



Global Research on Climate Change and Food Security: A Lesson for Indonesia

Andi Tenri Fitriyah^{1*}, Apiaty Kamaluddin¹, Baharuddin Baharuddin¹, Sulfiana Ardin²,
Tawakkal Baharuddin³

¹ Department of Agribusiness, Bosowa University, Indonesia

² Department of Agribusiness, Makassar Islamic University, Indonesia

³ Department of Government Science, Makassar Muhammadiyah University, Indonesia

Corresponding Author Email: tenri.fitriyah@universitasbosowa.ac.id

Abstract

This research highlights the need for climate change adaptation in Indonesia, a country highly vulnerable to climate change impacts that threaten national food security. This research aims to explore published global studies' findings and identify adaptive solutions that can be implemented in Indonesia. This research method uses bibliometric analysis with the Scopus database as the primary data source. The findings of this study show a significant increase since the early 2000s, dominated by countries such as the United States, India, the United Kingdom, Australia, and China. However, there is an imbalance in the representation of research from other countries, including Indonesia, which faces similar challenges but still needs to be fully represented in the global academic literature. These findings indicate the need for further research in climate change mitigation, livelihoods, nutrition, and resilience. The implications of these findings also highlight the importance of Indonesia increasing carbon absorption capacity, adaptation to climate change, and food system resilience for national sustainability. Integrating these findings into local policies can strengthen adaptive food systems and ensure people's access to safe food in the future, with the support of cross-sector collaboration and green technology.

Keywords: Climate change, food security, sustainable food systems, sustainable agriculture, agricultural resilience, livelihood, nutritional needs

Introduction

The urgency of this research is critical, considering that Indonesia, as an archipelagic country, is vulnerable to the impacts of climate change. Climate change refers to long-term changes in temperature and weather patterns in a region or worldwide [1]. Data shows that an increase in average temperatures in Indonesia, changes in rainfall patterns, and an increase in the frequency of natural disasters such as floods and droughts are detrimental to the agricultural sector [2]. In general, climate change can reduce agricultural productivity [3], threaten national food security, and affect the livelihoods of millions of farmers [4]. This research is very urgent in finding practical and innovative adaptation solutions to reduce the negative impacts of climate change and ensure sustainable food security in Indonesia.

The problem of food security in Indonesia is increasingly complex and urgent due to the actual impacts of climate change. Changes in rainfall patterns cause uncertainty in the growing season while increasing temperatures cause thermal stress in plants and reduce crop yields [5]. More frequent natural disasters, such as floods and droughts, damage agricultural land and irrigation infrastructure, disrupting food supply chains [6]. In addition, climate change affects land productivity and accelerates land degradation, further limiting the ability of agriculture to meet national food needs [7]. As a result, food security is disrupted, food prices rise, and low-income communities are the most affected.

Similar problems are also found in several other countries, where food security is closely correlated with climate change. For example, in Sub-Saharan Africa, climate change is causing prolonged droughts and drastic reductions in crop yields, triggering food crises and famine [8]. Farmers in this region need help adapting to changing climatic conditions and worsening food security. Additionally, in South Asia, countries such as India and Bangladesh face similar challenges with increasing frequency of floods and cyclones that damage crops and agricultural infrastructure [9].

Food security related to climate change is a global problem that is increasingly urgent and complex [10]. In many regions, as described above, climate change is causing increases in average temperatures, unpredictable changes in rainfall patterns, and increased frequency of natural disasters such as floods and droughts. These impacts disrupt agricultural production, reduce crop yields, and damage irrigation infrastructure, threatening food security at the national and regional levels. In addition, climate change is accelerating land degradation and limiting agriculture's ability to meet the population's food needs. This global challenge requires innovative adaptation and mitigation efforts to address the ever-increasing threat to food security worldwide.

Farmers and governments in various countries have taken necessary steps to deal with the impact of climate change on food security. Farmers are starting to adopt sustainable agricultural practices that are more environmentally friendly, such as using plant varieties that are more resistant to heat or drought stress, as well as more efficient water

management and technology [11]. Farmers are also expanding the use of modern technologies, such as weather information systems and precision farming techniques, to improve seasonal predictions and more optimal crop management [12]. On the other hand, governments are investing in better irrigation infrastructure, training farmers on adaptive farming practices, and developing policies that support the diversification of food sources and disaster risk management [13]. This collaborative effort is essential to improve food security amidst the growing challenges of climate change.

In addition, the government is also active in promoting policies and incentives that encourage the use of renewable energy and sustainable agricultural practices [14]. These initiatives include increasing farmers' access to green technologies, such as solar panels for irrigation or organic fertilizers, which help reduce agriculture's carbon footprint and increase resource efficiency. At the international level, cooperation between countries and international organizations is increasingly being increased to exchange knowledge and technology and support the development of adaptive capacity for countries most vulnerable to climate change [15]. This joint effort is essential to create a more resilient and sustainable food system in the future.

