RJOAS: Russian Journal of Agricultural and Socio-Economic Sciences
ISSN 2226-1184 (Online) | Issue 4(148), April 2024

UDC 339

EFFECTS OF ENVIRONMENTAL FACTORS ON CROP PRODUCTION IN BRICS

Damiyano Luwisa*, Researcher
Netswera Fulufhelo, **Dorasamy Nirmala**, Professors
Faculty of Management Sciences, Durban University of Technology, Durban, South Africa
*E-mail: luwched@gmail.com

ABSTRACT
This study investigated the effect of environmental factors on crop production in BRICS countries. The systematic literature review was used in this study, and the bibliometric analysis was used to find data for this systematic search. The results show that there is a growing interest in the study area. It is indicated that environmental factors are a major variable that affects crop production in the BRICS. This is justified by the number of publications in the subject area, the number of affiliations, funding, co-occurrences, co-citations, keywords, author collaborations, and country collaborations. Thus, it shows that crop production and environmental factors should not be taken as simple matters but as major concerns that require countries to work together. This will help countries share their experiences on how to improve crop production. This study encourages BRICS countries to engage in the goal of improving agricultural production and output. More so, policymakers should design policies that will improve environmental factors so as to ensure sustainable agriculture development. In addition, these countries should adopt climate-smart agriculture to enhance crop production because the study found that climate change and crop production have a positive and significant association.

KEY WORDS
Crop, environmental, BRICS, production.

BRICS countries have been arguably facing different levels of economic growth and development due to the heterogeneity of agricultural production, and such imbalances cause a large percentage of the population to live under the threat of food insecurity and poor quality of life. One of the major issues that this study focuses on is environmental factors, as Asmare et al. (2019:518-535) argue that crop life is highly proximate to environmental challenges. This unequivocally becomes a mantra for BRICS countries that endeavor to push the goal of promoting the growth of agricultural productivity so as to end poverty, hunger and income inequality.

In addition, Descheemaeker et al. (2018:282-295) asserted that environmental problems are detrimental to total factor productivity, thus leading to low agricultural production. Furthermore, Cedrez et al. (2020: 15) argued that agricultural productivity is a pre-requisite and a foundational industry for human beings, which laterally contributes to employment creation, an increase in GDP, a source of foreign currency, etc. Njoronje et al. (2018:49) noted that it must be a rule of thumb for every country to ensure the growth and stability of the agriculture sector so as to build a foundation for the prosperity of their economies.

However, Rhodes and Atewamba (2019:35-78) noted that, as a result of environmental factors, countries are failing to attain sustainability in agriculture production. BRICS economies are still fostering industrial development; therefore, due to toxic gases, such as Greenhouse gas emissions, these countries are victims of high climate change, which is one of the greatest factors that causes agricultural fragility among these countries. FAO et al. (2018) argued that, if the current situation of GHG emissions and climate change continues, by the year 2100 there will be a decline in the production of major cereal crops (20–45% in maize yields, 5–50% in wheat, and 20–30% in rice). Hence, if the trends continue, in the very near future, crop losses may increase at an unprecedented rate, which

will substantially contribute to reduced production and spiked food prices, and it will become difficult to cope with the rising needs of a growing population.

Furthermore, Hansen et al. (2019:28-46) the increasing demand for food due to an ever-growing population has resulted in intensive agricultural practices, including unprecedented use of agrochemicals, livestock generation, exploitation of water resources, etc. This has further aggravated the situation by releasing GHG due to agricultural activities, resulting in pollution of natural resources (Kurgat et al. 385-398). Thus, it becomes unambiguous that to restore and maintain the development of agricultural production, scientists, agricultural experts, and scholars must develop their enthusiasm by conducting different methodological frameworks for the study of environmental effects on agricultural production. It is therefore the thrust of this study to pinpoint the impact of environmental factors on crop production for BRICS countries, in which the major crops that this study intends to focus on are maize, wheat, and soy bean.

According to the systematic literature reviews that studied the effect of climate change on maize production in the BRICS, it is shown these countries are investing heavily in encouraging the detrimental effects of climate change (Fonta et al. 2018:11). It is shown by a growing number of publications, total citations, co-citations, country affiliations, institutions, and country collaborations towards the concepts of wheat, soy bean, and maize production and climate change. However, most of the systematic literature review exhibited that a large number of studies related to crop production and environmental factors are done in China, South Africa, and Russia, and they have shown little interest in the study area.

Aksenov (2021: 273-296) argued that countries that have invested much in research and development in a certain economic development area would quickly benefit from finding possible alternative ideas that would accelerate development. In light of this, China's agricultural productivity is growing rapidly as compared to other BRICS countries. The diagram below illustrates the production of maize for BRICS countries, and it is depicted that China, due to their diligence, has their institutions working tirelessly towards improving the agriculture sector.

