most-productive and the country with overall highest citations among the 397 SDG 2-related publications extracted in this study. Even though, African region is currently the region experiencing the highest level of hunger and food insecurity globally, only four African countries (South Africa, Nigeria, Ghana, and Kenya) were among countries with minimum of 10 zero hunger-related publications. This showed weak intercontinental research collaborations among African researchers.

Again, only one African author (South Africa) was among the top 10 productive authors while the rest were from the developed countries such as United States, Netherlands, and Belgium. Further, SDG 2-related publications' keyword analysis highlighted main research domains such as: *food security, sustainable development, humans, zero hunger, poverty, malnutrition, climate change, COVID-19, agriculture, food supply, and Africa*. The emergence of COVID-19 exacerbated the level of hunger and

food insecurity globally while Africa was the most affected region 2. More SDG2-related research collaborations (especially with researchers from developed nations) is emphasized among African researchers, and attracting research funding opportunities if zero hunger target of 2030 would be a possibility.

#### Author Contribution

The conceptualization, methodology, writing - original draft preparation, and editing by O.A.O. The author have read and agreed to the published version of the manuscript.

#### Acknowledgement

The author appreciates the anonymous reviewers and editors for their invaluable comments and suggestions on the initial draft of this paper.

#### Funding

No funding received for this research.

#### Conflicts of interests

Author declare no conflicts of interests.

### References

1. UNGA Economic and Social Council. Progress towards the Sustainable Development Goals: Towards a Rescue Plan for People and Planet. Report of the Secretary-General (Special Edition), 2023. 1-43.
2. FAO, IFAD, UNICEF, WFP and WHO. The State of Food Security and Nutrition in the World 2023. Urbanization, agrifood systems transformation and healthy diets across the rural-urban continuum. Rome, FAO.
3. Merriam-Webster Dictionary. Definition of Hunger. 2023. Available online: <https://www.merriam-webster.com/dictionary/hunger> (accessed on 10 August 2023)
4. Action Against Hunger. What is Hunger? 2023. <https://www.actionagainsthunger.org/the-hunger-crisis/world-hunger-facts/what-is-hunger/> (accessed on 17 August 2023).
5. United Nations. Sustainable Development Goal 2, 2017. <https://sustainabledevelopment.un.org/sdg2>
6. Otegunrin O.A, Otegunrin OA, Sawicka B, Ayinde I. A. Three decades of fighting against hunger in Africa: Progress, challenges and opportunities. *World Nutrition*, 2020, 11(3): 86-111.
7. Otegunrin O.A., Otegunrin, O.A., Momoh, S., Ayinde, I.A. How far has Africa gone in achieving the Zero Hunger Target? Evidence from Nigeria. *Glob Food Secur*, 2019, 22: 1-12.
8. von Grebmer, K., Bernstein, j, Resnick D, Wiemers M. *et al.* 2022 Global Hunger Index: Food Systems Transformation and Local Governance. Bonn: Welthungerhilfe; and Dublin: Concern Worldwide, 2023.
9. Neary J, Osborne M. University engagement in achieving sustainable development goals: a synthesis of case studies from the SUEUAA study. *Aust J Adult Learn*. 2018, 58(3):336-64.
10. Purcell W.M, Henriksen H, Spengler J.D. Universities as the engine of transformational *Sustainability* toward delivering the sustainable development goals. *Int J Sustain High Educ*. 2019, 20(8):1343-57.

