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**REVIEW**

# Climate change impact on food security: A review

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**Abstract.** Countries all over the globe are facing climate change. Global warming is a real problem that occurs and affects food production. Precipitation and temperature rise are causes of the changes observed in this study. This study examines the relationship between food security level due to climate change. To provide further clarity, a systematic literature review (SLR) towards the impacts of climate change was conducted to identify the extent of its impacts on food security and to identify the extent of its impacts on the level of food security and research gaps. This systematic review identifies and analyzes documents on the impact of climate change on the level of food security in terms of the impact of climate change, the methods used to analyze climate change, and the available climate change adaptation policies. Following SLR guidelines, Google Scholar is the main database. This research can broaden our knowledge about the impacts of climate change and the role we can play in maintaining food security.

**Keywords:** climate change; food security; vulnerability

## 1. Introduction

Climate is the average measure and the variability of the relevant quantities of a particular variable (precipitation, temperature, and wind) over months to years. Climate is constantly changing due to interactions of external factors such as solar irregularity, volcanic eruptions, and anthropogenic factors such as changes in land use and fossil fuel usage (Kementerian Lingkungan Hidup dan Kehutanan, 2017). Climate change indicates a shift in climate from anthropogenic activities, altering the global atmospheric composition and natural climate change on comparable timescales, the global atmosphere's composition, and natural climate irregularity on similar time scales (United Nations Framework Convention on Climate Change, 2020). World's largest imbalances are manifested in the causes and consequences of climate change. In line with the Sustainable Development Goals (SDGs), there are objectives that require dire action to address climate change and its effects.

Food is fundamental human needs; the lack of food supply will result in malnutrition. According to reports from FAO et al. (2021) for 2020, between 720-811 million people worldwide suffer hunger. The number of people starving has also increased due to the Covid-19 pandemic which has resulted in an increase in the prevalence of malnutrition to 9.9% in 2020, from 8.4% in 2019. Malnutrition is caused by a lack of food security or a high level of food vulnerability.

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Food Law No. 18 of 2012 states that there should be an adequate supply of food that is safe and healthy, diverse, and reasonably priced. Adequate national nutrition is a basis of a healthy, energetic, and successful life. The Food Act not only addresses food security, but also clarifies and reinforces the attainment of food independence.

Food problems are faced by almost all developing countries. Indonesia as a developing country which is also an agricultural country is very dependent on agricultural products. As agricultural country, it means most of Indonesia's population works in the agricultural industry, which contributes to the country's economy. Therefore, the sustainability and existence of the agricultural sector must be improved. Food security is an important issue in Indonesia. Evidence suggests that ensuring food security at the national level is not typically pass on household level (Yuniarti & Purwaningsih, 2017).

In respond to this research, a systematic literature review (SLR) was conducted. SLR was conducted to gain more systematic understanding of how climate change affects food security. SLR can describe areas of research and identify research gaps (Snyder, 2019). SLR allows researcher to investigate and find the relevant literature, debate the themes, and identify research gaps. This study includes an introduction, materials and methods, results, discussion and conclusion.

## 2. Materials and Methods

The first step in this SLR was choosing keywords by determining the topic's relevance to sustainability. Keywords comprehensively cover topics and research questions. The literature search process for this SLR used the search string in Figure 1. The keywords for the search were a combination of "Climate change impact*" and "food security*". The literature was identified using the largest database of citations from literatures, focusing on scientific journal articles (review articles), at a custom range between 2012-2021, using the Google Scholar database with keywords that yielded 1,420 article results.