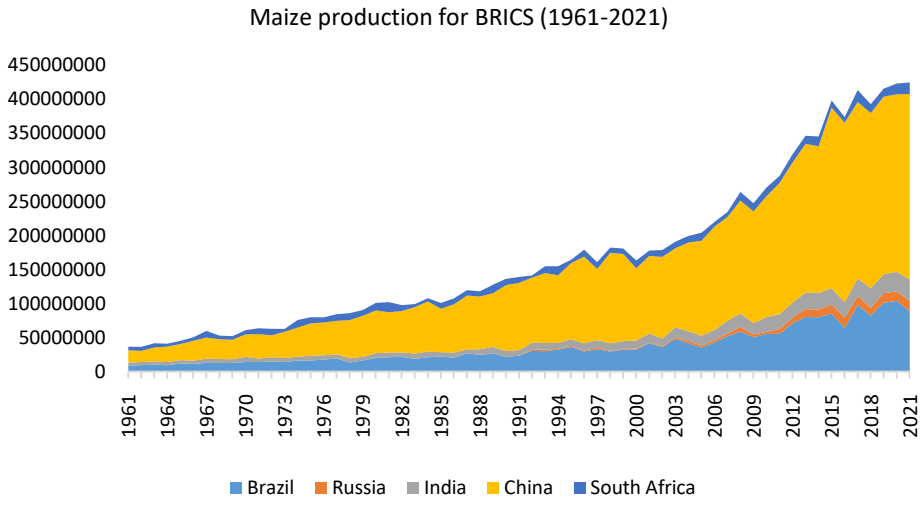

Figure 1 – Maize production for BRICS (Adapted from World Bank dataset)

In addition, apart from maize production, FAO (2022: 5) added that in relative value, in wheat production, China between 1961 and 2021 had a high relative change of 1414%, followed by India with 879%, Russia with 634%, and Brazil with 614%. However, in soy bean production, Brazil had a high relative change of 646% during the same period, while China had 491%, India had 308%, South Africa had 195%, and Russia had 13%, respectively.

Against this background, it is shown that the world is still under threat from climate change and other environmental factors, which have a negative impact on crop production.

The main concern of this study is examining the effect of environmental factors on crop production. In order to meet this primary objective, this study used a systematic literature review. Systematic literature review is the process of synthesizing scientific evidence from all the relevant literature to derive an answer to a certain research question in a clear and reproducible manner (Rethlefsen et al. 2015:617–626).

The reason for conducting this methodological approach is that it has been argued to significantly minimize subjective bias as compared to applied, descriptive, and quantitative methodologies. The bias in this systematic review can be reduced through the selection process and inclusion of studies by assessing the quality of the studies that have been included and summarizing them objectively (Rethlefsen et al. 2015:617–626). In addition, this study used the PRISMA flow chart approach.

The structure of this study is organized as follows: The first section comprises an introduction, where the study derived a detailed explanation of environmental factors and crop production; the second section comprises the research methods, where the procedures used to partake in and collect data have been presented. The third section comprises data analysis and presenting all the information relevant to the literature search. Finally, the fourth section, composed of a summary and conclusion,

MATERIALS AND METHODS OF RESEARCH

This study adopted the VOSviewer database to search publications, with the period selection spanning from 2012 to 2023. The rationale behind selecting this period is that, according to the VOSviewer database, the studies that contain the keywords related to the current search started to be published in 2012; therefore, any publications published before 2012 are not considered in this study. The retrieval date was July 21, 2023. The search statement is "environmental factors," "crop production," and BRICS." The Vosviewer is currently one of the primary sources for most bibliometric analyses. The study was limited to documents published in English. We chose categories including Environmental Science, energy, social science, engineering, economics, econometrics, finance, business, management, and accounting, agricultural and biological sciences, computer science, mathematics, earth and planetary sciences, biochemistry, genetics, and molecular biology. We finally selected original research and review articles, filtering publication to 16403 records. As an exclusion criterion, the study selected the studies that contain keywords that are not related to environmental factors and crop production. The timeframe spanned more than 11 years, making analysing the structure and trends of knowledge domains more typical. To ensure an accurate search, our theoretical approaches consider what is now understood as environmental factors such as climate change, rainfall, relative humidity, soil fertility, carbon dioxide emissions and these constitute the independent variables of this study, while crop production is expressed as the dependent variable.

In addition, the theme of this study is the effect of environmental factors on crop production in the BRICS. This study focuses much on the changes in the environment and agricultural output in BRICS countries. Special attention is devoted to whether environmental factors would cause crop production to increase, decrease, or not affect agricultural output. Eventually, relevant policy implications will be articulated so as to help the regional bloc (BRICS) maintain sustainable agricultural production.

Kurgat et al. (2020:55) stress that bibliometric analysis is one of the significant analytical methods that various researchers use to analyze documents. Fur 2023 asserted that bibliometric analysis helps the researcher review all the statistical results of research publications that have been using bibliometric analytical tools, such as VOSviewer and bibliometrics. Bibliometrix is a significant research-tool that is used to perform bibliometric analysis. With a complete process of data import, transformation, analysis, and scientific visualization. Zhao et al. (2018:85-94) noted that bibliometrics is used to make diagrams and tables, including thematic maps, evolution maps, network maps, cocitation networks, co-authorship networks, and co-occurrence networks. VOSviewer is a program developed to construct and view bibliometric maps. The program is freely available to the bibliometric

research community. Therefore, we use VOSviewer, which also has three types of visualization: network, overlay, and density. It is color-coded depending on the popularity and similarity of the studies. The line used in the interconnection of words also changes in contrast.