Although the issues of food security and climate change have attracted global research attention, more research is needed that explicitly disentangles the complexity of these issues, with a focus on the case of Indonesia. Global studies tend to only partially integrate Indonesia's local context, such as unique geographic, demographic, and socio-economic conditions and specific challenges in agriculture and food security. Apart from that, minimal research still needs to examine this issue using a bibliometric analysis approach. More in-depth and focused research is needed to understand in detail how current global research trends and existing findings can be adapted to the Indonesian context and identify appropriate and sustainable adaptation solutions.

This research aims to explore essential findings from various cases published in the global literature regarding the impact of climate change on food security. This study evaluates these findings to identify patterns, strategies, and practices successfully implemented in other countries, focusing on aspects that Indonesia can learn from and adapt. In addition, this research also examines current research trends in the context of climate change and food security to highlight the latest innovations, methodological approaches, and significant findings that can provide additional insights into developing relevant and effective adaptation solutions for Indonesia. Thus, it is hoped that this study can contribute to increasing Indonesia's adaptive capacity and food security in the future,

Method

This research method uses bibliometric analysis to investigate published climate change and global food security literature. This approach involves identifying, collecting, and analyzing data from various scientific articles in related academic databases. Using bibliometric techniques such as trend analysis and theme mapping, this research describes publication trends, research focus, and the evolution of research topics in this field. This research provides a comprehensive overview of the development and direction of global research related to climate change and food security using a bibliometric analysis approach.

The academic database chosen as the research data source is the Scopus database. The Scopus database was chosen because it extensively covers multidisciplinary scientific literature, including climate change and food security [16]. Another advantage is its ability to access indexed articles that have undergone an expert review process, providing high validity and quality to the data collected [17]. To collect data, this research uses keywords based on document titles, namely "Climate change" and "food security," as the basis for the search, ensuring that relevant and vital documents can be identified and analyzed comprehensively in this bibliometric study.

The data collection results in July 2024 found 899 published documents. The data visualization stage is carried out in two stages: utilizing the analysis results available in the Scopus database and the Vosviewer analysis tool. Data visualization from databases helps display research trends based on the number of documents, affiliations, and frequently cited documents. On the other hand, Vosviewer helps map and analyze research themes that influence discussions around climate change and food security. Analysis using Vosviewer was carried out by moving 889 documents into the analysis tool.

In this study, no specific restrictions were applied regarding publication year, affiliation, document type, or specific subject area other than using the keywords "Climate Change" and "food security" as the basis for the search. This approach allows for data that spans a wide range of geographic contexts, methodologies, and viewpoints in the relevant literature to be included. Without these limitations, bibliometric studies can more broadly capture the range of contributions and perspectives related to climate change and food security globally, ensuring that the data analyzed reflects the diversity and complexity of existing research.

Results And Discussion

Global research trends on climate change and food security

This section reveals several significant findings related to global research trends on climate change and food security. Considering the growing number of documents, this research highlights the increasing interest in this field from various academic institutions and researchers worldwide. Affiliation analysis provides an overview of the contributions of different countries to the scientific literature. At the same time, identifying frequently cited documents shows the research's primary focus and intellectual impact. These findings provide an overview of the dominant information flows in global climate change and food security research.

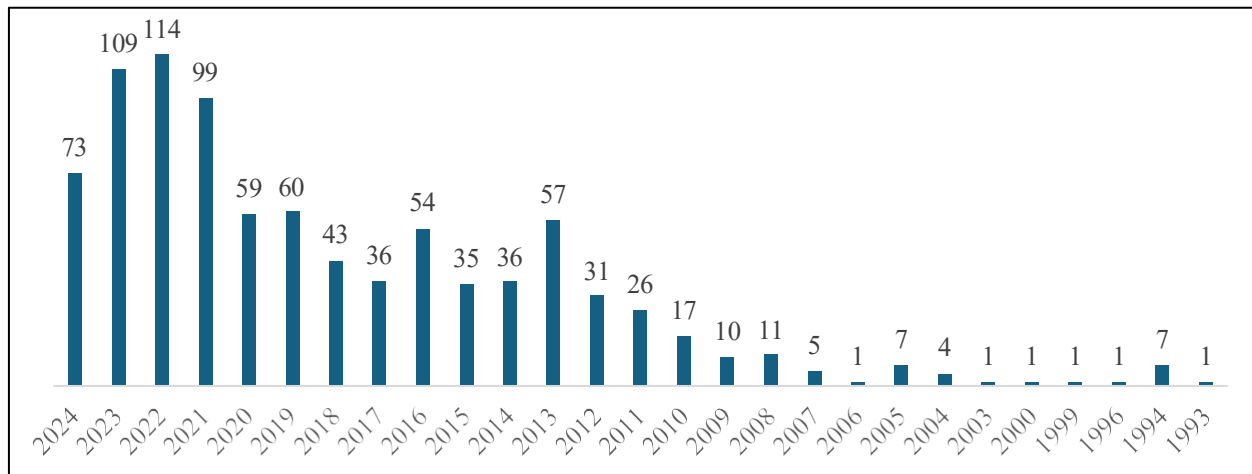


Figure 1. Research trends on climate change and food security based on number of documents

Figure 1 shows research trends on climate change and food security based on the number of documents indexed in the database from 1993 to 2024. The data shows a significant increase in the number of publications on this topic since the early 2000s, with a peak occurring in 2022 with 114 documents, although there was a slight decrease in 2023 and 2024. This reflects increasing interest in understanding the impact of climate change on food security, driven by the need to address increasingly global challenges. The findings also reveal year-on-year variations in the number of documents, reflecting changes in research focus and global priorities regarding climate change and food security. The period between 2010 and 2020 shows fluctuations in the number of publications, while recent years show an increasing trend, indicating that this topic is receiving increasing attention in the global academic literature.

