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Climate Change and Security with Reference to Food Security: A Systematic Literature Review

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ABSTRACT

Purpose: This research aims to investigate the link between climate change and food security. The study seeks to understand the potential impacts of climate change on food supplies and examine how climate resilient agriculture is the way forward. By addressing this critical issue, the research aims to provide insights to policymakers and stakeholders to develop effective strategies for ensuring food security in the face of climate change.

Design/Methodology/Approach: A systematic review of existing literature was conducted for this research using Scopus. E-contents from reputable sources like World Bank, FAO, IFAD, NAFSA, and other reputed websites were systematically analysed in second phase. The research methodology ensures a comprehensive evaluation of the impacts of climate change on food security, based on reliable and credible data.

Findings: The research findings highlight the profound impact of climate change on food security. Climate-induced disruptions to weather patterns have significant implications for agricultural productivity, heightening the risk of crop failures and reduced food production. This disturbance directly affects the availability, accessibility, and affordability of food, particularly for vulnerable populations. Moreover, the intensification of extreme weather events, such as droughts, floods, and heatwaves, driven by climate change, exacerbates food insecurity in many regions. Furthermore, the study underscores the critical role of climate-resilient agriculture as a forward-looking solution. Implementing climate-resilient practices, including crop diversification, improved irrigation, and climate-resistant crop varieties, is essential in safeguarding food production, promoting economic stability, and mitigating greenhouse gas emissions.

Originality: This research contributes significantly to the existing body of knowledge by offering a focused and in-depth analysis of the intricate relationship between climate change and food security. The systematic review of authoritative sources enhances the reliability and credibility of the findings. This study sheds a spotlight on the specific and pressing challenges posed by climate change to food security, emphasising the need for targeted and coordinated efforts to address this critical issue. By addressing the urgency of climate-induced food insecurity and underscoring the potential of climate-resilient agriculture as a forward-looking solution, this research provides a fresh and essential perspective on the intersection of climate change and global food supplies.

Paper Type: Review of Literature

KEYWORDS: Agriculture | Climate-Resilient Practices | Climate Change | Food Security

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Introduction:

Climate change is a global issue that presents a significant threat to the security of nations and their populations. It stems from various human activities, leading to elevated concentrations of greenhouse gases in the atmosphere, resulting in increased temperatures and altered weather patterns. This phenomenon has wide-ranging implications, particularly for food security and energy security. The importance of food security for the global population cannot be overstated, and climate change has the potential to exacerbate this concern. Changes in weather patterns and extreme events such as droughts and floods can adversely affect agricultural production, leading to food shortages and higher prices. Additionally, the shifting climate can impact the nutritional content of crops, diminishing their quality and nutritional value.

Climate change has become a topic of widespread concern in the contemporary world. Rezvi et al. (2023) emphasize that the primary driver of global climate change is the increase in greenhouse gases, particularly CO_2, with current CO_2 levels standing at approximately 412 ppm. The concentration of CO_2 has risen by 47% since the Industrial Age and 11% since 2000 (Sizing Up Humanity's Impacts on Earth's Changing Atmosphere: A Five-Part Series By Alan Buis, NASA's Jet Propulsion Laboratory, 2022). Globally, climate change exerts environmental pressure, resulting in various issues such as floods, storms, droughts, heatwaves, and shortages of food and water, particularly affecting societies reliant on agriculture and ecosystem services (Shivanna, 2022).

According to the IPCC Climate Change 2023: Synthesis Report, human-induced climate change is a consequence of over a century of greenhouse gas emissions originating from factors like energy usage, land use changes, consumption patterns, and production processes (IPCC, 2023; Rogelj et al., 2016). The report underscores the significant vulnerability of those who have contributed the least to climate change, making developing countries, particularly dependent on agriculture, particularly affected, as indicated in studies by Asmare et al. (2019) and Malhi et al. (2021). The World Bank Group (2023) states that South Asia is the most impacted region by climate change-related disasters, affecting approximately 64% of the world's population. Over the past 30 years, the region has experienced over 1,000 climate-related disasters, resulting in damages exceeding USD 127 billion and affecting over 1.7 billion people. Schmidhuber and Tubiello, (2007) estimate that climate change may increase the number of undernourished people by 5–26% in 2080, with variations depending on climate projections from general circulation models (GCM). SRES scenarios suggest that global income growth may enable a substantial part of the population to address potential local food supply shortfalls through imports while managing safety and stability issues of food supplies.