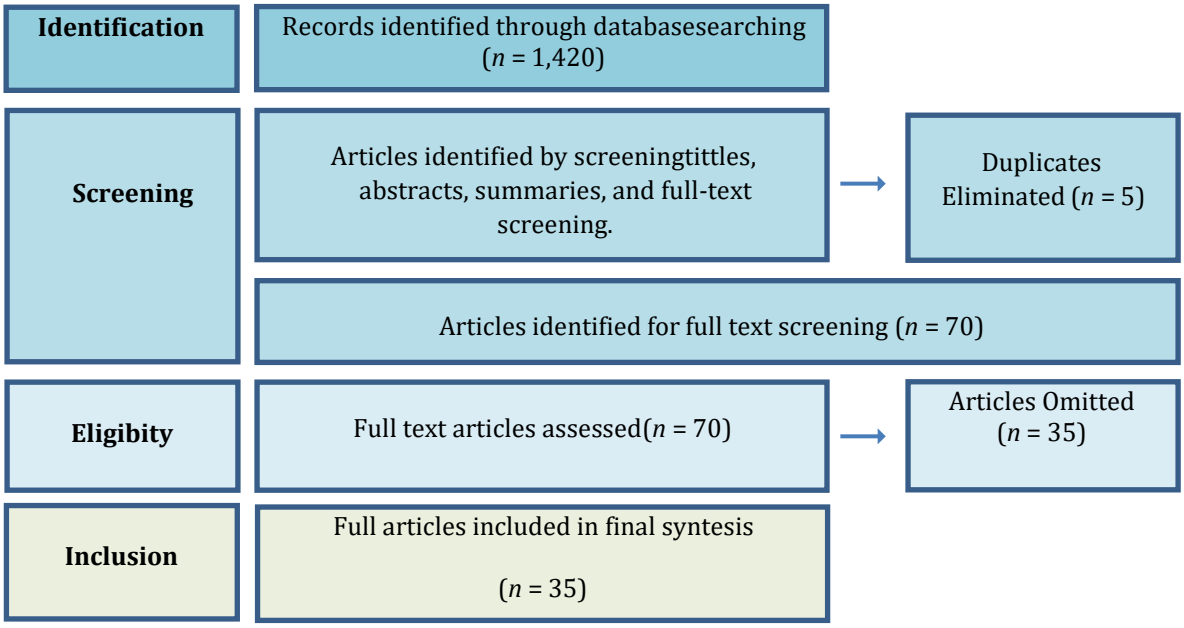


**Figure 1.** Flowchart of literature search starting from identification, screening, eligibility, and inclusion

Journals were selcted to include findings that are of the highest quality and are current. The sample was taken from 52 journals by considering the number of published article citations and the ranking of the journals indexed by the SCImago Journal Ranking (SJR).

**Table 1.** Details of the search terms for systematic review

| Literature | Source | Search Phrase |
|---|---|---|
| Peer Reviewed | Google Scholar https://scholar.google.com | "Climate change impact*" AND "food security*" |

Inclusion criteria were (1) climate change impact, (2) food security.

## 3. Result

### 3.1. Searches and document inclusion

During the identification phase, the initial search yielded 1,420 papers. After screening titles and abstracts, 75 relevant hits from all databases were retained and five duplicates were eliminated. From 70 documents identified by full-text checking, 35 were excluded based on the omission criteria. At the end of the search, 35 definitive documents were obtained from peer-reviewed journals.

### 3.2. In-depth analysis

#### 3.2.1. Climate change impact on food security emphasized in the context of managing adaptation and mitigation

Climate change is an actual phenomenon and affecting global food security. Table 2 below describes previous researches related to adaptation and mitigation management undertaken to combat climate change:

**Table 2.** Managing adaptation and mitigation highlights the effect of climate change on food security.

| Article | Research Method | Research Result |
|---|---|---|
| Misra (2014) | Data gathering | Explored resources availability under various modeling scenarios |
| Vermeulen et al. (2012) | Literature review | Technological innovation and investment in agricultural intensification to maximize agricultural potency |
| Raza et al. (2019) | Data gathering, survey | Climate-smart agriculture is solution to reduce the negative impacts of climate change |
| McKersie (2015) | Literature review, data gathering | Genetic engineering revolution to resolve the issue of food security against extreme environmental conditions |
| El-Beltagy & Madkour, (2012) | Literature review, data gathering | Adopt agricultural research and technology transfer under a new paradigm, to overcome obstacle |

Agriculture and food security are key areas of action on climate change. Adaptation measures are divided into two categories, accelerating adaptation to ongoing climate change and better handling of the agricultural risks brought on by rising temperatures and more extreme weather. To fully realize the potential of agricultural mitigation, technological innovation and investment in agricultural intensification are required (Vermeulen et al., 2012). Desertification, floods, and droughts that cause food shortages are prominent effects of climate change. Misra (2014) emphasized groundwater recharge with wastewater from soil aquifer treatment (SAT) methods and artificial groundwater recharge methods in irrigation. Set wastewater using SAT system helps minimize the impact of climate change on water resources and agricultural yields. This study offers practical adaptation, mitigation, and policy strategies to reduce climate change impact on water resources and irrigation, as well as a straightforward method for ensuring water and food security. This study explored resources availability such as water and land under various

modeling scenarios in different regions throughout the world revealing declining levels of production for various crops.

Raza et al. (2019) stated that the only way to lessen the harmful effects of climate change is climate-smart agriculture, because climate change has a dramatic impact on global crop production. Researchers list the factors that contribute to climate change, the stress that climate change has caused, their impact on crops, the latest breeding techniques, and biotechnology strategies to face climate change and develop climate-tolerant crops. The genetic engineering revolution can also help overcome the problem of food security against extreme environmental conditions through the crop production. Integrated research programs that combine agronomic and genetic approaches are expected to be successful by utilizing strategies that integrate and coordinate work on plant will increase the likelihood of accomplishment (McKersie, 2015).