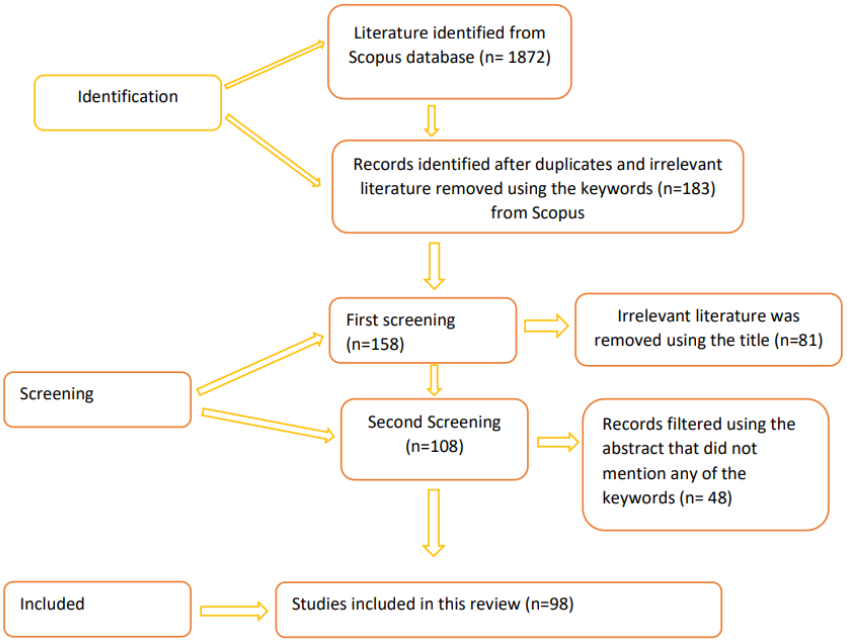

Figure 2 – PRISMA flow chart

The colour becomes vibrant as the word is commonly used in different studies. The viewing capabilities of VOSviewer are particularly useful for analyses that contain at least a moderate number of items. In addition, this study used the PRISMA flow chart approach. The advantage of using this approach is that it guarantees the consistency and completeness of the research process (Moher et al., 2015:145–15). The approach also assists in showing the number of studies that were assessed, the sources, the included and excluded studies, and the reasons.

RESULTS AND DISCUSSION

Initially, the study summarises the data and creates a network diagram of all the documents and statistical data retrieved from the VOSviewer database. The diagrammatic network shown in Table 1 below visualizes two categories: performance analysis and science mapping. The performance analysis category is made up of key terms retrieved from the Scopus database, such as publication-related, citation-related, citation publication-related, and author-related metrics. While science mapping contains the statistical results retrieved from VOSviewer, for instance, network visualization, overlay and density, co-occurrence analysis, co-citation, etc.

By combining these two bibliometric statistical results (performance analysis and science mapping), this study will be able to examine the current situation of environmental components and their effect on crop production in BRICS economies, as well as identify the degree of citation of literature relevant to environmental and crop production and the overall level of the authors. The VOSviewer in this study retrieved about three types of graphs: network, overlay, and density visualization maps. These three kinds of diagrams represent co-occurrence, citation, and co-citation analyses. The table below indicates the statistical summary of the bibliometric analysis.

Figure 3 below depicts the changes in the number of publications related to the current systematic search from 2012 to 2023. The statistical results indicated that in 11 years

(2012–2023), the average growth rate of published papers stood at 15.76%. The table shows a steady growth in the rate of publications between 2012 and 2017, as on average about 2 documents were published annually. In response to this poor campaign on environmental factors affecting crop production, various organizations made different efforts to encourage countries to invest heavily in research and development in agriculture. For instance, the United Nations, through the 17 SDGs, the Food and Agricultural Organization, and other affiliated institutions, have initiated funding programs with the mantra of finding ways in which agricultural production has been improved. As a result, from 2018 to 2023, the rate of published documents grew substantially, reaching 26.49%. There have been massive campaigns from every corner of the world, as climate change is seen as the topic of the day. Wolka et al. (2018:30-45) conducted a bibliometric analysis of the effect of climate change on agricultural productivity in Sub-Saharan Africa. They found that the number of documents published grew at an average rate of 5.45% per year between 2007 and 2018. In addition, Suckall et al. (2018:946-957) found that in G7 countries, there is a rapid growth in the publication of papers related to climate change and agricultural production. This clearly shows that special attention is needed since environmental factors, such as climate, rainfall pattern, temperature, land conservation, etc., are the most important factors that affect crop production. Figure 3 below indicates an overview of documents published per year.

Table 1 – Summary of Bibliometric Analysis

Bibliometric Analysis		
Performance analysis ⇩		*Science mapping* ⇩
Publication-related metrics • Total publications • Documents by affiliation • Number of journals • Co-authorship per publication	Value 24980 5054 158 12.85	VOSviewer • Network visualisation • Network overlay • Network density
Citation-related metrics • Total number of citation • Total number of references	Value 589 680 160	Co-occurrence analysis • Author keywords • Keywords index • All keywords
Citation-publication related papers • Collaboration index • Average citations per publication • Average citation per year publication	Value	Citation analysis • Documents • Journals • Authors • Countries • Organisations
Author-related metrics • Author appearances • Authors per publication • Number of contributing authors	Value	Co-citation analysis • Cited references • Cited sources • Cited authors

Source: Scopus search and VOSviewer database, 2023.