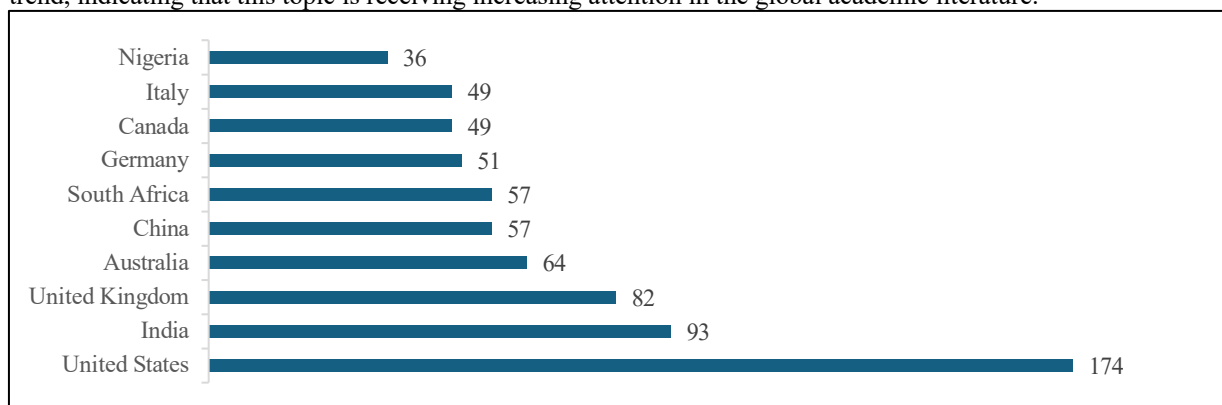


Figure 2. Research trends on climate change and food security based on author affiliation

Apart from the number of documents above, other trends based on the author's country affiliation were also identified in Figure 2.

Figure 2. Research trends on climate change and food security based on author affiliation

Research trends on climate change and food security show the dominance of contributions from countries such as the United States, India, the United Kingdom, Australia, and China in the scientific literature. The United States stands out with 174 documents, followed by India with 93, and the United Kingdom and Australia with 82 and 64 documents, respectively. China and South Africa contributed 57 documents, while Germany, Canada, Italy, and Nigeria also played significant roles with 36 and 51 documents. This research reflects global interest in addressing the challenges of climate change and food security, with widespread contributions from many countries.

The implication of the dominance of countries such as the United States, India, the United Kingdom, Australia, and China in climate change and food security research is that there is strong global attention to these issues from a scientific and policy perspective. The rich literature from these countries reflects their commitment to scientific research in facing this global challenge. It underscores their role in formulating and influencing international policy regarding climate change and food security. It also reflects inequalities in access to resources and research capacity between countries, which must be addressed to ensure an inclusive and effective global response to this challenge.

It is also a fact that the contribution of countries like Indonesia still needs to be improved even though this country has similar challenges in food security and climate change. Although Indonesia is one of the countries with rich biodiversity and significant vulnerability to climate change [18], the contribution of scientific research from Indonesia in this domain has yet to reach a level commensurate with the challenges. This could indicate expanding access, increasing research capacity, and closer international collaboration so that Indonesia can play a more active role in solving this global problem while ensuring sustainable food security and effective climate change mitigation at the national and global levels.

Apart from the trends mentioned above, Table 1 also identified another trend, namely the number of citations. The number of citations reflects how often a scientific work is cited by other researchers in their literature, showing its impact and influence on that field of study [19]. Discussions about the number of citations are essential because they can provide insight into the most influential works and contribute significantly to understanding and handling climate change and food security issues globally.

Table 1. Document with the highest number of citations

Title	Year	Citation
Soil carbon sequestration impacts on global climate change and food security	2004	5,576
Prioritizing climate change adaptation needs for food security in 2030	2008	2,136
Climate change impacts on global food security	2013	1,999
Global food security under climate change	2007	1,394
Simultaneously mitigating near-term climate change and improving human health and food security	2012	968

The main findings of the first study show that the carbon sequestration capacity of agricultural and degraded soils could account for 50 to 66% of historical carbon losses, estimated at 42 to 78 gigatons of carbon. The recommended technology and characteristics, such as soil texture, structure, rainfall, temperature, farming systems, and soil management, influence organic carbon uptake. Strategies to increase soil carbon pools include restoration, forest regeneration, no-till farming, cover crops, nutrient management, fertilizer and sludge applications, improved grazing, water conservation, efficient irrigation, agroforestry practices, and planting energy crops on land-wasted land. Besides increasing food security, carbon sequestration can also reduce fossil fuel emissions by 0.4 to 1.2 gigatons of carbon per year, or around 5 to 15% of total global fossil fuel emissions [20]. Thus, efforts to increase soil carbon sequestration can help overcome global climate change and support the sustainability of the global food system by significantly increasing crop yields.