The impacts of climate change where crops, cropping systems, rotation, and biota can traverse boundaries. New knowledge, alternative strategies, and institutional changes are required to keep the system in balance. Marginalized people living in dry regions are likely to be most impacted by fluctuations in temperature and humidity due to global climate change. To aid them in overcoming this obstacle, agricultural research and technology transfer must be conducted under a new paradigm, maximizing the usage of technology and modern science combined with traditional knowledge (El-Beltagy & Madkour, 2012). More funding from international organizations and national governments is necessary to support integrated research from local communities. Climate change exists and its effects are felt in many countries. It takes efforts and awareness of all parties to maintain the sustainability of the environment. Past research has described ways to manage both adaptation and mitigation for the effects of climate change on food security. Adaptation and mitigation efforts such as wastewater utilization and water absorption, climate-smart agriculture using modern technology, institutional adjustments, and policy formulation are all part of sustainable development efforts.

### 3.2.2. Climate change impact on food security focusing on specific climate change consequences

Climate change affects the volatility of both dry and rainy seasons. This disrupts food crop production patterns. Ultimately, food crop production will decline, impacting food security. Table 3 describes previous research on the climate change's effects on food security levels, as follows:

**Table 3.** Climate change impact on food security focusing on specific climate change consequences

| Article | Research Method | Research Result |
|---|---|---|
| Parvin & Ahsan (2013) | Survey | Help government understand the nature and scale of the problem, thereby facilitating the adoption of effective policies and measures. |
| Adewuyi et al. (2015) | Survey, data gathering | Climate change will affect food production |

Parvin andAhsan (2013) assessed food security due to climate change of poor rural women by examining their difficulties and perceptions of climate change impacts. Food availability, women's consumption patterns and daily work patterns, and lifestyle changes all contribute to household food security. The findings help development officials understand the nature and scale of the problem, thereby facilitating the adoption of effective policies and measures.

Adewuyi et al. (2015) determined the size of household vulnerability to climate change and how it will affect cassava and yam production in Oyo State, Nigeria. They analyzed the collected data using trending, regression, and analysis tools. Their findings indicated that the length of sun exposure had a significant effect on sweet potatoes yield. Climate change will affect food

production such as cassava, yams, and sweet potatoes. Food availability, consumption patterns, and lifestyle also affect food security. Therefore, the need for an effective policy can be a solution in dealing with climate change.

### 3.2.3. Climate change impact on food security focusing on method for analyzing food security to climate risks

Food is a basic need that maintains the survival of all living things. Climate change that occurs affects the availability of food. Therefore, food security needs to be analyzed to prevent and overcome food availability and safety problems. Table 4 below describes previous research regarding the methods used to analyze food security:

**Table 4.** Climate change impact on food security focusing on method for analyzing food security to climate risks

| Article | Research Method | Research Result |
|---|---|---|
| Krishnamurthy et al. (2014) | Survey, data gathering | Using HCVI to indicate the relative susceptibility of food resilience |
| Saxena et al. (2018) | Data gathering | Predictions about which sections of the world will be most affected by climate change and alleviate pressure on environmental resources. |
| Bandara & Cai (2014) | Data gathering | Climate change's effects on agriculture productivity may have a severe negative impact on food prices and production |
| Masipa (2017) | Data gathering | Demonstrate how food availability, accessibility, use, and affordability are impacted by climate change |
| Wiebe et al. (2019) | Literature review, data gathering | Mitigation and adaptation options to climate change |
| Mirzaei et al. (2021) | Data gathering | Gathered information on climate change issues |
| Firdaus et al. (2020) | Literature review, data gathering | Rice production is seriously threatened by climate change, which has an impact on food security |
| van Wijk et al. (2014) | Literature review, data gathering | Integrated analysis of food security at the farm level is still lacking |
| Chhogyel & Kumar (2018) | Data gathering | Understanding and mitigating impacts of climate change |
| Aggarwal, Vyas, Thornton, Campbell, et al. (2019) | Data gathering | Climate change impact assessments have a greater positive impact on yield |
| Akpoti et al. (2019) | Data gathering | Using Agricultural Land Suitability Analysis (ALSA) in crop production |
| Luedeling et al. (2014) | Data gathering | Examines options for predicting impacts of climate change on agroforestry systems |

There is a strong correlation between food security and climate risk, especially in the world's poorest regions. Krishnamurthy et al. (2014) described a test index for climate vulnerability and hunger that incorporates socio-economic and environmental data to indicate susceptibility of food resilience to climate risks at national level. This study outlines a technique for analyzing food vulnerability to climate risks. The method can be replicated at various scales to provide decision-makers with a powerful planning tool to monitor vulnerabilities, assess the program efficacy, and/or study opportunities for climate change impacts. Saxena et al. (2018) predicted resources availability such as water, soil, and forecast declines in production levels for

various types of crops. The study makes predictions about which parts of the world will be most affected by climate change and how growing sorghum and other crops can help alleviate pressure on environmental resources.