The United Nations (2015:6), through the 17 SDGs, has a total of 169 targets and 244 indicators; however, about 93 of them are environmentally related. Thus, the environmental factors that are argued to be detriments to agriculture production are climate change, natural resource management, biodiversity and ecosystems, environmentally sound management of chemicals and waste, etc. Through these initiatives by the United Nations, the concept of environmental conservation has become one of the hot topics that has been put at the forefront of everything. Devetak et al. (2017:1–599) performed quantitative research on the impact of environmental issues on agricultural production and found a significant and positive relationship between agriculture and climate change. They also found bidirectional causality between these two variables. This clearly shows that it is of paramount importance for every nation worldwide to work tirelessly towards the goal of environmental protection to ensure food security. In addition, Edokpayi et al. (2020:83–115) asserted that policymakers

should understand the concept of environmental factors and crop production to better design policies that promote agriculture production, thereby ensuring food security. Fu (2015:1-434) carried out a systematic literature review on the effects of climate change and institutional qualities on agricultural productivity in Asian countries and found a notable increase in the rate of publication, thus also showing a growing interest in the concept of the link between institutional qualities and crop production. In line with this empirical evidence, this study shows a growing interest among various scholars studying the effect of environmental factors on agricultural production.

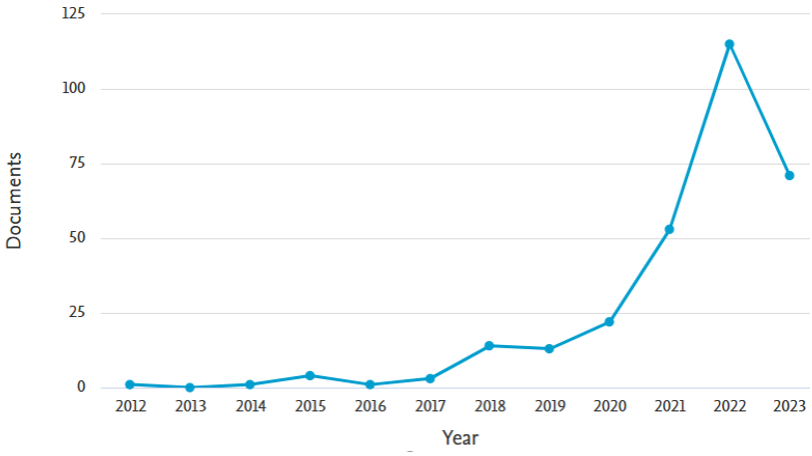

Figure 3 – Publication output by year

The table below summarises the top 10 most cited documents by affiliation and publication by authors. The results show that according to the number of total citations, total citations per year, and local citation scores, Zhang et al. (2015), published in the journal of Environmental Science with China Agricultural University in China in 2015, are cited the most (3,305 times) and have a 125 h-index. Zhang et al. (2015) studied the effects of environmental change on livestock production. Ashraf et al. (2014), published in the journal Energy with the University of Lahore in Pakistan, have a total citation count of 34663, 1030 total documents, and a 95 h-index. Siddique et al. (2018) have a total citation count of 20350 and a total number of documents of 814. Reynolds (2018), published in the Economics, Econometrics, and Finance journal at the Centro Internacional de Maiz y Trigo in Mexico, has 14063 total citations, 274 total documents, and an 81 h-index.

In addition, Chen et al. (2019), published in the journal of Business Management and Accounting with Southwest University, have total citations of 13517 and 358 total documents; Tesfaye et al. (2018:410-419), published in the journal of Agricultural and Biological Sciences with Florida University in the United States, has 13113 total citations, 522 total documents, and a 69 h-index. These results indicated that China is the leading country with the most published papers related to crop production and environmental factors, followed by Pakistan, Australia, Oman, Mexico, the United States, Bangladesh, and Germany. These results indicated that there is a growing interest in the subject area, despite other countries still lagging behind. However, considering the BRICS countries, more research has been done in China. More importantly, it means that countries with more publications are performing better in terms of their crop productivity.

Co-citation is a bibliographic analysis method that indicates a connection between two documents that are both cited by an identical third document. The co-citation analysis of VOSviewer software includes cited references, cited sources, and cited authors, which can help find close relationships between articles, journals, and authors in that field. In the co-citation network, a cluster can be defined as a group of well-connected articles in a research field, and the connection with articles in other clusters or research fields is limited. Among the 1963–13 cited references, according to the calculated total strength of links with other cited references.