Giddens, (2009) identifies three main positions in the climate change debate: skeptics denying human-induced global warming, skeptics believing the danger is exaggerated, and the mainstream view represented by the Intergovernmental Panel on Climate Change. "Radicals" argue that climate change may pose even more urgent and significant threats than acknowledged, including tipping points and threshold effects. The Intergovernmental Panel on Climate Change's Sixth Assessment Report (AR6) offers the most comprehensive and authoritative scientific assessment of climate change, highlighting unprecedented climate changes due to human-induced global warming of 1.1 degrees C. Even limiting temperature rises to 1.5 degrees C may not be entirely safe, with adverse climate impacts such as water scarcity, vector-borne diseases, and extreme floods and storms surpassing previous estimations. Global politics has considered climate change a security issue since 2007, according to McDonald, (2013) and Lewis and Lenton, (2015). The UN Security Council and UN General Assembly have discussed its implications for regional and international security, leading to a nonbinding resolution in 2009 acknowledging climate change as an international security concern. However, there remains no consensus on the definition of climate security, with different actors and disciplines offering diverse interpretations. Cho, (2023) emphasize climate change as a cause of conflict and a risk to national security, while (Eriksen et al. 2021) focus on the challenges climate change presents to international stability and vulnerable human populations directly experiencing its consequences. Greaves, (2021) defines threats to human security from climate-related factors as arising from extreme weather events like floods, wildfires, and heatwaves, resulting in harm, loss of life, and damage to essential infrastructure and homes. Additionally, pollution and disease vectors contribute to health effects, alongside potential food and water scarcity.

Numerous studies acknowledge climate change as a significant global security threat, with Shivanna, (2022) exploring its role as a threat multiplier that amplifies existing risks. Climate change can heighten the probability and intensity of conflicts over resources such as water and food, leading to displacement and migration (Ide, 2023). The enactment of the National Food Security Act (NFSA) in 2013 by the Indian Parliament is vital for securing the food needs of a significant portion of the population. It addresses food insecurity and malnutrition in India by legally guaranteeing access to subsidised food grains, aiming to enhance the overall food and nutritional security of the country. To tackle challenges and achieve food security, the Indian government has implemented various schemes like the National Food Security Act, Integrated Child Development Services, and the National Food Security Mission. These programs aim to improve agricultural productivity, provide nutrition to vulnerable populations, and enhance food distribution systems.

However, persistent obstacles include climate change, low agricultural productivity, inadequate distribution mechanisms, rural-urban migration, and gender inequalities. Achieving food security in India requires an integrated approach involving technological advancements, sustainable agricultural practices, effective social welfare schemes, and improved distribution systems. International organizations such as the Food and Agricultural Organization (FAO), World Food Programme (WFP), International Fund for Agricultural Development (IFAD), and the World Bank play a crucial role in addressing global food security challenges and supporting countries like India in their efforts to achieve food security. Food security extends beyond providing enough food; it involves ensuring access to nutritious food, reducing inequality, and promoting sustainable agricultural practices for the well-being and prosperity of a nation's population.

Implementing agricultural practices that are resilient to climate changes is a crucial factor in addressing hunger and poverty in the face of the challenges posed by climate change. This strategy is essential because climate change poses a significant risk to agriculture, potentially resulting in a substantial decrease in agricultural income.. This threat is not hypothetical but is already impacting farmers worldwide, undermining their livelihoods and exacerbating food insecurity and poverty. Prioritising climate-resilient agriculture (CRA) is urgent, encompassing strategies and techniques designed to make agriculture more robust and adaptive to unpredictable weather patterns, extreme events, and shifting climate conditions. Such methods encompass diversifying crops, enhancing irrigation systems, adopting sustainable soil management practices, and cultivating crop varieties resistant to climatic variations. CRA not only safeguards food production but also promotes economic stability, protects the environment, and contributes to the mitigation of greenhouse gas emissions.

A study by Tirado et al. (2022) emphasises the need to learn from practical examples of coordinated climate adaptation efforts, proposing a multi-phased approach to combat climate-related food security and malnutrition challenges. This approach includes immediate assistance, climate services, improved risk management, and long-term investments in various sectors to build resilience and ensure access to healthy food and essential services. Developing crops capable of withstanding the adverse effects of climate change, such as drought and heat, is pivotal, and breeding methods are essential for this purpose. Approaches like genome-wide association studies (GWAS), genomic selection (GS), and advanced genotyping, coupled with high-throughput phenotyping, are instrumental in identifying specific genes to enhance crops in response to climate challenges (Raza et al. 2019). Researchers utilized a computer method (Artificial Neural Network) to identify drought-tolerant types of durum wheat, highlighting specific measurements and wheat varieties suitable for dry areas. This method has broader applications beyond wheat and can aid in selecting drought-resistant crops for various scenarios.

It is imperative for society, governments, international organisations, and agricultural stakeholders to underscore the rationale behind CRA and take comprehensive steps towards its wider adoption. This entails significant investments in research, education, infrastructure development, and providing resources and support to farmers for transitioning to climate-smart agriculture. By doing so, we can empower farmers to weather the challenges of a changing climate while simultaneously elevating their livelihoods and food security. Moreover, embracing CRA practices aligns with broader goals of achieving sustainable development and a more resilient, equitable, and climate-ready future for generations to come.