Bandara & Cai (2014) used the dynamic general balance model focusing on Bangladesh, India, Nepal, Pakistan, and Sri Lanka. Their research explains how climate change altered crop yields of South Asia's thus affecting food prices and security. Climate change's effects on food prices may be adversely affected by major reductions in agricultural productivity in all countries of South Asia, and their likely impact on food security issues is that of hunger and it shows a high correlation with climate risk, especially in parts of the world where food security is the worst. Masipa (2017) examined the impact of climate change on South Africa's food security. The study used a desktop learning approach in research, reports, climate change, food security research, and policy. The findings demonstrate how food availability, accessibility, use, and affordability are impacted by climate change, particularly global warming.

Wiebe et al. (2019) summarized The International Food Policy Research Institute (IFPRI)'s most recent long-term climate change projections impact on agriculture, crop yields, consumption, production, prices, and trade in key livestock commodities, and their impact on food security. This research focused on mitigation and adaptation options and institutions, governance, politics, and finance play a crucial role. Mirzaei et al. (2021) gathered information on climate change issues, their probable causes, near-term projections, impacts on crops, impacts on plant growth and productivity, and impacts on the agricultural sector, including plant breeding strategies and crop adaptations to climate change.

Firdaus et al. (2020) attempted to briefly discuss the climate change effect in Malaysia regarding rice production and food security. Their analysis used Mann-Kendall and Sen slopes, showing the lowest (T-min) and highest (T-max) temperature rises in the stall area, respectively 3°C every 10 years. The amount of precipitation, which ranged from 133 mm to 200 mm, was also increasing at the same time. In addition of our arguments, we performed a literature review. The research demonstrates that climate change poses a significant risk to rice production, which is connected to and consequently affects food security. van Wijk et al. (2014) conducted a systematic literature review on farming models, focusing on small farming systems. This review showed that an integrated analysis of food security at the farm level is still lacking. This is where decision theory-based strategies that harness the strength of (dynamic) mathematical programming and expert system decision models appear to be most promising. Chhogyel & Kumar (2018) indicates that agroecology is undergoing changes in cropping patterns, suggesting that Bhutan's agriculture has declined significantly. Food production is difficult in Bhutan's mountainous regions, and climate change impacts may put additional pressure on agriculture. The impacts of climate change are already showing signs, so it is imperative that we focus our research on understanding and mitigating their impacts. Aggarwal, Vyas, Thornton, Campbell, et al. (2019) found that climate change impact assessments have a greater positive influence on yield than negative consequences. This discrepancy is due to technical advances in climate impact assessment and large differences in yields of these countries, uncertainties correlated with methodologies used, and incomplete consideration of regional differences. By responding appropriately to modern technology, it can significantly increase the global impact assessments, enabling targeted investments and small-and large-scale developments.

SDGs can be accomplished by using Agricultural Land Suitability Analysis (ALSA) in crop production, according to Akpoti et al. (2019). Their research used the current review to demonstrate that ALSA is a global land-use planning approach, making it one of the most crucial tools for achieving in the context of the debate over sustainable agriculture and global environmental change. It emphasized that the way to ideal agriculture and food security is to incorporate estimates for the present and future of climate change into ALSA. ALSA system, called

Hybrid Land Valuation System (HLES), incorporates both qualitative and quantitative methods to achieve this integration, and enhance soil assessment methods.

Luedeling et al. (2014) described an agroforestry system as a complex assembly of intricate ecosystem elements, each of which reacts to the climate. Proper tree-based ecosystem management requires long planning horizons and therefore impact projections are necessary. This study examined options for predicting impacts of climate change on agroforestry systems. Wang et al. (2014) showed that (1) Research on vulnerability to climate change has grown rapidly since 2006, with widespread publication in multi-source journals; (2) Collaboration at the author level is growing, and institutional and national levels are establishing closer collaboration; (3) Health problems in socioeconomic systems, food security in agricultural systems, and problems with resource management are the three most popular research topics in this area; (4) According to articles in top journals, research on vulnerability to climate change in these publications were found to be ecosystem diversity, ecosystem services, water resource management, and electricity supply. Based on previous research, food security that is affected by climate risk can be identified through qualitative and quantitative approaches. The types of analyses used include descriptive analysis, dynamic general equilibrium models, desktop studies, Mann-Kendall and Sen slopes, and topography studies. The majority of the analytical methods used were literature studies on climate change on food in various countries in the world.