Table 2 – Top 10 citation, Affiliation, total documents

Name	Latest Affilation	Affiliation by Country	Total citations	Total documents	h-index
Zhang, Fusuo, 2015	*China Agricultural University*	China	35305	864	125
Ashraf, Muhammad Yasin, 2013	*University of Lahore*	Pakistan	34663	1030	95
Siddique, Kadambot H.m., 2018	*The University of Western Australia*	Australia	20350	814	86
Farooq, Muhammad Ahsan, 2016	*Sultan Qaboos University*	Oman	18092	492	76
Reynolds, M. P. 2019	*Centro Internacional de Mejoramiento de Maiz y Trigo*	Mexico	14063	274	81
Chen, Xinping., 2018	*Southwest University*	China	13517	358	74
Hoogenboom, Gerrit, 2016	*University of Florida*	United States	13113	522	69
Hasanuzzaman, Mirza., 2017	*Sher-e-Bangla Agricultural University*	Bangladesh	12157	338	71
Peng, Shaobing., 2016	*Key Laboratory of Crop Ecophysiology and Farming System in the Middle Reaches of the Yangtze River*	China	12093	290	70
Ewert, Frank., 2020	*UniversitÃ¤t Bonn*	Germany	12022	239	66

Source: Scopus Search, 2023.

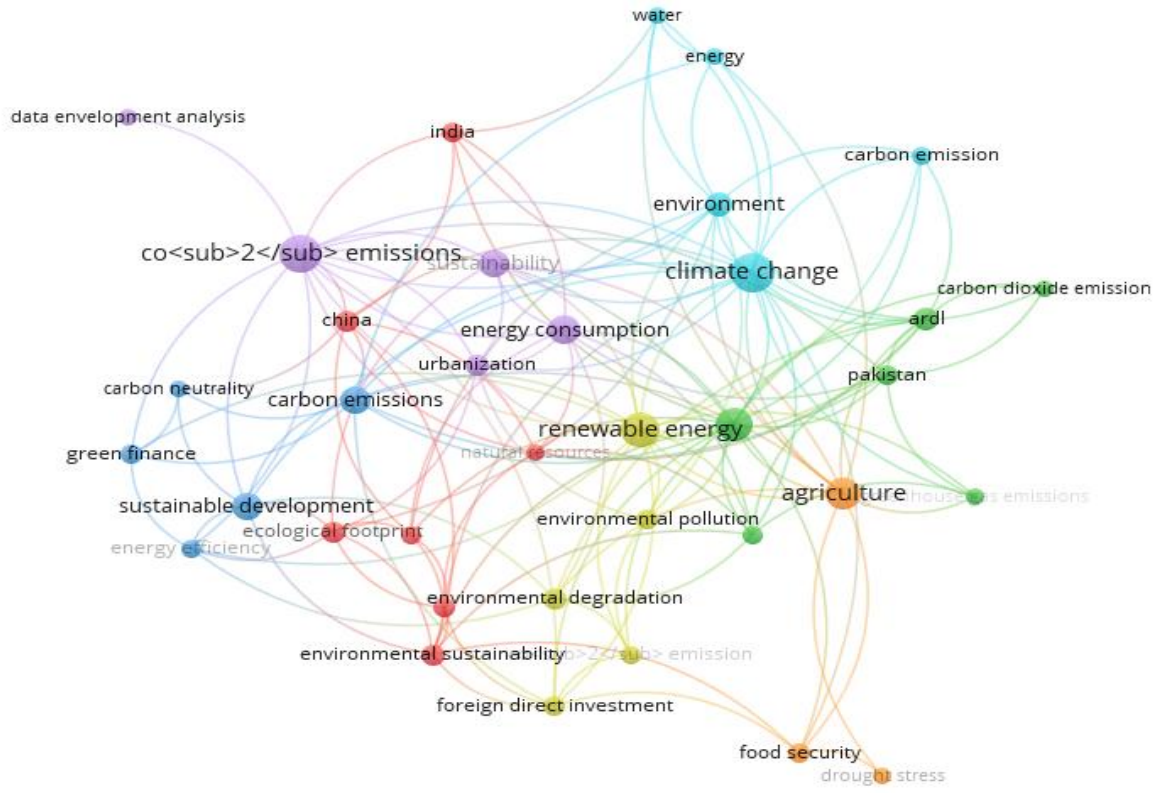

Figure 4 – Co-Citation Network Analysis

There is Figure 4 for co-citation network composed of the top 30 influential articles (each with more than 60 cited references) shown in the figure, which has a small table of

information for the top 3. The reason for choosing the top 50 articles for the network diagram is that 50 items can display the main content of the graph reasonably when drawn without cluttering the graph because of too many items.

Figure 5 below depicts the findings from the Vosviewer software. It exhibits the most cited keywords used by authors in the published documents related to the systematic search indicated in this study. The results visualize that over the past 11 years of publications, about 98 papers were found with 1342 keywords related to crop production and environmental factors; however, out of those 1342 keywords, only 480 of the most important keywords were visualized in the map below. The bibliometric coupling visualizes that these keywords are captured into nine (9) clusters, and each cluster contains a group of keywords that are similar to each other in the research field. This resembles that; scholars are working hard to promote the protection of environmental issues as they affect various sectors of the economies.