Findings from the second study highlight the importance of prioritizing the need for adaptation to climate change to achieve food security by 2030. The climate risks to crops in 12 food-insecure regions were analyzed to identify adaptation priorities based on crop statistical models and climate projections from 20 general circulation models. The research results show that South Asia and South Africa are two regions that could experience negative impacts on several crops important for food-insecure human populations if adequate adaptation measures are not taken. In addition, this study found that the level of uncertainty varies widely between crops so that adaptation priorities will be strongly influenced by the risk attitudes of investment institutions [21]. This highlights the need for timely and effective adaptation measures to protect food security in regions most vulnerable to the impacts of future climate change.

Findings from the third study underscore the potential disruption climate change could have on global food security. A strong and consistent pattern of impacts of climate change on crop productivity was found, which could significantly impact food availability. The stability of the overall food system may be threatened due to short-term variability in supply resulting from climate change. Although the impact is not yet clear on a regional scale, it is predicted that climate variability and change will exacerbate food insecurity in regions currently vulnerable to hunger and malnutrition. In addition, food access and utilization are also predicted to be affected indirectly through collateral effects on household and individual income. They may be disrupted by losing access to drinking water and damage to health [22]. This study emphasizes the need for significant investments in adaptation and mitigation measures toward a "climate-smart food system," which is more resilient to the effects of climate change on food security.

The finding of the fourth article is that climate change has the potential to impact global food security significantly. However, only food availability is often considered in simulation studies. Published results show that the impacts of climate change could lead to a significant increase in the risk of famine, with estimates of between 5 and 170 million additional people at risk of hunger by 2080, depending on socio-economic development assumptions. The possible impacts on other critical dimensions of food security, such as stability, utilization, and access, are discussed qualitatively, indicating the potential for further negative impacts beyond those currently evaluated with the model. This article also identifies the strengths and weaknesses of current evaluation studies, suggesting improvements and offering new directions for further analysis [23]. This emphasizes the importance of broadening the scope of research to fully understand how climate change can affect food security and develop appropriate adaptation strategies.

The key findings of the fifth study show that reducing tropospheric ozone and black carbon emissions can improve air quality, reduce global warming, and significantly impact human health and food security. By applying approximately 400 existing emissions control measures, the study identified 14 measures that could effectively reduce global warming by an average of about 0.5°C by 2050 by targeting methane and black carbon emissions. This strategy is also estimated to avoid 0.7 to 4.7 million premature deaths from outdoor air pollution annually while increasing annual crop yields by 30 to 135 million metric tons due to ozone reduction in 2030 and beyond. The benefits of reducing methane emissions are valued at \$700 to \$5000 per metric ton, well above the marginal abatement costs of typically less than \$250. The selected control measures target different sources and affect the climate over a shorter period than carbon dioxide reduction measures. Implementing these two measures significantly reduces the risk of

exceeding the two °C threshold, demonstrating that this approach reduces the impacts of climate change and improves food security and human health simultaneously [24].

These five findings highlight the complexity and urgency of the challenges faced in maintaining food security amidst global climate change. It was found that increasing carbon sequestration by agricultural soils and adapting to climate change could significantly improve global food security while reducing the impacts of climate change. Prioritizing adaptation in South Asia and South Africa is needed to protect vital crops from the negative impacts of climate change. In addition, the need to consider food stability, utilization, and access in response to climate change was emphasized to face future challenges. Concrete measures such as reducing ozone and black carbon emissions also show great potential in improving air quality and increasing crop yields; investing in adaptation and mitigation strategies is essential in realizing a food system resilient to climate change.

Mapping global research themes on climate change and food security

This section maps global research themes on climate change and food security. This analysis identifies and explores key themes emerging in the academic literature, enabling a deeper understanding of the research focus and themes that still require further exploration. Mapping of global research themes on climate change and food security can be seen in Figure 3.