### 3.2.4. Climate change impact on food security focusing on review of previous study and policy implication

Food security is the responsibility of all related parties. In this case the policy makers, namely the government, play a key role in policy making to maintain food security stability. Table 5 summarizes previous research related to the policies developed to preserve food security.

According to Wheeler & von Braun (2013), significant investment is needed in mitigation and adaptation measures towards a “climate smart food system” that uses simulations that are more resistant to how climate change will affect food security. This study provides policy recommendations that governments can adopt by adhering to six principles on climate change impact on food security, aimed at creating effective policies. Kogo et al. (2021) research discussed Kenya's food security in the past, present, and future for crops under climatic variables, this review examines seasonal variations in precipitation, varying degrees of intensity and length, despite its over-reliance on rainwater. It concludes that the country experienced an episode of climate change manifested by temperature. The results offer decision-makers and interested parties’ in-depth analyses of climate impacts and adaptation tactics aimed at increasing crop production and food security.

Mukhopadhyay et al. (2021) compiled data from published literature about the extent, mechanisms of development, and existing mitigating measures for addressing soil salinity. As a result, benefits such as soil carbon sequestration, resource conservation, and recycling can be achieved. We need to expand our focus beyond boosting crop productivity and yields. Leisner (2020) research took a multifaceted approach, combining physiological and genomic tools, and conducts extensive experiments while considering future climate projections realistically. This overview explored the questions that need to be asked in the future and the steps that must be taken to create a sustainable food supply while considering the state of the world's climate.

Current agricultural practices rely entirely on monsoon rains and short growing seasons, making them particularly potentially impacted by the effects of climate change. According to Sorgho et al. (2020), the majority of West African nations have climate protection laws in place. The results of Escarcha et al. (2018), beyond particular geographic contexts to key vulnerability priorities, need to be addressed. It is critical that research into the impacts of climate change and livestock adaptation begin to be conducted in order to clarify policy ramifications and efficiently direct funding toward impact-specific adaptation measures. Loboguerrero et al. (2019) found that

food safety for a population that is expanding globally is being ensured by making agriculture a crucial area for mitigation and adaptation. This study investigated various options for climate change adaptation and mitigation. Although productivity, adaptation, and mitigation can all benefit from climate-smart agriculture, there are also clear trade-offs. In the context of state-determined contributions, this study emphasized the significance of locating and taking advantage of these synergies.

**Table 5.** Climate change impact on food security focusing on review of previous study and policy implication

| Article | Research Method | Research Result |
|---|---|---|
| Wheeler & von Braun (2013) | Literature review, simulations data gathering | Provides policy recommendations that governments can adopt |
| Kogo et al. (2021) | Data gathering | Analyses of climate impacts and adaptation tactics to increase crop production and food security |
| Mukhopadhyay et al. (202 | Literature review, data gathering | Expand our focus from just boosting crop productivity and yields to consider climate change that affect the nutritional content of these crops |
| Leisner (2020) | Data gathering | Explores the questions that need to be asked in the future and the steps that must be taken to create a sustainable food supply |
| Sorgho et al. (2020) | Literature review | Climate protection laws |
| Escarcha et al. (2018) | Literature review | Study climate change effects and livestock adaptability collectively to clarify policy ramifications and efficiently direct funding toward impact-specific adaptation measures |
| Loboguerrero et al. (2019) | Literature review | Food security is being ensured by making agriculture a crucial area for climate change adaptation and mitigation |
| Tirado et al. (2015) | Literature review | The impact of climate change on food security in Africa and the need for adaptation and mitigation measures |
| Aggarwal et al. (2019) | Literature review | Technology helps bridge gaps in political, economic, and climatic disparities |
| Gomez-Zavaglia et al. (2020) | Literature review | Agriculture, livestock, and fisheries negatively impacted by climate change |
| Gezie (2019) | Literature review | Climate change endangers food security by reducing precipitation, increasing precipitation variability, and temperatures |
| Iizumi & Ramankutty (2015) | Literature review | Explains how farmers' choices and technological advancements can alter how production reacts to the climate |

Malnutrition is made worse by climate change, which also hinders efforts to fight poverty and increase resilience in vulnerable populations. Economic growth is also slowed down, and hunger levels are rising due to droughts. Tirado et al. (2015) reviewed the body of knowledge on climate variability and change, with an emphasis on sub-Saharan Africa, and their implications for food security. Strategies for adaptation and mitigation were used to address these issues. This article discussed the consequences of climate change on Africa's food security and the need for mitigation and adaptation measures in the following 10 to 15 years. Aggarwal et al. (2019)

explained that rice and wheat yields are low (but negative) and maize yields are moderate if farmers implement procedures and methods such as planting high-yielding varieties when it is optimal to manage water and fertilizer better. The technology may also help bridge gaps in political, economic, and climatic disparities. To encourage the adoption and expansion of such practices and to combat climate change, significant financial, political, and institutional support are required.