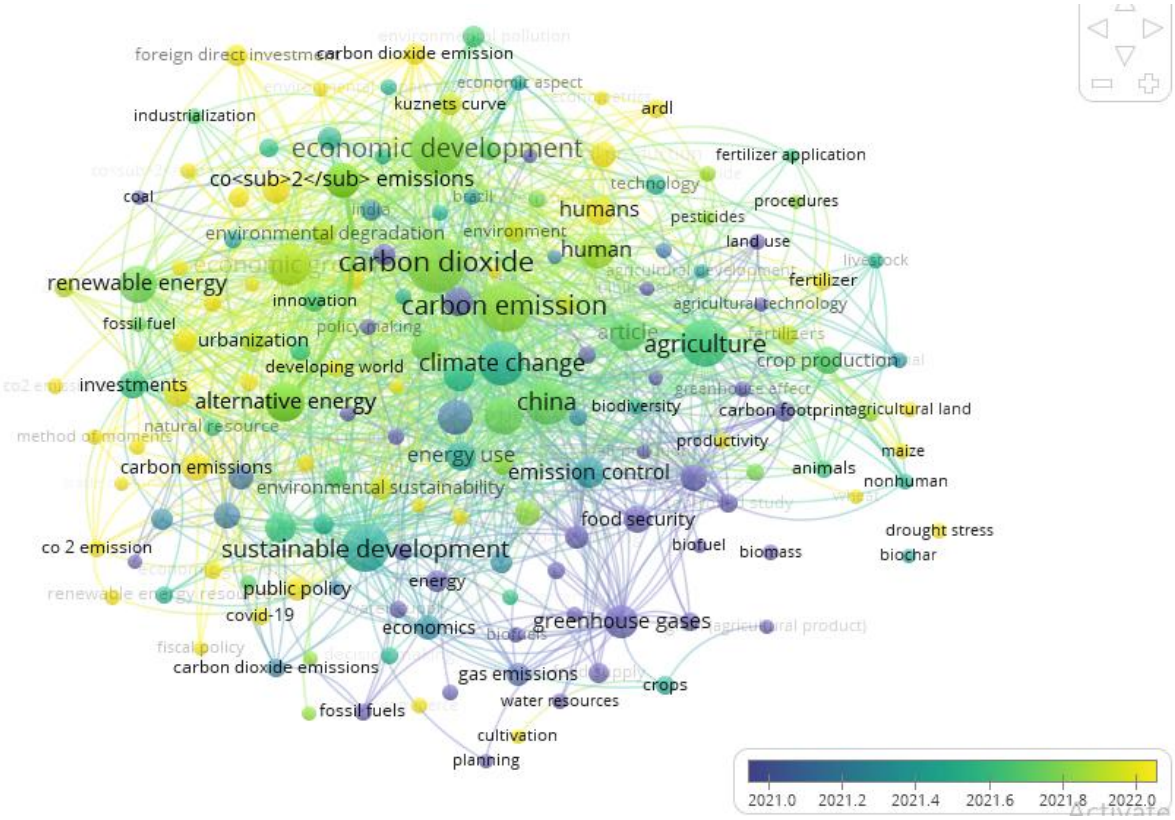

Figure 5 – Co-occurrence keyword analysis

The study on the effect of environmental factors on crop production reported the need for countries to collaborate towards a common goal. The results indicated that the number of publications retrieved from 2012 to 2023 had an annual growth rate of 5.45%, and the number of citations, documents, co-citations, co-occurrences, all keywords, collaborations, and affiliations had increased. This outlines the complexity of the component environmental factors affecting crop production. This shows that environmental factors have a significant impact on crop production in BRICS countries. Tongwane and Moeletsi (2018:124-134) indicated that environmental problems lead to decreased crop production and are caused by changes in temperatures and precipitation patterns. Rhodes and Atewamba (2019:35-78) asserted that a persistence increase in weather conditions would accelerate droughts and soil degradation, which eventually leads to a reduction in crop production. In addition, Oremo et al. (2021:1371-1391) noted that a persistent increase in warm temperatures would attract pests and diseases, which would compromise total crop yields. Furthermore, climate change can also be associated with an increase in the frequency and intensity of storms, which

eventually leads to floods and soil erosion, thus causing crop failure. Olubode et al (2018:75-100) reiterated that, in areas in which agricultural production is taking place in coastal areas, changes in the sea level will have detrimental effects on crop production.

However, this clearly supports the results obtained in this study: environmental factors have a significant impact on food security as persistent increases in temperatures cause a decline in crop yield and thus shortages. Tarfasa et al., (2018:410-419) argued that the BRICS countries are failing to account for the variations in the output of some important crops, resulting in food insecurity and inequality. However, the Food and Agricultural Organization (2022:15–35) and the United Nations (2022:15) reported that environmental, socio-economic, and technological factors were the major causes of food insecurity in the BRICS. For instance, about 30 million people in South Africa are living under the threat of food insecurity, while 307.7 million people in India will be living under chronic hunger and severe food insecurity in 2021. In China, about 1.4 billion people are under threat of food insecurity, and 33.1 million in Brazil are currently facing severe food insecurity. Therefore, this situation has made a clarion call for BRICS countries to come together with mitigation measures to fight against environmental issues.