11. Sweileh, W. M. Bibliometric analysis of scientific publications on “sustainable development goals” with emphasis on “good health and well-being” goal (2015–2019). *Global and Health*, 2020, 16(1), 1–13.
12. Yamaguchi, N.U., Bernardino, E.G., Ferreira, M.E.C., de Lima, B.P. *et al.* Sustainable development goals: a bibliometric analysis of literature reviews. *Environ Sci Poll Res*, 2023, 30, 5502-5515.
13. Mishra, M., Desul, S., Santos, C.A.G., Mishra, S.K. *et al.* A bibliometric analysis of sustainable development goals (SDGs): a review of progress, challenges, and opportunities. *Environ, Dev Sustain*, 2023, 1-43.
14. Herrera-Calderon, O., Yuli-Posadas, R.A., Pena-Rojas, G., Andia-Ayme, V. *et al.* A bibliometric analysis of the scientific production related to "zero hunger" as a sustainable development goal: trends of the pacific alliance towards 2030. *Agric Food Secur*, 2021, 10, 34.
15. Raji, S.A., Demehin, M.O. “Long walk to 2030”: A bibliometric and systematic review of research trends on the UN sustainable development goal 3. *Dialog Health*, 2023, 100132.
16. Rogers G, Szomszor M, Adams J. Sample size in bibliometric analysis. *Scientometrics*. 2020, 125: 777–94.
17. Scopus Blog. Available on <https://blog.scopus.com/posts/scopus-now-includes-90-million-content-records> (21 July 2023).
18. Vera-Baceta M.A, Thelwall M, Kousha K. Web of Science and Scopus language coverage. *Scientometrics*. 2019, 15-26.
19. Raghavendra, N.D., Mallya, J., Manish, T.K. A Bibliometric Framework for Quantifying Research on Kimchi, a Staple Korean Dish. *Curr Res Nutr Food Sci*, 11(1): 61-76.
20. Van Eck, N.J., Waltman, L. Software survey: VOSviewer: A computer program for bibliometric mapping. *Scientometrics*, 2010, 84(2):523–38.
21. Meschede C. The Sustainable Development Goals in Scientific literature: a bibliometric overview at the meta-level. *Sustainability*, 2020, 12:4461.
22. Prieto-Jiménez E, López-Catalán L, López-Catalán B, Domínguez-Fernández G. Sustainable Development Goals and education: a bibliometric mapping analysis. *Sustainability*, 2020, 13:2126.
23. van der Waal J.W.H, Thijssens T. Corporate involvement in Sustainable Development Goals: Exploring the territory. *J Clean Prod*, 2020, 252, 119625.
24. Gil J.D.B., Reidsma P., Giller K., Todman L. *et al.* Sustainable development goal 2: Improved targets and indicators for agriculture and food security. 2019, *Ambio* 48, 685–698
25. Blesh J., Hoey L., Jones A.D., Friedmann H. *et al.* Development pathways toward “zero hunger”. *World Dev*, 2019, 118, 1-14.
26. Fanzo J., Haddad L., Schneider K.R., Bene C. *et al.* Viewpoint: Rigorous monitoring is necessary to guide food system transformation in the countdown to the 2030 global goals. *Food Policy*, 2021, 102, 102163.
27. Mugambiwa S.S., Tirivangasi H.M. Climate change: A threat towards achieving 'sustainable development goal number two' (end hunger, achieve food security and improved nutrition and promote sustainable agriculture) in South Africa. Jamba: *J Dis Risk Stud*, 2017, 9(1): 350.
28. Jouzdani J., Govindan K. On the sustainable perishable food supply chain network design: A dairy products case to achieve sustainable development goals. *J Clean Prod*, 2021, 278, 123060.
29. Monteiro N.B.R., da Silva E.A., Moita Neto J.M. Sustainable development goals in mining. *J Clean Prod*, 2019, 228, 509-520.
30. Waldron A., Garrity D., Malhi Y., Girardin C. *et al.* Agroforestry Can Enhance Food Security While Meeting Other Sustainable Development Goals. *Trop Conser Sci*, 2017, 10: 1-6.
31. Udmale P., Pal I., Szabo S., Pramanik M. *et al.* Global food security in the context of COVID-19: A scenario-based exploratory analysis. *Progress Dis Sci*, 2020, 7, 100120.
32. Jewkes R., Fulu E., Tabassam Naved R. *et al.* Women’s and men’s reports of past-year prevalence of intimate partner violence and rape and women’s risk factors for intimate partner violence: A multicountry cross-sectional study in Asia and the Pacific. *PLOS Medicine*, 2017, 14(9): e1002381.
33. Santika W.G., Anisuzzaman M., Bahri P.A.,