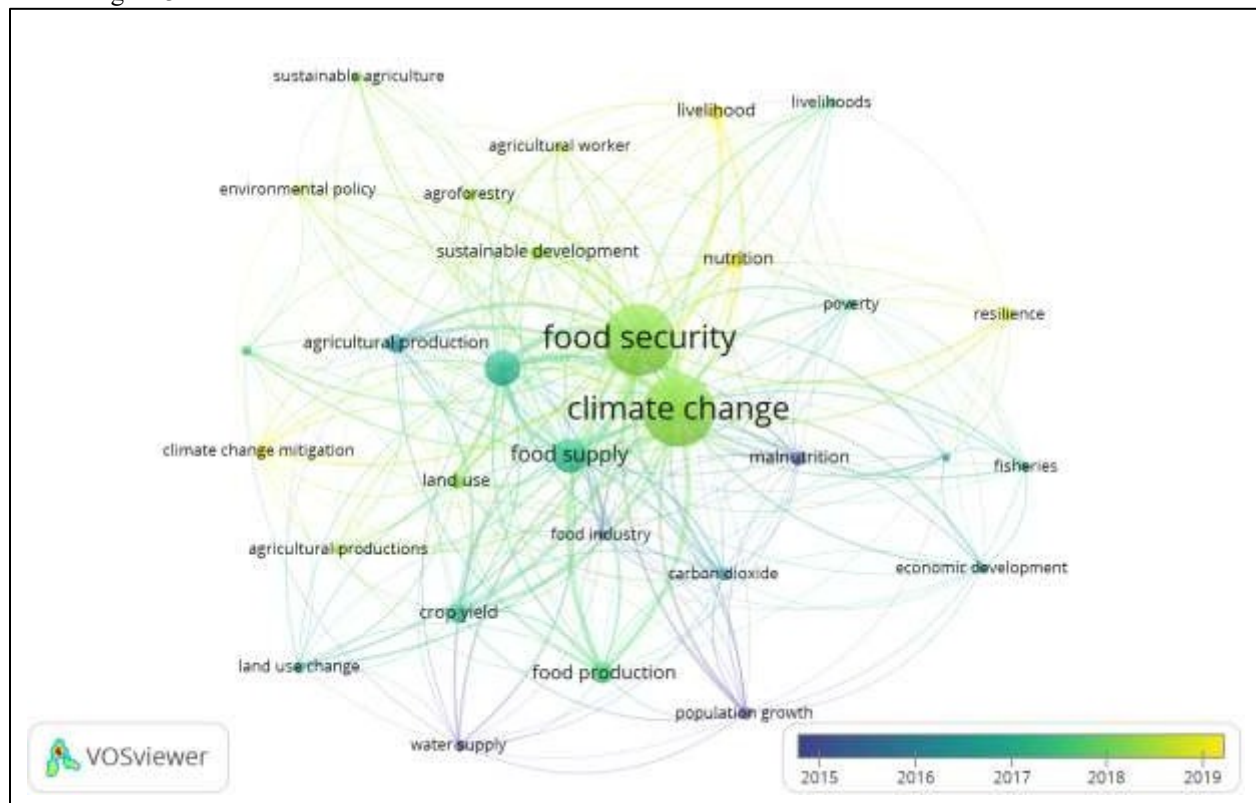


Figure 3. Mapping research themes on climate change and food security

Various research themes influence discussions around climate change and food security. However, several research themes, including climate change mitigation, livelihood, nutrition, dan resilience.

Climate change mitigation refers to efforts to reduce or prevent the long-term impacts of climate change by reducing greenhouse gas emissions and increasing carbon sequestration. In food security, mitigation strategies are essential in protecting agricultural productivity and ensuring stable food supplies amidst changing climate conditions. Mitigation measures aim to limit global warming and reduce disruption to food production systems by reducing emissions from sources such as agriculture, industry, and transportation. Additionally, increasing carbon sequestration through practices such as afforestation, soil carbon sequestration, and sustainable land management helps mitigate climate change and strengthens resilience in agricultural ecosystems [25]. Effective mitigation strategies are critical to maintaining food security by reducing climate-related risks and supporting sustainable food production systems capable of facing future climate challenges.

Climate change has great potential to disrupt livelihoods, especially in the context of food security, with impacts spanning various economic and social sectors. For example, extreme fluctuations in weather patterns, such as drought or floods, can reduce crop yields and threaten the sustainability of traditional agriculture. This affects farmers directly and the entire food supply chain, including distribution, trade, and public access to food [26]. In addition, climate change can affect other sectors related to food security, such as fisheries and livestock, through changes in water temperature and feed availability. These impacts can also exacerbate socio-economic inequalities between rich and poor regions and increase the risk of social conflict related to natural resources. Therefore, protecting livelihoods and

food security from the impacts of climate change requires collaborative efforts in adaptation, mitigation, and capacity building to face these challenges holistically.

Climate change has a significant impact on food security, especially in terms of nutritional aspects. Changes in extreme weather patterns, such as more frequent droughts or floods due to climate change, can disrupt food production and reduce the availability of nutritious food [27]. This has the potential to increase malnutrition in already vulnerable communities, exacerbating stunting, vitamin deficiencies, and other health problems. In addition, climate change can also change the nutritional composition of plants and food resources, potentially affecting the quality of available food. Thus, to overcome the impact of climate change on nutrition and food security, a comprehensive strategy is needed to increase food security by strengthening sustainable food systems and ensuring people's access to safe, nutritious, and sufficient food.

Climate change highlights the need for solid food security, which includes the ability of food systems to survive, recover, and adapt after experiencing external disruptions caused by extreme weather and climate change. Resilience in this context requires the food system to face challenges such as drought, floods, or temperature spikes that can disrupt agricultural production and access to food. Required strategies include agricultural diversification to reduce single-source risks, investment in disaster-resilient infrastructure, and development of policies that support adaptation and innovation in sustainable agriculture [28]. Strengthening the capacity of local communities to manage and adapt to the risks of climate change is also crucial in building resilient food security in the future.