CONCLUSION

This study investigated the effect of environmental factors on crop production in BRICS countries. The systematic literature review was used in this study, and the bibliometric analysis was used to find data for this systematic search. The results show that there is a growing interest in the study area. It is indicated that environmental factors are a major variable that affects crop production in the BRICS. This is justified by the number of publications in the subject area, the number of affiliations, funding, co-occurrences, co-citations, keywords, author collaborations, and country collaborations. Thus, it shows that crop production and environmental factors should not be taken as simple matters but as major concerns that require countries to work together. This will help countries share their experiences on how to improve crop production. This study encourages BRICS countries to engage in the goal of improving agricultural production and output. More so, policymakers should design policies that will improve environmental factors so as to ensure sustainable agriculture development. In addition, these countries should adopt climate-smart agriculture in order to enhance crop production because the study found that climate change and crop production have a positive and significant association.

REFERENCES

1. Agula, C., Akudugu, M.A., Dittoh, S., et al., 2018. Promoting sustainable agriculture in Africa through ecosystem-based farm management practices: evidence from Ghana Agric. Food Secur. 7, 5.
2. Agula, C., Mabe, F.N., Akudugu, M.A., et al., 2019. Enhancing healthy ecosystems in northern Ghana through eco-friendly farm-based practices: insights from irrigation scheme types BMC Ecol. 19, 38.
3. Ahiale, E.D., Balcombe, K., and Srinivasan, C., 2019. Determinants of farm households' willingness to accept (WTA) compensation for conservation technologies in Northern GhanaBiobase Appl. Econ. 8 (2), 211–234.
4. Ali, E., Egbendewe, A.Y.G., Abdoulaye, T., et al., 2020. Willingness to pay for weather index-based insurance in semi-subsistence agriculture: evidence from northern Togo Clim. Pol. 20 (5), 534–547.
5. Asmare, F., Teklewold, H., and Mekonnen, A., 2019. The effect of climate change adaptation strategies on farm households welfare in the Nile basin of Ethiopia: is there synergy or trade-offs? Int. J. Clim. Chang. Strateg. Manag. 11 (4), 518–535.
6. Cedrez, C.B., Chamberlin, J., Guo, Z., et al., 2020. Spatial variation in fertilizer prices in Sub-Saharan Africa PloS One 15 (1), e0227764.

7. Descheemaeker, K., Zijlstra, M., Masikati, P., et al., 2018. Effects of climate change and adaptation on the livestock component of mixed farming systems: a modeling study from semi-arid Zimbabwe Agric. Syst. 159, 282–295.
8. FAO, 2018. In: Lipper, L., McCarthy, N., Zilberman, D., et al. (Eds.), Climate Smart Agriculture: Building Resilience to Climate Change. Springer International Publishing, Switzerland.
9. Fonta, W.M., Sanfo, S., Kedir, A.M., et al., 2018. Estimating farmers' willingness to pay for weather index-based crop insurance uptake in West Africa: insight from a pilot initiative in Southwestern Burkina Faso Agricultural and Food Economics, 6, 11.
10. Hansen, J., Hellin, J., Rosenstock, T., et al., 2019. Climate risk management and rural poverty reduction Agric. Syst. 172, 28–46.
11. Kurgat, B.K., Lamanna, C., Kimaro, A., et al., 2020. Adoption of climate-smart agriculture technologies in Tanzania. Frontiers in Sustainable Food Systems, 4, 55.
12. Kurgat, B.K., Ngenoh, E., Bett, H.K., et al., 2018. Drivers of sustainable intensification in Kenyan rural and peri-urban vegetable production Int. J. Agric. Sustain. 16 (4–5), 385–398.
13. Land Use Policy 73, 1–10. D.P. Akinyi, S.K. Nganga, and E. Girvetz, Regional Sustainability 2 (2021), 130–143.
14. Lankoski, J., Ignaciuk, A., and Jesus, F., 2018. Synergies and Trade-Offs between Adaptation, Mitigation, and Agricultural Productivity: A Synthesis Report OECD Food, Agriculture, and Fisheries Papers OECD Publishing, Paris.
15. Loboguerrero, A.M., Campbell, B.M., Cooper, P.J., et al., 2019. Food and earth systems: priorities for climate change adaptation and mitigation for agriculture and food systems Sustainability 11, 1372.
16. Maredia, M.K., Shupp, R., Opoku, E., et al., 2019. Farmer perception and valuation of seed quality: evidence from bean and cowpea seed auctions in Tanzania and Ghana Agric. Econ. 50, 495–507.
17. Nassary, E.K., Baijukya, F., and Ndakidemi, P.A., 2020. Sustainable intensification of grain legumes optimizes food security on smallholder farms in sub-Saharan Africa: a review Int. J. Agric. Biol. 23 (1), 25–41.
18. Njoroge, R., Otinga, A.N., Okalebo, J.R., et al., 2018. Maize (Zea mays L.) response to secondary and micronutrients for profitable N, P, and K fertilizer use in poorly responsive soils Agronomy, 8 (4), 49.
19. Olubode, O.O., Joseph-Adekunle, T.T., Hammed, L.A., et al., 2018. Evaluation of production practices and yield-enhancing techniques on the productivity of cashew (Anacardium occidentale L.) Fruits 73 (2), 75–100.
20. Oremo, F., Mulwa, R., and Oguge, N., 2019. Knowledge, attitude, and practice in water resources management among smallholder irrigators in the Tsavo Sub-Catchment, Kenya Resources 8, 130.
21. Oremo, F., Mulwa, R., and Oguge, N., 2021. Sustainable water access and willingness of smallholder irrigators to pay for on-farm water storage systems in Tsavo sub[1] catchment, Kenya Environ. Dev. Sustain. 23, 1371–1391.
22. Rhodes, E.R., and Atewamba, C., 2019. Climate change impact factors in ECOWAS Journal of Agriculture and Environment for International Development, 113 (1), 35–78.
23. Suckall, N., Tompkins, E.L., Nicholls, R.J., et al., 2018. A framework for identifying and selecting long-term adaptation policy directions for deltas Sci. Total Environ. 633, 946–957.
24. Tarfasa, S., Balana, B.B., Tefera, T., et al., 2018. Modeling smallholder farmers' preferences for soil management measures: a case study from South Ethiopia Ecol. Econ. 145, 410–419.
25. Teklewold, H., Gebrehiwot, T., and Bezabih, M., 2019. Climate-smart agricultural practices and gender-differentiated nutrition outcomes: empirical evidence from Ethiopia World Dev. 122, 38–53.