- Shafullah G.M. *et al.* From goals to joules: A quantitative approach of interlinkages between energy and the Sustainable Development Goals. *Energ Res Soc Sci*, 2019, 50, 201-214.
34. Haddad L., Achadi E., Bendeck M.A., Ahuja A. *et al.* The global nutrition report 2014: Actions and accountability to accelerate the world's progress on nutrition. *J Nutr*, 2015, 145(4): 663-71
35. Agarwal B. Gender equality, food security and the sustainable development goals. *Curr Opinion Env Sustain*, 2018, 34, 26-32.
36. Janssen A.B.G., Hilt S., Kosten S., de Klein J.J.M. *et al.* Shifting states, shifting services: Linking regime shifts to changes in ecosystem services of shallow lakes. *Fresh Biology*, 2020, 00: 1-12
37. Lorenz K., Lal R., Ehlers K. Soil organic carbon stock as an indicator for monitoring land and soil degradation in relation to United Nations' Sustainable Development Goals. *Land Degrad Dev*, 2019, 30: 824-838
38. Ben Hassen T., El Bilali H. Impacts of the Russia-Ukraine War on Global Food Security: Towards More Sustainable and Resilient Food Systems? *Foods*, 2022, 11, 2301.
39. Ayompe L.M., Schaafsma M., Egho B.N. Towards sustainable palm oil production: The positive and negative impacts on ecosystem services and human wellbeing. *J Clean Prod*, 2021, 278, 123914.
40. Lal R., Bouma J., Brevik E., Dawson L. *et al.* Soils and sustainable development goals of the United Nations: An International Union of Soil Sciences perspective. *Geoderma Reg*, 2021, 25, e00398.
41. Viana C.M., Freire D., Abrantes P., Rocha J., Pereira P. Agricultural land systems importance for supporting food security and sustainable development goals: A systematic review. *Sci Total Environ*, 2022, 806, 150718.
42. Esfandabadi Z.S., Ranjbari M., Scagnelli S.D. The imbalance of food and biofuel markets amid Ukraine-Russia crisis: A systems thinking perspective. *Biofuel Res J*, 2022, 34, 1640-1647.
43. Islam M.M., Shamsuddoha M. Coastal and marine conservation strategy for Bangladesh in the context of achieving blue growth and sustainable development goals (SDGs). *Environ Sci Policy*, 2018, 87, 45-54.
44. Keeling L., Tunon H., Olmos Antillon G., Berg C. *et al.* Animal Welfare and the United Nations Sustainable Development Goals. *Front Vet Sci*, 2019, 6, 336.
45. Mugagga F., Nabaasa B.B. The centrality of water resources to the realization of Sustainable Development Goals (SDG). A review of potentials and constraints on the African continent. *Int Soil Water Conser Res*, 2016, 4, 215-223.
46. Janowski T. Implementing Sustainable Development Goals with Digital Government – Aspiration-capacity gap. *Govt Info Quart*, 2016, 33, 603-613.
47. Cernev T., Fenner R. The importance of achieving foundational Sustainable Development Goals in reducing global risk. *Futures*, 2020, 115, 102492.
48. Bouma J., Montanarella L., Evanylo G. The challenge for the soil science community to contribute to the implementation of the UN Sustainable Development Goals. *Soil Use Manag*, 2019, 35(4): 538-546.
49. Nash K.L., Blythe J.L., Cvitanovic C., Fulton E.A. *et al.* To Achieve a Sustainable Blue Future, Progress Assessments Must Include Interdependencies between the Sustainable Development Goals. *One Earth*, 2020, 2(2): 161-173.
50. Atukunda, P., Eide, W.B., Kardel, K.R., Iversen, P.O. *et al.* Unlocking the potential for achievement of the UN Sustainable Development Goal 2 – 'Zero Hunger' – in Africa: targets, strategies, synergies and challenges. *Food Nutr Res*, 2021, 65: 7686.
51. Santika, W.G., Anisuzzaman, M., Simsek, Y., Bahri, P.A. *et al.* Implications of the Sustainable Development Goals on the national energy demand: The case of Indonesia. *Energy*, 2020, 196, 117100.
52. Bizikova, L., Jungcurt, S., McDougal, K., Tyler, S. How can agricultural interventions enhance contributions to food security and SDG 2.1? *Glob Food Secur*, 2020, 26, 100450.
53. Lal R. Food security impacts of the "4 per Thousand" initiative. *Geoderma*, 2020, 374, 114427.
54. INRA, IRD, CIRAD. "4 Per Thousand", Carbon Sequestration in Soils. Ministere De L'Agriculture De L'Enseignement Superieur