Alterations in the frequency and intensity of floods and droughts can be extremely difficult for farmers and jeopardize food security. Gomez-Zavaglia et al. (2020) asserted that agriculture, livestock, and fisheries may be negatively impacted by climate change. In addition to other evolutionary factors that could influence agricultural production, the effects of climate change must be considered. Aspects like technological advancements and changes in agricultural practices are considered crucial. For food availability and cost, each of these has significant implications. This study offers pertinent and significant information on how climate change affects food consumption and production, especially mitigation measures. Gezie (2019) described that climate change in Ethiopia is threatening food security by reducing precipitation, increasing precipitation variability and temperatures. In response to temperature change and perceived precipitation, this study looks at the impacts and variability of climate change as well as the strategies used at agricultural scales to adapt to it. Agriculture, nutrition, groundwater health, growth, organic matter in the soil, and poverty will all be negatively impacted by climate change. Ethiopian farmers are implementing a variety of climate change adaptation measures. According to other studies, farmers in dry lowlands experience more climate change than those in wet lowlands.

Iizumi and Ramankutty (2015) reviewed the available evidence on how climate can affect this less-studied component of crop production. This study explains how farmers' choices and technological advancements can alter how production reacts to the climate. This is an important knowledge gap that should be filled in by future research and possible directions. Otto et al. (2017) outlined which social and demographic groups in various regions are more likely in order to battle climate change on four dimensions of well-being in the most recent scientific research on the issue. The goal is to determine who is most vulnerable to the effects of health, safety, food security, and evacuation. According to the review, climate change is predicted to exacerbate present vulnerabilities and inequalities. According to research by Zurovec et al. (2015), agricultural production sustains the rural economy and contributes significantly to GDP. The current state of Bosnia and Herzegovina's agricultural industry is discussed in this study, along with possible effects of climate change.

We propose possible approaches to reduce potential climate change effects on the agricultural sector. Harmonizing and centralizing national agricultural policies, performing vulnerability analyses, and bolstering public-private advisory systems are all important components of building policy and research capacity. Crop development, improved irrigation, and better water management should all be included in future technological advancements. A study by Juroszek & von Tiedemann (2013) summarized projections which were made using a variety of climate models and downscaling techniques, which can have significant implications for uncertainty; therefore, long-term simulation results of future disease risk should be viewed with caution. Climate change impacting food security requires the support of all stakeholders, including governments as policy makers. Previous studies have examined the implications of policies implemented in various countries, such as agricultural sector investment policies, regulation of agricultural production during the rainy and dry seasons, policies for expanding agricultural land and disaster mitigation, as well as climate projections as a policy basis.

## 4. Conclusion

This study intended to identify important research topics that have been discussed and research gaps in the literature as the number of publications revealing the importance of the topic increases. This study answers several research questions: (1) What is the impact of climate change? Climate change can change wet and dry conditions with uncertainty and can create a serious impact on the condition of food security if it is not managed wisely. The agricultural sector is the hardest hit, which in turn will affect the productivity of the agricultural sector and resulted in a shortage of food supply which disrupts food security. (2) What are the methods used to analyze climate change? Literature study shows several methods in analyzing climate change related to its effect on food security such as trend analysis, regression, and GIS. (3) What are the available climate changeadaptation policies? To support success, government policy intervention is required in this matter. Based on SLR, there are several policy recommendations governments can take to reduce the detrimental effects of climate change on food security. Overall, our review enabled us to determine the need for additional research on climate change, especially in terms of food security in the form of case studies, projects, approaches, and methodologies, constituting a thorough review of the literature.

## References


Adewuyi, S. A., Folorunso, B., Okojie, L. O., & Akerele, D. (2015). Effect of climate change on food crop production and vulnerability assessment in Oyo State. *Journal of Economics and International Finance*, *7*(1), 18–24. https://doi.org/10.5897/jeif2013.0516

Aggarwal, P., Vyas, S., Thornton, P., & Campbell, B. M. (2019). How much does climate change add to the challenge of feeding the planet this century? *Environmental Research Letters*, *14*(4). https://doi.org/10.1088/1748-9326/aafa3e

Aggarwal, P., Vyas, S., Thornton, P., Campbell, B. M., & Kropff, M. (2019). Importance of considering technology growth in impact assessments of climate change on agriculture. *Global Food Security*, *23*(April), 41–48. https://doi.org/10.1016/j.gfs.2019.04.002

Akpoti, K., Kabo-bah, A. T., & Zwart, S. J. (2019). Agricultural land suitability analysis: State-of-the-art and outlooks for integration of climate change analysis. *Agricultural Systems*, *173*(January 2018), 172–208. https://doi.org/10.1016/j.agsy.2019.02.013