26. Teklewold, H., Mekonnen, A., Gebrehiwot, T., et al., 2020. Open access post-harvest grazing and farmers' preferences for forage production incentives in Ethiopia LandUse Pol. 96, 104685.
27. Tesfaye, A., Brouwer, R., van der Zaag, P., et al., 2016. Assessing the costs and benefits of improved.
28. Tongwane, M.I.; Moeletsi, M.E., 2018. A review of greenhouse gas emissions from the agriculture sector in Africa Agric. Syst. 166, 124–134.
29. vom Brocke, K., Kondombo, C.P., Guillet, M., et al., 2020. Impact of participatory sorghum breeding in Burkina Faso. Agric. Syst. 180, 102775.
30. Wolka, K., Sterk, G., Biazin, B., et al., 2018. Benefits, limitations, and sustainability of soil and water conservation structures in the Omo-Gibe basin, Southwest Ethiopia.
31. Zhao, C.L., Yan, Y., Wang, C.X., et al., 2018. Adaptation and mitigation for combating climate change—from single to joint Ecosys. Health Sustain. 4 (4), 85–94.
32. Zougmore, R.B., Partey, S.T., Ouedraogo, M., et al., 2018. Facing climate variability in sub-Saharan Africa: an analysis of climate-smart agriculture opportunities to manage climate-related risks Cah. Agric. 27, 34001. https://doi.org/10.1111/agec.12309.
33. Liefert W. M., Liefert O., Seeley R., and Lee T., 2019. The effect of Russia's economic crisis and import ban on its agricultural and food economies Journal of Eurasian Studies, 10 (2), pp. 119–135. https://doi.org/10.1177/1879366519840185.
34. Linderhof, V., Janssen, V., and Achterbosch, T., 2019. Does agricultural commercialization affect food security? The case of crop-producing households in the regions of post-reform Vietnam Sustainability, 11, pp. 1263–1280. https://doi.org/10.3390/su11051263.
35. Linderhof, V., Janssen, V., and Achterbosch, T., 2019. Does agricultural commercialization affect food security? The case of crop-producing households in the regions of post-reform Vietnam Sustainability, 11, pp. 1263–1280. https://doi.org/10.3390/su11051263.
36. Macro Trends, 2020 India's GDP growth rate for 1961–2020[online] Available at: https://www.macrotrends.net/countries/IND/india/gdp-growth-rate [Accessed on February 2, 2020].
37. McArthur, J. W., and Sachs, D. J., 2019. Agriculture, aid, and economic growth in Africa. World Bank Economic Review, 33(1), pp. 1–20. https://doi.org/10.1093/wber/lhx029.
38. Munn, Z., Stern, C., Aromataris, E., Lockwood, C., and Jordan, Z. (2018), "What kind of systematic review should I conduct? A proposed typology and guidance for systematic reviewers in the medical and health sciences", BMC Medical Research Methodology, Vol. 18 No. 1, p. 5. http://doi.org/10.1186/s12874-017- 0468-4.
39. Murad, M.H., Asi, N., Alsawas, M., and Alahdab, F. (2016), "New Evidence Pyramid,", Evidence-Based Medicine, Vol. 21 No. 4, pp. 125–127. http://doi.org/10.1136/ebmed-2016-110401.
40. Organization for Economic Co-operation and Development (OECD), 2019. Inclusive growth. [online] Available at: https://www.oecd.org/inclusive-growth/inequality-and-opportunity/ [Accessed on December 28, 2019].
41. Rethlefsen, M.L., Farrell, A.M., Osterhaus Trzasko, L.C., and Brigham, T.J. (2015), "Librarian co-authors correlated with higher quality reported search strategies in general internal medicine systematic reviews", Journal of Clinical Epidemiology, Vol. 68, No. 6, pp. 617–626.
42. United Nations, 2020 Sustainable development goals [online] Available at: <https://sustainabledevelopment.un.org/?menu=1300 [Accessed on March 20, 2020].
43. World Bank, 2019. Agriculture and Food, 2019. [online] Available at: <https://www.worldbank.org/en/topic/agriculture [Accessed on December 23].
44. World Bank, 2020 World Bank indicators [online] Available at: <https://data.worldbank.org/ [Accessed on January 1, 2020].