- et de la Recherche. 2016, Paris, France.
55. U.N. 2015. Transforming Our World: The 2030 Agenda for Sustainable Development. 23rd August 2015, U.N., New York, USA.
56. Bouma J., Montanarella L., Evanylo G. The challenge for the soil science community to contribute to the implementation of the UN Sustainable Development Goals. *Soil Use Manag*, 2019, 35, 538-546.
57. Gebremedhin S., Bruneel S., Getahun A., Anteneh W., *et al.* Scientific methods to understand fish population dynamics and support sustainable fisheries management. *Water*, 2021, 13, 574.
58. Yin C., Pereira P., Hua T., Liu Y. *et al.* Recover the food-energy-water nexus from COVID-19 under Sustainable Development Goals acceleration actions. *Sci Total Environ*, 2022, 817, 153013.
59. Anser M.K., Godil D.I., Aderounmu B., Onabote A. *et al.* Social inclusion, innovation and food security in West Africa. *Sustainability*, 2021, 13, 2619.
60. Otekunrin O.A. Investigating food insecurity, health and environment-related factors, and agricultural commercialization in Southwestern Nigeria: evidence from smallholder farming households. *Environ Sci Poll Res*, 2022, 29, 51469-51488.
61. Nhamo L., Mpanzeli S., Senzanje A., Liphadzi S. *et al.* Transitioning toward sustainable development through the water-energy-food nexus. *Sustaining Tomorrow via Innovative Engineering*, 311-332.
62. Olabi A.G., Alami A.H., Ayoub M., Aljaghoub H. *et al.* Membrane-based carbon capture: Recent progress, challenges, and their role in achieving the sustainable development goals. *Chemosphere*, 2023, 137996.
63. Olabi A.G., Abdelkareem M.A., Al-Murisi M., Shehata N. *et al.* Recent progress in Green Ammonia: Production, applications, assessment; barriers, and its role in achieving the sustainable development goals. *Energ Conver Manag*, 2023, 277, 116594.
64. Kumar M., Raut R.D., Jagtap S., Choubey V.K. Circular economy adoption challenges in the food supply chain for sustainable development. *Bus Strat Environ*, 2023, 32, 1334-1356.
65. Cluver L.D., Orkin F.M., Meinck F., Boyes M.E. *et al.* Can social protection improve sustainable development goals for adolescent health? *PLOS ONE*, 2016, 11, e0164808.
66. Byerlee D., Fanzo J. The SDG of zero hunger 75 years on: Turning full circle on agriculture and nutrition. *Glob Food Secur*, 2019, 21, 52-59.
67. Kumar M., Sharma M., Raut R.D., Mangla S.K. *et al.* Performance assessment of circular driven sustainable agri-food supply chain towards achieving sustainable consumption and production. *J Clean Prod*, 2022, 372, 133698.
68. Olabi A.G., Alami A.H., Ayoub M., Aljaghoub H. *et al.* Membrane-based carbon capture: Recent progress, challenges, and their role in achieving the sustainable development goals. *Chemosphere*, 2023, 320, 137996.
69. Cluver L., Pantelic M., Orkin M., Toska E. *et al.* Sustainable Survival for adolescents living with HIV: Do SDG-aligned provisions reduce potential mortality risk. *J Int AIDS Society*, 2018, 21, e25056.
70. von Braun J., Sorondo M.S., Steiner R. Reduction of Food Loss and Waste: The Challenges and Conclusions for Actions. *Science and Innovations for Food Systems Transformation*, 2023, 569-578.
71. Wuni, I.Y., Shen G.Q.P., Osei-Kyei, R. Scientometric review of global research trends on green buildings in construction journals from 1992 to 2018. *Energy Build*, 2019, 190:69–85.
72. Pizzi, S., Caputo, A., Corvino, A., Venturelli, A. Management research and the UN sustainable development goals (SDGs): a bibliometric investigation and systematic review. *J Clean Prod*, 2020, 276:124033.
73. Otekunrin, O.A., Otekunrin, O.A. Healthy and Sustainable Diets: Implications for Achieving SDG2. W. Leal ilho *et al.* (eds), Zero Hunger, Encyclopedia of the UN Sustainable Development Goals, 1-21.
74. Tumushabe J.T. Climate Change, Food Security and Sustainable Development in Africa. In: Oloruntoba S, Falola T. (eds) The Palgrave Handbook of African Politics, Governance and Development. *Palgrave Macmillan*, New York, 2018, 853-868.
75. Otekunrin OA, Otekunrin OA, Momoh S, Otekunrin, O.A. Assessing the Zero