In facing the complex challenges climate change presents for food security, mitigation efforts, restoring livelihoods, improving nutrition, and strengthening food system resilience are very important. Mitigation strategies that effectively reduce greenhouse gas emissions and increase carbon absorption from the soil can maintain the sustainability of food production amidst unstable climate conditions. Meanwhile, protecting livelihoods and improving nutrition through sustainable food systems is crucial to ensuring access to safe and nutritious food for all. On the other hand, strong food system resilience, supported by agricultural diversification, disaster-resistant infrastructure, and community adaptive capacity, will help overcome external challenges that are increasingly occurring due to climate change. Through global collaboration and shared commitment, we can build a solid foundation for sustainable and adaptive food security in the future.

Global research on climate change and food security: A lesson for Indonesia

The findings from the existing study bring a deep understanding of the impact of climate change on global food security, with significant implications relevant to the Indonesian context. First, increasing the carbon sequestration capacity of agricultural and degraded soils has excellent potential to reduce global emissions and increase crop productivity. Practices such as soil restoration, agroforestry, and nutrient management can reduce vulnerability to climate change and support a sustainable food system in Indonesia. This is crucial considering that Indonesia is an agricultural country with challenges to land degradation and wide geographic diversity.

Second, studies on adaptation to climate change highlight the importance of rapid and practical reactions to threats to food security in South Asia and South Africa. These findings are relevant for Indonesia, considering that this country is highly vulnerable to climate change, including threats to crop yields and food availability [29]. Timely and risk-based adaptation strategies are urgently needed to protect farmers' livelihoods and ensure national food security. In addition, investment in climate-smart food systems is also essential to reduce the negative impacts of climate change on public health and the domestic economy as a whole.

Of the four research themes that still require deeper exploration, each has relevant implications for the Indonesian context in facing the challenges of climate change on food security. Mitigating climate change by focusing on reducing greenhouse gas emissions and increasing carbon absorption can make a significant contribution to the sustainability of Indonesia's food system. As a country with high levels of deforestation and rapid economic growth, Indonesia has an excellent opportunity to implement reforestation, agroforestry, and sustainable land management strategies to mitigate the impacts of climate change and increase agricultural productivity [30].

Furthermore, in the context of livelihoods, climate change can threaten the sustainability of farmers and the food supply chain. Extreme weather fluctuations like floods and droughts can reduce crop yields and disrupt farmers' economic stability. Risk-based adaptation strategies, including agricultural diversification and investment in disaster-resilient infrastructure, are critical to protecting the livelihoods of Indonesian farmers and ensuring stable food supplies. Third, the nutritional aspect is crucial because climate change can affect the quality and availability of nutritious food. With various nutritional challenges such as stunting and vitamin deficiencies, Indonesia needs to implement strategies to strengthen a sustainable food system to ensure people's access to safe and nutritious food amidst changes in unstable weather patterns.

On the other hand, strong food system resilience is critical in facing external disturbances caused by climate change. Agricultural diversification, disaster-resilient infrastructure, and community adaptive capacity will help Indonesia reduce its vulnerability to climate fluctuations and strengthen national food security. Overall, integrating findings from global research on climate change and food security provides valuable lessons for Indonesia to develop sustainable and adaptive evidence-based strategies. Collaboration between sectors, investment in green technology, and strengthening local capacity are crucial to building a resilient foundation for food security that can adapt to future climate challenges.

Apart from that, from the findings of this study, Indonesia needs to be actively involved in distributing similar discourse through scientific publications. Even though Indonesia has valuable knowledge and experience in dealing

with the impact of climate change on food security, scientific documentation and publications regarding innovation, adaptation strategies, and research results still need to be improved. By sharing this knowledge widely, Indonesia can strengthen its position in the global arena as a contributor to food sustainability, gain international support, and expand collaboration networks to improve global food security. This is an essential step in ensuring that solutions found in Indonesia can be adopted and implemented effectively in other countries facing similar challenges, moving towards a more sustainable and adaptive future under the pressures of global climate change.

Conclusion

Global research trends on climate change and food security show a significant increase in scientific interest and publications since the early 2000s. Countries such as the United States, India, United Kingdom, Australia, and China dominate contributions in this scientific literature, reflecting these countries' strong commitment and research capacity in facing this global challenge. However, there are apparent disparities in the representation of research from other countries, including Indonesia, which, despite similar challenges to climate change and food security, still needs to be fully represented in the global academic literature. To address this, efforts are needed to expand access, increase research capacity in less participating countries, and increase international collaboration to ensure an inclusive and effective global response to this problem.

These findings also show the importance of developing further research on four main themes, namely climate change mitigation, livelihoods, nutrition, and resilience. An in-depth exploration of the theme of climate change mitigation is needed to identify effective strategies for reducing greenhouse gas emissions and increasing carbon absorption, thereby maintaining the sustainability of the global food system amidst increasingly complex climate change challenges. Meanwhile, further research on the livelihoods theme helps understand how climate change affects livelihoods, especially in vulnerable agricultural communities. Nutrition research is needed to address the impact of climate change on food quality and human health. In contrast, resilience research helps build resilient and adaptive food systems in the face of external disruptions caused by climate change.