Climate-resilient agriculture involves strategies, biodiversity conservation, and sustainable practices to combat climate change, encompassing five capacities: threshold, coping, recovery, adaptive, and transformation. Adaptation aims to reduce vulnerability, strengthen resilience, and enhance the ability to anticipate and respond to climate change successfully. Key issues include adopting mitigation technologies, managing water and nutrients efficiently, providing timely crop advice, and implementing conservation agriculture to improve soil health and support plant growth and manure management to achieve climate goals and sustainable development (Sun, 2023).

Research Questions

1. To assess the impacts of climate change on security- namely food security
2. To examine the role of climate resilient agriculture systems as way forward considering inevitable climate change

Climate Change and Food Security Nexus

The significant issues of recent times revolve around climate change and its repercussions on food security. This portion provides essential perspectives from different authors regarding the correlation between climate change and the stability of our food supply.

Understanding Climate Change

Climate change pertains to shifts in a region's climate caused by both human-induced and natural disturbances, encompassing phenomena like the depletion of the ozone layer and the greenhouse effect (Muluneh, 2021). Contributors to climate change encompass changes in solar emission, natural processes, and human activities (Baede, n.d.). Future forecasts primarily focus on the consequences of human-related factors, particularly the rise in greenhouse gases, on climate change (IPCC, 2014). Since the adoption of the 2015 Paris Agreement, there has been an increased global dedication to substantially decrease CO2 emissions, with a notable emphasis on transitioning to cleaner energy sources.

Impact on Agriculture and Food Security

Climate change is anticipated to cause enduring alterations in weather patterns, resulting in severe consequences for agricultural output, food security, and the availability, accessibility, and utilization of food (Godde et al. 2021). Consequently, this can lead to increased volatility in global and regional food trade, which in turn threatens people's ability to access food in a reliable manner (Mbow et al. 2019). These disruptions can have a particularly adverse impact on land-locked countries with limited access to global food trade infrastructure, as well as on vulnerable social groups, especially in regions lacking functioning or adequate social protection programs (FAO, 2018).

Food security, as defined by the Food and Agriculture Organization (FAO), encompasses access to sufficient, safe, and nutritious food, both physically and economically, to maintain a healthy lifestyle (FAO, 2009). Achieving food security aligns with Sustainable Development Goals (SDGs) such as zero hunger and good health and mental wellbeing (Swinburn et al., 2019).Climate change affects food security most significantly in regions relying on rain-fed agriculture (Pickson & Boateng, 2021) and it may lead to fluctuations in global food market prices (Myers et al. 2017).In the face of climate change ,investigating the impact on crop productivity and food production is crucial (Bai et al. 2022).Food and energy are interconnected, with environmental and nutritional effects affecting each other (Taher, 2020; Keskinen, 2019).The global food system contributes significantly to greenhouse gas emissions (Keskinen, 2019).

Challenges and Future Projections

Ensuring food security while protecting biodiversity is a significant challenge (Hanspach et al. 2017) Severe weather conditions are reducing yields and livestock numbers, exacerbating food shortages (Hanspach et al., 2017). Expanding agricultural land is becoming difficult due to land scarcity and the need to protect biodiversity (Kanianska, 2016) and mitigating food waste could reduce the need for further land conversion and biodiversity loss (Dalin & Outhwaite, 2019). Various non-climate factors also influence food security (Richardson et al., 2018). The global population increase poses challenges to food security (Kanianska, 2016). A growing global population is expected to require 70-100% additional food by 2050, with increased demand for cereals and meat (Besada & Werner, 2014).

Mitigating Climate Change Effects

Technological progress holds promise for addressing the challenges posed by climate change and enhancing agricultural outcomes (McLachlan et al. 2020). The regional aspect is pivotal, as the impact of climate change on food security varies depending on the region and the scale of analysis (McLachlan et al. 2020). While elevated CO2 levels can boost crop productivity, the adverse effects of excessive heat can counterbalance these gains (McLachlan et al. 2020).

The assessment of climate change's impact on food insecurity incorporates a vulnerability index (VFI), underscoring the importance of both mitigation and adaptation strategies (Richardson et al. 2018). In a study conducted by Etminan et al. (2019), an Artificial Neural Network was employed to identify drought-resistant varieties of durum wheat. The researchers cultivated these wheat types in both rainy and irrigated conditions for two years, concluding that specific measurements like YSI, HM, and SSI can indicate drought tolerance. Furthermore, metrics such as MP, GMP, and HM can assist in identifying drought-resistant wheat varieties, including G9, G12, G21, G23, and G24, which proved suitable for cultivation in arid regions. This method has broader applications beyond wheat and can aid in selecting drought-resistant crops for various scenarios.