Bandara, J. S., & Cai, Y. (2014). The impact of climate change on food crop productivity, food prices and food security in South Asia. *Economic Analysis and Policy*, *44*(4), 451–465. https://doi.org/10.1016/j.eap.2014.09.005

Chhogyel, N., & Kumar, L. (2018). Climate change and potential impacts on agriculture in Bhutan: A discussion of pertinent issues. *Agriculture and Food Security*, *7*(1), 1–13. https://doi.org/10.1186/s40066-018-0229-6

El-Beltagy, A., & Madkour, M. (2012). Impact of climate change on arid lands agriculture. *Agriculture and Food Security*, *1*(1), 1–12. https://doi.org/10.1186/2048-7010-1-3

Escarcha, J. F., Lassa, J. A., & Zander, K. K. (2018). Livestock under climate change: A systematic review of impacts and adaptation. *Climate*, *6*(3), 1–17. https://doi.org/10.3390/cli6030054

FAO, IFAD, UNICEF, WFP, & WHO. (2021). *The State of Food Security and Nutrition in the World (SOFI). FAO, IFAD, UNICEF, WFP and WHO*. https://doi.org/10.4060/cb4474en

Firdaus, R. B. R., Leong Tan, M., Rahmat, S. R., & Senevi Gunaratne, M. (2020). Paddy, rice and food security in Malaysia: A review of climate change impacts. *Cogent Social Sciences*, *6*(1). https://doi.org/10.1080/23311886.2020.1818373

Gezie, M. (2019). Farmer's response to climate change and variability in Ethiopia: A review. *Cogent Food and Agriculture*, *5*(1), 1–13. https://doi.org/10.1080/23311932.2019.1613770

Gomez-Zavaglia, A., Mejuto, J. C., & Simal-Gandara, J. (2020). Mitigation of emerging implications of climate change on food production systems. *Food Research International*, *134*(April), 109256. https://doi.org/10.1016/j.foodres.2020.109256

Iizumi, T., & Ramankutty, N. (2015). How do weather and climate influence cropping area and intensity? *Global Food Security*, *4*, 46–50. https://doi.org/10.1016/j.gfs.2014.11.003

Juroszek, P., & von Tiedemann, A. (2013). Climate change and potential future risks through wheat diseases: A review. *European Journal of Plant Pathology*, *136*(1), 21–33. https://doi.org/10.1007/s10658-012-