Overall, findings from global research on climate change and food security also provide Indonesia with valuable lessons for facing these complex challenges with practical and sustainable strategies. Increasing carbon absorption capacity, responsive adaptation to the threat of climate change, and focusing on mitigation and resilience of the food system are the keys to ensuring national food sustainability and security. By integrating these findings into local policies and practices, Indonesia can strengthen a food system that is adaptive to climate fluctuations, maintain the sustainability of natural resources, and ensure people's access to safe and nutritious food in the future. Cross-sector collaboration and investment in green technology innovation and local capacity building will be essential for building a more sustainable future under the pressure of global climate change.

References

- [1] Sippel, S., Meinshausen, N., Fischer, E. M., Székely, E., & Knutti, R. (2020). Climate change now detectable from any single day of weather at global scale. *Nature Climate Change*, 10(1): 35–41. <https://doi.org/10.1038/s41558-019-0666-7>
- [2] Imelda, & Hidayat, R. (2024). Climate change impacts, adaptation and mitigation in the agricultural sector. *Global Journal of Environmental Science and Management*, 10(3): 1457–1476. <https://doi.org/10.22034/gjesm.2024.03.30>
- [3] Kuswanto, H., Salamah, M., Retnaningsih, S. M., & Prastyo, D. D. (2018). On the Impact of Climate Change to Agricultural Productivity in East Java. *Journal of Physics: Conference Series*, 979(1): 12092. <https://doi.org/10.1088/1742-6596/979/1/012092>
- [4] Sudomo, A., Leksono, B., Tata, H. L., Rahayu, A. A. D., Umroni, A., Rianawati, H., ... Baral, H. (2023). Can Agroforestry Contribute to Food and Livelihood Security for Indonesia's Smallholders in the Climate Change Era? *Agriculture (Switzerland)*, 13(10): 13101896. <https://doi.org/10.3390/agriculture13101896>
- [5] Busthanul, N., Demmallino, E. B., Sultani, H. R., Lampe, M., Ismail, A., Yassi, A., ... Zainuddin, A. (2023). Ecological adaptation of smallholders to tropical climate change in the highland zone of South Sulawesi, Indonesia. *Biodiversitas*, 24(10): 5328–5335. <https://doi.org/10.13057/biodiv/d241014>
- [6] Isa, M., Farid Wajdi, M., Mabruroh, Hayati, S. F. N., & Kamarulzaman, N. H. (2021). Sustainability of Rice Business in Flood-Prone Areas. *Environmental Research, Engineering and Management*, 77(4): 6–18. <https://doi.org/10.5755/j01.irem.77.4.28096>
- [7] Surahman, A., Soni, P., & Shivakoti, G. P. (2018). Reducing CO2 emissions and supporting food security in Central Kalimantan, Indonesia, with improved peatland management. *Land Use Policy*, 72: 325–332. <https://doi.org/10.1016/j.landusepol.2017.12.050>
- [8] Makhubu, F. N., Laurie, S. M., Rauwane, M. E., & Figlan, S. (2024). Trends and gaps in sweet potato (*Ipomoea batatas* L.) improvement in sub-Saharan Africa: Drought tolerance breeding strategies. *Food and Energy Security*, 13(3): 2024. <https://doi.org/10.1002/fes3.545>
- [9] Wang, S. W., Lee, W. K., & Son, Y. (2017). An assessment of climate change impacts and adaptation in South Asian agriculture. *International Journal of Climate Change Strategies and Management*, 9(4): 517–534. <https://doi.org/10.1108/IJCCSM-05-2016-0069>
- [10] Malik, I., Prianto, A. L., Roni, N. I., Yama, A., & Baharuddin, T. (2023). Multi-level Governance and Digitalization in Climate Change: A Bibliometric Analysis. In S. Motahhir & B. Bossoufi (Eds.), *International*

Conference on Digital Technologies and Applications (pp. 95–104). Springer, Cham.
https://doi.org/https://doi.org/10.1007/978-3-031-29860-8_10