Continual research and development for crops are essential to address the effects of climate change on agriculture. Given the decreasing viability of existing systems, there is a growing urgency for transformative adaptation, which entails systemic changes in cropping systems.. This shift calls for localised and specific research on crop viability, economics, and social impacts, alongside investments in research and development capacity. Key strategies include precision phenotyping, diverse genetic traits, and participatory breeding approaches. Investments should also support farmers in adopting new crops, necessitating policy changes to incentivize climate-resilient crops. Crucially, considerations of gender and social equity are vital to ensure that marginalised communities benefit from these transformative changes (Niles et al. 2020).

Role of FAO

The crucial role of addressing global food security issues is undertaken by the Food and Agriculture Organization (FAO), as highlighted by Mahmood et al. (2022). FAO defines food security as having the means to access sufficient and nutritious food for a healthy life (Mahmood et al. 2022). Food security comprises four key dimensions: availability, stability, access, and utilization (Mahmood et al. 2022).

Current Challenges and Regional Implications

Recent reports indicate a rise in global food insecurity, driven by various factors (GRFC 2022; World Bank report). The number of people facing severe food insecurity has increased (GRFC 2022). Factors such as conflict, supply chain disruptions, and economic consequences of the COVID-19 pandemic contribute to food insecurity (World Bank report).

Climate Resilient Agriculture / Crops and Way Forward

In this section, we conducted a comprehensive analysis of various perspectives and case studies on climate-resilient agricultural systems and the way forward

The Food and Agriculture Organization (FAO) introduced the concept of climate-smart agriculture (CSA) in 2009, representing an approach that offers guidance on necessary actions to reshape and adapt agricultural systems effectively. This transformation aims to support sustainable development and ensure food security, particularly in the face of a changing climate (Lipper & Zilberman, 2018; "CLIMATE-SMART AGRICULTURE Sourcebook," 2013). Climate change is adversely impacting maize production and the well-being of smallholder farmers in many developing countries. Research by Zizinga et al. (2022) suggests that climate smart agriculture (CSA) practices can mitigate these effects by improving soil moisture storage, water use efficiency, increasing soil carbon and nutrient supply, and promoting long-term resilience to climate change, ultimately enhancing agricultural production and food security in Uganda.

A key problem with Climate-Smart Agriculture (CSA) initiatives is that they frequently overlook social differences and divisions among the target populations, as well as the inequalities rooted in local power dynamics. This often results in a lack of consideration for whether CSA interventions align with and address the priorities and needs of the diverse farming communities (Glover et al., 2016; Kyeyune & Turner, 2016). What is often missing is the practical understanding of how a particular technology can be integrated into the daily practices and real-life conditions of farmers within various farming systems, encompassing both agronomic and social aspects (Sinclair & Coe, 2019).

Hellin et al. (2023) argues for a shift from a focus on climate-smart agriculture to climate-resilient agriculture. This shift entails not only ensuring ecological aspects like persistence and recovery but also creating conditions that enable households to improve their assets and livelihoods. The goal is to transform undesirable socioeconomic conditions, such as inequalities in power and income, into more desirable ones without harming the environment. However, they note that strategies to enhance climate resilience may not equally benefit all smallholder farmers, potentially leading to greater resilience for some and no benefit at all for others, which they refer to as maladaptation. Achieving climate-resilient agriculture necessitates addressing social equity and power dynamics within farming communities. Neglecting these issues could perpetuate maladaptive outcomes that benefit a few at the expense of many, potentially exacerbating existing inequities and vulnerabilities in society due to climate change (Araos et al., 2021; Fisher et al., 2022).

Climate-resilient agriculture (CRA) entails the sustainable utilization of available natural resources within crop and livestock production systems to attain increased long-term productivity and farm incomes in the presence of climate fluctuations (*Climate Resilient Agriculture Systems: The Way Ahead*, 2021). The success of these new technologies hinges on understanding how plants adapt to their environment, combat stress, and interact with pathogens and pollinators. Developing balanced genetic content in crop varieties is crucial to mitigate losses from environmental stressors, pests, and changing conditions. Key objectives include improving photosynthesis, optimizing resource usage, and promoting beneficial plant-microorganism interactions (Rivero et al., 2021). Like India, many farming communities globally, especially in low-income countries, are expected to confront severe food insecurity by 2050 due to climate change and associated challenges like resource degradation, poverty, and urbanization. Coping with more extreme weather events, changing climate patterns, and increased pests and diseases will demand transformative adaptation, requiring fundamental changes in agriculture, including what, where, and how we produce food.