- Hunger Target Readiness in Africa: Global Hunger Index (GHI) patterns and Indicators: Proceedings of the 33rd Annual National Conference of the Farm Management association of Nigeria (FAMAN), 7th-10th October, 2019, 456-464.
76. Otekunrin, O.A. Is Africa ready for the SDG 2 (Zero Hunger) Target by 2030? *Curr Agric Res J*, 2021, 9(1): 01-03.
77. Kent G. *Caring About Hunger*. Sparsnäs, 2016, Sweden: Irene Publishing
78. Kent G. Are we serious about ending Hunger? *World Nutr*, 2019, 10(3): 3-22.
79. El-Jardali, F., Ataya, N., Fadlallah, R. Changing roles of universities in the era of SDGs: rising up to the global challenge through institutionalising partnerships with governments and communities. *Health Res Policy Sys*. 2018, 16:38.
80. Didegah, F., Thelwall, M. Which factors help authors produce the highest impact research? Collaboration journal and document properties. *J Informetrics*, 2013, 7(4), 861–873.
81. Gush, J., Jaffe, A., Larsen, V., Laws, A. The effect of public funding on research output: the New Zealand Marsden fund. *N Z Econ Pap*. 2017, 52 (2), 227–48.
82. Al-Moghrabi, D., Tsihlaki, A., Pandis, N., Fleming, P.S. Collaboration in orthodontic clinical trials: prevalence and association with sample size and funding. *Prog Orthod*. 2018 (1), 19, 16.
83. Drivas, K., Balafoutis, A.T., Rozakis, S. Research funding and academic output: evidence from the Agricultural University of Athens. *Prometheus*. 2016, 33 (3), 235–56.
84. Asubiaro, T. How collaboration type, publication place, funding and author's role affect citations received by publications from Africa: a bibliometric study of LIS research from 1996 to 2015. *Scientometrics*. 2019, 120(3), 1261–87.
85. Zhang, F., Yan, E., Niu, X., Zhu, Y. Joint modeling of the association between NIH funding and its three primary outcomes: patents, publications, and citation impact. *Scientometrics*. 2018, 117