- [11] Tanure, T., Faria de Abreu Campos, R., dos Reis, J. C., Benzeev, R., Newton, P., de Aragão Ribeiro Rodrigues, R., & Hermeto Camilo de Oliveira, A. M. (2024). Farmers' perceptions of climate change affect their adoption of sustainable agricultural technologies in the Brazilian Amazon and Atlantic Forest biomes. *Climatic Change*, 177(1): 10584. <https://doi.org/10.1007/s10584-023-03657-3>
- [12] Ahmed, B., Haji, J., Ketema, M., & Jemal, K. (2023). Impacts and adaptation extents of climate smart agricultural practices among smallholder farmers of Ethiopia: Implication to food and nutrition security. *Cogent Economics and Finance*, 11(1): 23322039. <https://doi.org/10.1080/23322039.2023.2210911>
- [13] Le, H. N., Sofija, E., Harris, N., Nguyen, T., & Phung, H. (2024). Food security in slow-onset disasters: A policy review in Southeast Asian regions. *World Medical and Health Policy*, 2024. <https://doi.org/10.1002/wmh3.604>
- [14] Hsu, H. W., & Yang, C. C. (2024). Assessing land resource planning for agrivoltaics development: Examining synergies approaches between government and farmers. *Energy*, 298: 131363. <https://doi.org/10.1016/j.energy.2024.131363>
- [15] Korsager, M., & Slotta, J. D. (2015). International peer collaboration to learn about global climate changes. *International Journal of Environmental and Science Education*, 10(5): 717–736. <https://doi.org/10.12973/ijese.2015.262a>
- [16] Tamasiga, P., Ouassou, E. houssin, Onyeaka, H., Bakwena, M., Happonen, A., & Molala, M. (2023). Forecasting disruptions in global food value chains to tackle food insecurity: The role of AI and big data analytics – A bibliometric and scientometric analysis. *Journal of Agriculture and Food Research*, 14: 100819. <https://doi.org/10.1016/j.jafr.2023.100819>
- [17] Umar, I. M., Mustafa, H., Lau, W. Y., & Sidek, S. (2022). Ninety-three years of agricultural accounting studies in Scopus journals: a bibliometric analysis from 1923 to 2020. *Journal of Accounting in Emerging Economies*, 12(5): 741–760. <https://doi.org/10.1108/JAEE-01-2021-0011>
- [18] Toiba, H., Rahman, M. S., Nugroho, T. W., Priyanto, M. W., Noor, A. Y. M., & Shaleh, M. I. (2024). Understanding the link between climate change adaptation and household food security among shrimp farmers in Indonesia. *Marine Policy*, 165: 106206. <https://doi.org/10.1016/j.marpol.2024.106206>
- [19] Aksnes, D. W., Langfeldt, L., & Wouters, P. (2019). Citations, Citation Indicators, and Research Quality: An Overview of Basic Concepts and Theories. *SAGE Open*, 9(1): 1–17. <https://doi.org/10.1177/2158244019829575>
- [20] Lal, R. (2004). Soil carbon sequestration impacts on global climate change and food security. *Science*, 304(5677): 1623–1627. <https://doi.org/10.1126/science.1097396>
- [21] Lobell, D. B., Burke, M. B., Tebaldi, C., Mastrandrea, M. D., Falcon, W. P., & Naylor, R. L. (2008). Prioritizing climate change adaptation needs for food security in 2030. *Science*, 319(5863): 607–610. <https://doi.org/10.1126/science.1152339>
- [22] Wheeler, T., & Von Braun, J. (2013). Climate change impacts on global food security. *Science*, 341(6145): 508–513. <https://doi.org/10.1126/science.1239402>
- [23] Schmidhuber, J., & Tubiello, F. N. (2007). Global food security under climate change. *Proceedings of the National Academy of Sciences of the United States of America*, 104(50): 19703–19708. <https://doi.org/10.1073/pnas.0701976104>
- [24] Shindell, D., Kuylenstierna, J. C. I., Vignati, E., Van Dingenen, R., Amann, M., Klimont, Z., ... Fowler, D. (2012). Simultaneously mitigating near-term climate change and improving human health and food security. *Science*, 335(6065): 183–189. <https://doi.org/10.1126/science.1210026>
- [25] Wang, X., Du, R., Cai, H., Lin, B., Dietrich, J. P., Stevanović, M., ... Popp, A. (2024). Assessing the impacts of technological change on food security and climate change mitigation in China's agriculture and land-use sectors. *Environmental Impact Assessment Review*, 107: 107550. <https://doi.org/10.1016/j.eiar.2024.107550>
- [26] Safi, L., Mujeeb, M., Sahak, K., Mushwani, H., & Hashmi, S. K. (2024). Climate change impacts and threats on basic livelihood resources, food security and social stability in Afghanistan. *GeoJournal*, 89(2): 11077. <https://doi.org/10.1007/s10708-024-11077-8>
- [27] Mirzabaev, A., Bezner Kerr, R., Hasegawa, T., Pradhan, P., Wreford, A., Cristina Tirado von der Pahlen, M., & Gurney-Smith, H. (2023). Severe climate change risks to food security and nutrition. *Climate Risk Management*, 39: 100473. <https://doi.org/10.1016/j.crm.2022.100473>
- [28] Abdi, A. H., Sugow, M. O., & Halane, D. R. (2024). Exploring climate change resilience of major crops in Somalia: implications for ensuring food security. *International Journal of Agricultural Sustainability*, 22(1): 14735903. <https://doi.org/10.1080/14735903.2024.2338030>
- [29] Iskandar, I., Anas, A., Bahri, S., Menne, F., & Baharuddin, T. (2024). Social vulnerability and climate change: a bibliometric analysis. *Cogent Social Sciences*, 10(1): 2402849. <https://doi.org/10.1080/23311886.2024.2402849>
- [30] Yamamoto, Y., Shigetomi, Y., Ishimura, Y., & Hattori, M. (2019). Forest change and agricultural productivity: Evidence from Indonesia. *World Development*, 114: 196–207. <https://doi.org/10.1016/j.worlddev.2018.10.001>