Climate services (CS) need to focus more on long-term climate impact analysis, specifically up to 2050, to support transformative adaptation in agricultural systems. Existing CS have been beneficial for short-term decision-making, but planning for more significant and long-term interventions requires data projecting further into the future. This information should also account for shifts in productivity, especially regarding temperature and precipitation projections. To drive systemic change, CS must integrate data from various sectors, such as biological, environmental, economic, and social factors, to reduce competition and conflicts between sectors. Additionally, CS must be tailored to meet the needs of adaptation entities to assess the viability of existing agricultural production systems and alternatives. Support in the form of tools, guidance, capacity building, and networks is required to incorporate this information into plans and policies. Transformative adaptation pathways need to be developed, guided by high-quality, tailored CS, and embedded within planning processes to address climate-induced inequalities (Ashley et al., 2020). In climate change hotspots, transformative adaptation acknowledges the need for fundamental changes in agricultural systems, including shifts in where, how, and what types of food are produced.

In Ethiopia, farmers engage in participatory plant breeding, shaping breeding goals and processes. They improve seed sharing within local networks (Gee, 2023)

The National Mission for Sustainable Agriculture (NMSA) is a crucial initiative within India's National Action Plan on Climate Change (NAPCC). Its primary objective is to address the challenges posed by climate change in the agricultural sector and enhance the resilience of Indian agriculture to these challenges. The NMSA is dedicated to formulating and implementing strategies that ensure the sustainability of agriculture while considering the impacts of climate change. An illustrative example of transformative adaptation is the shift to millet in India, facilitated by climate services, research, and access to seeds. Through collaborative efforts between the government and NGOs, incentives were provided, drought-tolerant millet varieties were introduced, and weather information was disseminated, demonstrating how community engagement can effectively foster climate adaptation for long-term resilience (Gee, 2023). Millets are acknowledged as robust crops capable of serving as a reliable source of food and nutrition, particularly in regions vulnerable to the effects of climate change (Saxena et al., 2018).

Research by Wilson and VanBuren, (2022) stressed on shifting our attention from traditional staple cereals to the cultivation of highly resilient millets is paramount for the future of agriculture. This change has the potential to increase agrobiodiversity in our diets, mitigate micronutrient deficiencies, and reduce the demand for agricultural water, fertilizers, and pesticides. Different types of drought conditions demand specific adaptive varieties. In response to low rainfall in Aurangabad, Maharashtra (645 mm of rainfall), early-maturing and drought-tolerant strains of green gram (BM 2002-1), chickpea, and pigeon pea (BDN-708) were introduced on selected farms. These strains yielded 20-25 percent more than native varieties. Similarly, drought-tolerant, early-maturing pigeon pea (AKT-8811) and sorghum (CSH-14) cultivars were introduced in Amravati district, Maharashtra (877 mm of rainfall) (Ch Srinivasarao, 2021). A comprehensive approach is needed to address the challenges of climate change and food security, considering adaptation measures, technological innovations, sustainable agriculture, and global cooperation. The study by Acevedo et al. (2020) brings to light the significance of previously overlooked crops, specifically certain legumes, roots, and tuber crops like cassava, bambara groundnuts, and beans. These crops have demonstrated notable climate resilience, and they serve as rich sources of high-quality nutrition. Furthermore, they offer well-established environmental benefits, including soil enrichment, which can be more pronounced than what is typically associated with cereals. This research underscores the potential of diversifying agricultural practices by prioritizing such resilient and nutritionally valuable crops, aligning with climate-smart agriculture initiatives.

The research by Bahri et al. (2019) emphasizes the significance of the International Centre for Agricultural Research in the Dry Areas (ICARDA) in promoting conservation agriculture for bolstering the resilience of staple crop production in arid regions amid climate change and global uncertainties. Conservation Agriculture (CA), which involves practices like reduced ploughing, crop rotation, and crop residue retention, has been proven to enhance soil fertility, nutrient availability, and water conservation. Collaborative research with National Agricultural Research Systems (NARS) reveals that CA systems can yield up to a 15 percent increase in grain production, cost-effectiveness, and improved water utilization. Furthermore, a joint study with INRAT in Tunisia showcases how CA can assist farmers in adapting to higher temperatures and water scarcity, leading to a 15 percent rise in wheat yields and improved soil quality. The study also identifies priority areas in Tunisia where CA adoption is suitable, covering a substantial portion of the country's cereal production zones.

Study by Verslype et al. (2023) used computer algorithms to predict which grapevine varieties are better at surviving drought in the São Francisco Valley, Brazil. They collected data and tested different algorithms. The best one, called RF, was 98.57% accurate at predicting drought tolerance, while the worst, LDA, had 67.14% accuracy. They used the best model to predict the drought tolerance of three grapevine varieties that had never been tested before. Two of them were predicted to have high drought tolerance, while one had low tolerance. This could help grape growers in the São Francisco Valley. By using machine learning to predict the drought tolerance of grapevine varieties, the study contributes to the broader goal of climate-resilient agriculture, as it helps in selecting and breeding crop varieties that can better withstand climate-related stresses like drought

The Agriculture Modernization Project in Uzbekistan supported by World Bank has two primary objectives: first, to enhance productivity-supporting agricultural services, and second, to promote market-led, high-value horticulture value chains. The project is structured into four components. The first component, "Enhancing Productivity-Supporting Agricultural Services," aims to enhance knowledge and human capital to transform Uzbekistan's agriculture, making it more productive, climate-resilient, diversified, and market-oriented. This includes subcomponents focused on applied agricultural research and development, with an emphasis on adapting technologies to local conditions and evolving circumstances over time (*Development Projects : Agriculture Modernization Project - P158372*, 2023).