0144-9
Kementerian Lingkungan Hidup dan Kehutanan. (2017). *Info Iklim*. http://ditjenppi.menlhk.go.id/kcpi/index.php/info-iklim/perubahan-iklim
Kogo, B. K., Kumar, L., & Koech, R. (2021). Climate change and variability in Kenya: a review of impacts on agriculture and food security. *Environment, Development and Sustainability*, *23*(1), 23–43. https://doi.org/10.1007/s10668-020-00589-1
Krishnamurthy, P. K., Lewis, K., & Choularton, R. J. (2014). A methodological framework for rapidly assessing the impacts of climate risk on national-level food security through a vulnerability index. *Global Environmental Change*, *25*(1), 121–132. https://doi.org/10.1016/j.gloenvcha.2013.11.004
Leisner, C. P. (2020). Review: Climate change impacts on food security- focus on perennial cropping systems and nutritional value. *Plant Science*, *293*(December 2019), 110412. https://doi.org/10.1016/j.plantsci.2020.110412
Loboguerrero, A. M., Campbell, B. M., Cooper, P. J. M., Hansen, J. W., Rosenstock, T., & Wollenberg, E. (2019). Food and earth systems: Priorities for climate change adaptation and mitigation for agriculture and food systems. *Sustainability (Switzerland)*, *11*(5). https://doi.org/10.3390/su11051372
Luedeling, E., Kindt, R., Huth, N. I., & Koenig, K. (2014). Agroforestry systems in a changing climate-challenges in projecting future performance. *Current Opinion in Environmental Sustainability*, *6*(1), 1–7. https://doi.org/10.1016/j.cosust.2013.07.013
Masipa, T. S. (2017). The impact of climate change on food security in South Africa: Current realities and challenges ahead. *Jamba: Journal of Disaster Risk Studies*, *9*(1), 1–7. https://doi.org/10.4102/jamba.v9i1.411
McKersie, B. (2015). Planning for food security in a changing climate. *Journal of Experimental Botany*, *66*(12), 3435–3450. https://doi.org/10.1093/jxb/eru547
Mirzaei, S., Kahrizi, D., & Hassan, S. S. (2021). Climate change impacts on agriculture and food security; a global overview. *Central Asian Journal of Environmental Science and Technology Innovation*, *2*(5). https://doi.org/https://doi.org/10.22034/CAJESTI.2021.05.01
Misra, A. K. (2014). Climate change and challenges of water and food security. *International Journal of Sustainable Built Environment*, *3*(1), 153–165. https://doi.org/10.1016/j.ijsbe.2014.04.006
Mukhopadhyay, R., Sarkar, B., Jat, H. S., Sharma, P. C., & Bolan, N. S. (2021). Soil salinity under climate change: Challenges for sustainable agriculture and food security. *Journal of Environmental Management*, *280*(November), 111736. https://doi.org/10.1016/j.jenvman.2020.111736
Otto, I. M., Reckien, D., Reyer, C. P. O., Marcus, R., Le Masson, V., Jones, L., Norton, A., & Serdeczny, O. (2017). Social vulnerability to climate change: a review of concepts and evidence. *Regional Environmental Change*, *17*(6), 1651–1662. https://doi.org/10.1007/s10113-017-1105-9
Parvin, G. A., & Ahsan, R. M. R. (2013). Impacts of climate change on food security of rural poor women in Bangladesh. *Management of Environmental Quality: An International Journal*, *24*(6), 802–814. https://doi.org/10.1108/MEQ-04-2013-0033
Raza, A., Razzaq, A., Mehmood, S. S., Zou, X., Zhang, X., Lv, Y., & Xu, J. (2019). Impact of climate change on crops adaptation and strategies to tackle its outcome: A review. *Plants*, *8*(2). https://doi.org/10.3390/plants8020034
Saxena, R., Vanga, S. K., Wang, J., Orsat, V., & Raghavan, V. (2018). Millets for food security in the context of climate change: A review. *Sustainability (Switzerland)*, *10*(7). https://doi.org/10.3390/su10072228
Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research*, *104*(March), 333–339. https://doi.org/10.1016/j.jbusres.2019.07.039
Sorgho, R., Quiñonez, C. A. M., Louis, R., Winkler, V., Dambach, P., Sauerborn, R., & Horstick, O. (2020). Climate change policies in 16 West African countries: A systematic review of adaptation with a focus on agriculture food security and nutrition international journal of environmental research and public health. *International Journal of Environmental Research and Public Health*, *17*(23), 8897. https://doi.org/https://doi.org/10.3390/ijerph17238897
Tirado, M. C., Hunnes, D., Cohen, M. J., & Lartey, A. (2015). Climate Change and Nutrition in Africa. *Journal of Hunger and Environmental Nutrition*, *10*(1), 22–46. https://doi.org/10.1080/19320248.2014.908447
United Nations Framework Convention on Climate Change. (2020). *UN Climate Change*. https://unfccc.int/
van Wijk, M. T., Rufino, M. C., Enahoro, D., Parsons, D., Silvestri, S., Valdivia, R. O., & Herrero, M. (2014). Farm household models to analyse food security in a changing climate: A review. *Global Food Security*, *3*(2), 77–84. https://doi.org/10.1016/j.gfs.2014.05.001

Vermeulen, S. J., Aggarwal, P. K., Ainslie, A., Angelone, C., Campbell, B. M., Challinor, A. J., Hansen, J. W., Ingram, J. S. I., Jarvis, A., Kristjanson, P., Lau, C., Nelson, G. C., Thornton, P. K., & Wollenberg, E. (2012). Options for support to agriculture and food security under climate change. *Environmental Science and Policy*, *15*(1), 136–144. https://doi.org/10.1016/j.envsci.2011.09.003

Wang, B., Pan, S. Y., Ke, R. Y., Wang, K., & Wei, Y. M. (2014). An overview of climate change vulnerability: A bibliometric analysis based on Web of Science database. *Natural Hazards*, *74*(3), 1649–1666. https://doi.org/10.1007/s11069-014-1260-y

Wheeler, T., & von Braun, J. (2013). Climate change impacts on global food security. *Science*, *341*(6145), 508–513. https://doi.org/https://doi.org/10.1126/science.1239402

Wiebe, K., Robinson, S., & Cattaneo, A. (2019). Climate change, agriculture and food security. In *Sustainable Food and Agriculture* (Issue 2016). Elsevier Inc. https://doi.org/10.1016/b978-0-12-812134-4.00004-2

Yuniarti, D., & Purwaningsih, Y. (2017). Household food security and vulnerability: The sustainable livelihood framework. *Jejak*, *10*(2), 223–241. https://doi.org/10.15294/jejak.v10i2.11290

Zurovec, O., Vedeld, P. O., & Sitaula, B. K. (2015). Agricultural sector of Bosnia and Herzegovina and climate change—Challenges and opportunities. *Agriculture (Switzerland)*, *5*(2), 245–266. https://doi.org/10.3390/agriculture5020245