In China, the World Bank has invested $755 million in a series of projects that promote resilient and lower-emissions agricultural practices and institutions. One of these initiatives focuses on expanding climate-smart agriculture by improving water-use efficiency on 44,000 hectares of farmland. This project also introduces new technologies to enhance soil conditions, resulting in a 12% increase in rice production and a 9% increase in maize production. Over 29,000 farmers' cooperatives have reported higher incomes and greater climate resilience as a result of this project. Additionally, another recently completed project has successfully reduced greenhouse gas emissions by 23,732 tons of CO_2 equivalent and increased the soil carbon sink by 71,683 tons of CO_2. These efforts signify a significant contribution to sustainable and climate-resilient agriculture in China (*Development Projects : Integrated Modern Agriculture Development Project - P125496*, 2020)

Research Methodology

In this study, a systematic literature review was conducted to examine the intricate relationship between climate change and food security. The research methodology involved systematic database searches and a purposive sampling strategy to identify relevant articles published in English over the last 11 years from 2013 to 2023

Keywords:

Two sets of keywords were employed for the database search:

"Climate Change " and "Food Security"

"Climate Change " and "Agriculture Resilience"

Database Search:

The primary database utilised for this research was Scopus, a renowned multidisciplinary database. Scopus offers an extensive collection of academic journals, conference proceedings, and scientific publications, making it suitable for comprehensive literature exploration.

Inclusion Criteria:

Articles published in English.

Publications within the last eleven years, ensuring relevance and timeliness.

Exclusion Criteria:

Articles not directly related to the study's focus.

Publications in languages other than English.

Articles published before the eleven year timeframe.

Purposive Sampling:

Purposive sampling was employed to select articles that specifically addressed the impact of climate change on food security and agriculture resilience. This method allowed for the selection of articles that closely aligned with the research objectives and questions, ensuring the inclusion of high-quality, relevant literature.

Data Collection:

The initial database search in Scopus yielded a substantial number of articles, specifically 2640. After applying the inclusion and exclusion criteria and removing duplicates and irrelevant articles, a refined dataset of 58 articles was considered for review. Additionally, 17 relevant reports were included in our study. This dataset represented a comprehensive collection of scholarly articles and reports directly related to the research objectives.

Data Analysis:

The selected articles were thoroughly reviewed, and relevant findings and insights were extracted. The scrutiny cantered on the identification of major themes, patterns, obstacles, and possible solutions concerning the relationship between climate change and its effects on food security and agricultural resilience.

Prisma Flowchart:

The research process followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure transparency and rigor (Page et al., 2021)

A PRISMA flowchart was used to document the article selection process, including the number of articles identified, screened, included, and excluded at each stage.

This research methodology allowed for a systematic and comprehensive exploration of recent literature on the critical intersection of climate change, food security, and agriculture resilience. It ensured that the findings and insights presented in this study are based on a robust and up-to-date collection of scholarly articles.

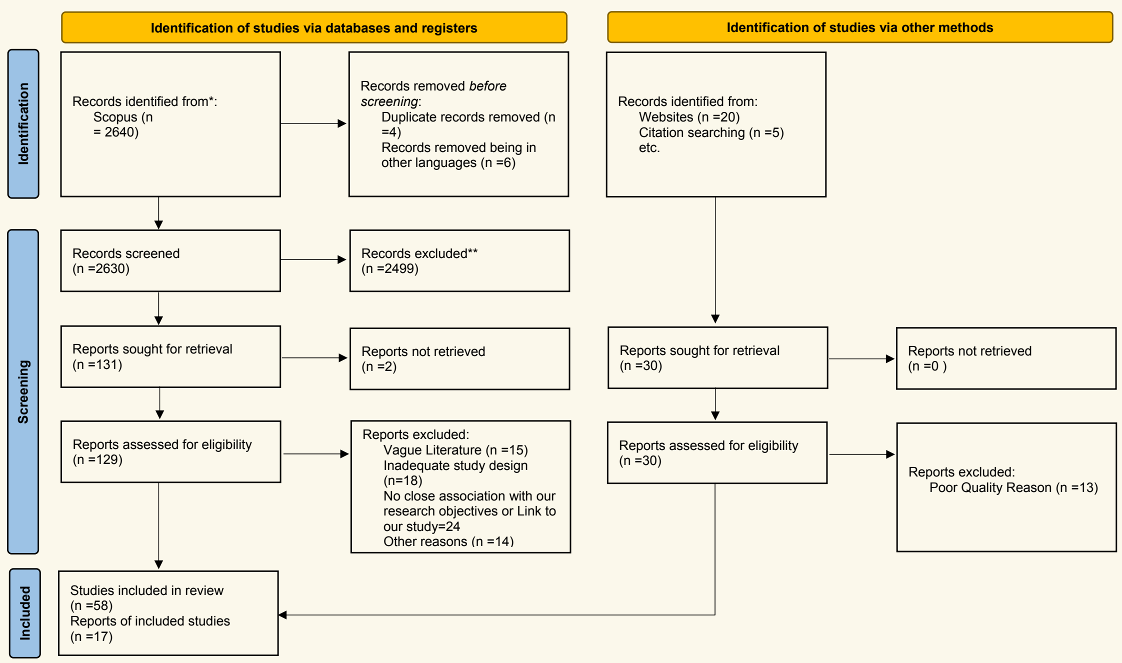

Figure 1: PRISMA 2020 flow diagram for new systematic reviews which included searches of databases, registers, and other sources (Page et al., 2021)

Discussion

Climate change poses a significant threat to food security, driven by both human activities and natural processes. Rising levels of CO_2, primarily due to human actions, have far-reaching effects on weather patterns and temperatures, impacting agricultural productivity and food security. Extreme weather events, such as floods, droughts, and heatwaves, adversely affect agricultural production and food availability, leading to food shortages and higher prices while compromising the nutritional quality of crops. These long-term changes in weather patterns due to climate change have severe consequences for agricultural output, food security, and accessibility (Muluneh, 2021; Myers et al., 2022; Rezvi et al., 2023; Shivanna, 2022; Godde et al., 2021; Hanspach et al., 2017). Moreover, the impact of climate change extends to agricultural productivity, with rising temperatures and altered rainfall patterns negatively affecting crop yields and food production. Even a small temperature increase of just 1°C can result in substantial reductions in crop yields, particularly for wheat (Ortiz-Bobea et al., 2021; Ahmed et al., 2023; Asseng et al., 2015; Rasul, 2021). As the global population is expected to reach nine billion by 2050, food demand is set to significantly increase, particularly in developing countries. This growth will notably impact cereals and meat, with a predicted increase in demand by 93% and 85%, respectively, by 2050 (Besada & Werner, 2014; Mahmood et al., 2022). Furthermore, developing countries, despite contributing less to climate change, are disproportionately affected, with regions like South Asia experiencing a high frequency of climate-related disasters (Malhi et al., 2021; GCA.org, 2022). Recognized as a global security issue since 2007, climate change's implications have been debated on the international stage. These discussions span a spectrum, encompassing perspectives that perceive climate change as a source of conflict and a threat to national security, while also acknowledging the difficulties it presents to global stability and susceptible populations (Donald, 2018; Vogler, 2023; Eriksen et al., 2021). Addressing climate change's threat to food security requires collective action and innovative solutions on a global scale (Wijaya, 2014; Mahmood et al., 2022; Chappell & LaValle, 2011). To combat these challenges, climate-resilient agriculture practices, including crop diversification, sustainable soil management, and climate-resistant crop varieties, play a crucial role. These practices aim to enhance agricultural resilience, protect food production, and contribute to economic stability while mitigating greenhouse gas emissions (Climate Resilient Agriculture Systems: The Way Ahead, 2021).

Investments in research, education, and infrastructure are essential to address the challenges posed by climate change. Regional variations in climate change impacts demand localized research on crop viability and social impacts. Precision phenotyping, diverse genetic traits, and participatory breeding approaches are essential for developing climate-resilient crop varieties (Ashley et al., 2020). International initiatives and collaboration, such as the National Mission for Sustainable Agriculture (NMSA) in India and projects supported by international organizations, play a significant role in promoting climate-resilient agriculture. These initiatives aim to enhance agricultural productivity, resource utilization, and climate resilience. Shifting the focus from traditional staple cereals to climate-resilient crops, such as millets, is crucial for the future of agriculture. Climate-resilient crops can increase agrobiodiversity in diets, mitigate micronutrient deficiencies, and reduce the demand for agricultural resources. Regional case studies in Ethiopia and China demonstrate the success of climate-resilient agriculture initiatives, which involve community engagement, the introduction of drought-tolerant crop varieties, and the use of climate services to enhance climate resilience. Additionally, conservation agriculture (CA), which includes reduced plowing and crop residue retention, has been effective in enhancing soil fertility, nutrient availability, and water conservation. Collaborative research has shown that CA can lead to increased grain production, cost-effectiveness, and improved water utilisation (Bahri et al., 2019).

Conclusion

In conclusion, the intricate relationship between climate change and food security presents a formidable global challenge. Rising CO_2 levels and their far-reaching effects on weather patterns have adverse implications for agricultural productivity and food availability. Developing countries, which contribute the least to climate change, are disproportionately vulnerable to its adverse effects, especially in regions like South Asia. However, there is hope in the form of climate-resilient agriculture (CRA) practices that encompass crop diversification, improved irrigation, and climate-resistant crop varieties. These strategies not only safeguard food production but also promote economic stability and environmental sustainability. Collaborative research and international initiatives, along with regional case studies, showcase the success of adopting climate-resilient crops and conservation agriculture as effective responses to climate change challenges. These strategies, when integrated with precision phenotyping and participatory breeding, hold promise for enhancing crop resilience.

The role of organisations like the Food and Agriculture Organization (FAO) in addressing food security is vital, particularly in the face of rising global food insecurity due to a multitude of factors. To secure a sustainable and resilient future, there is an urgent need for continued research, innovation, and global cooperation to promote climate-resilient agriculture and mitigate the impacts of climate change on food security. By embracing these approaches, we can work towards ensuring access to nutritious food, reducing inequality, and promoting sustainable agricultural practices for the well-being and prosperity of populations worldwide.

Recommendations

Recommendations for further study, include the following:

International Collaborations and Partnerships: Researchers recommend exploring the impact of international collaborations and partnerships on addressing climate change and enhancing global food security. This entails a comprehensive examination of successful initiatives, the exchange of best practices, knowledge transfer, and resource allocation in different regions. Researchers should assess the outcomes and challenges of these collaborations in mitigating the impact of climate change on food security.

Policy Evaluation: Researchers advocate for conducting thorough evaluations of existing national and international policies concerning climate-resilient agriculture and food security. The objective should be to analyse the effectiveness of these policies in achieving their intended objectives and to assess their real-world impact.

Limitations of the Study

This study specifically focused on food security as it relates to climate change. While this is an important aspect of the climate-security nexus, other aspects of the issue were not explored in this paper. While a systematic review of literature from reputable sources was conducted, the study did not include primary data collection or interviews, which could provide additional perspectives and insights.

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Annexure 15.4.7

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6	13	A
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4	www.iiche.org.in	<1	Publication
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7	ec.europa.eu	<1	Publication
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10	1library.co	<1	Internet Data
11	www.e3s-conferences.org	<1	Publication
12	www.intechopen.com	<1	Publication
13	www.researchgate.net	<1	Internet Data

Reviewers Memorandum

Reviewer's Comment 1: The title of the topic is self-explanatory and quite relevant in today's time considering the escalating concerns surrounding climate change and its multifaceted implications.. Author has done systematic literature review in two phases firstly she has analysed the existing literature from Scopus database and in second phase she analysed the various E-contents from reputable sources like World Bank, FAO,IFAD,NAFSA and other reputed website to understand the impact of climate change on food security.

Reviewer's Comment 2: One commendable aspect of the paper is the meticulous approach to the systematic literature review, which enhances the credibility and reliability of the findings. The inclusion criteria, search strategy, and data extraction methods are clearly outlined in the PRISMA flow chart, contributing to the transparency of the research process. This transparency is crucial for readers and fellow researchers seeking to replicate or build upon this review.

Reviewer's Comment 3: Author has defined the research question in the beginning itself. The manuscript is well-written and easy to understand. However, the author could have mentioned how her study is different from other existing studies. Also two-three database could have more been taken for the extracting data apart from Scopus only which also give scope for future studies.

Citation

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Conflict of Interest: Author of a Paper had no conflict neither financially nor academically.

Editorial Excerpt

The article has 06% of plagiarism which is the accepted percentage as per the norms and standards of the journal for publication. As per the editorial board's observations and blind reviewers' remarks the paper had some minor revisions which were communicated on a timely basis to the author (Ruchi), and accordingly, all the corrections had been incorporated as and when directed and required to do so. The comments related to this manuscript are noticeably related to the theme "**Climate Change and Security with Reference to Food Security: A Systematic Literature Review**" both subject-wise and research-wise. The author has successfully navigated through a vast array of literature to provide a comprehensive overview of current research on the subject. The systematic approach to literature review is a strong point, with the author demonstrating a rigorous methodology. The inclusion criteria are well-defined, and the search strategy is transparent. Overall, this paper constitutes a valuable contribution to the literature on climate change and security, specifically in relation to food security. After comprehensive reviews and editorial board's remarks the manuscript has been categorised and decided to publish under the "**Review of Literature**" category.

Acknowledgement

The acknowledgment section is an essential part of all academic research papers. It provides appropriate recognition to all contributors for their hard work and effort taken while writing a paper. The data presented and analysed in this paper by author (Ruchi) were collected first handily and wherever it has been taken the proper acknowledgment and endorsement are provided. The authors are highly indebted to others who facilitated accomplishing the research. Last but not least, endorse all reviewers and editors of GJEIS in publishing in the present issue.

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