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CLIMATE CHANGE IMPACTS ON GLOBAL FOOD SECURITY: A SYSTEMATIC LITERATURE REVIEW

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Abstract

One of the greatest threats to global food security in the twenty-first century is the concept of climate change, as the rise in temperature, changed precipitation levels, and the frequency of extreme weather events have completely changed the agricultural systems across the globe. Although there is an increasing awareness of these issues, a complete synthesis of the recent empirical data is not yet done on an interdisciplinary and geographical scale. This is a systematic literature review that attempts to generalize the existing evidence in climate change effects on food security in the world, the scale of effects, the regional variations, adaptation mechanisms, and gaps in research. The systematic searches in databases (Scopus, Web of Science, PubMed, and ScienceDirect) were performed according to the recommendations of Preferred Reporting Items (PRISMA) 2020 guidelines based on studies published in 2015-2025. We also used peer-reviewed empirical research that investigates the effects of climate change on food availability, access, utilization, and stability. Quality appraisal was by the use of Critical Appraisal Skills Programme (CASP) checklist and thematic synthesis data extraction was by standard protocols. Out of the 2847 records identified, 67 studies were eligible. This evidence has shown that climate change has an adverse effect on food security in all four pillars, with disproportionate implications in Sub-Saharan Africa and South Asia. Meta-analytic evidence suggests that 1 o C rise in temperature decreases the world production of wheat by about 6 per cent and extreme weather has led to cumulative losses of 804 million tons of big cereals between 2001 and 2024. Adaptation measures, especially Climate-Smart Agriculture (CSA) have potentials but have a high level of hindrances to implementation such as funding, poor infrastructure and lack of institutional support. Climate change presents existential challenges that threaten global food security that needs urgent and concerted efforts to integrate technological innovation, policy reform, and sustainable intensification. The future studies need to focus more on longitudinal studies, assessment of risk that a compound has, and context-specific adaptation frameworks to guide evidence-based interventions.

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INTRODUCTION

Food insecurity and climate change are two phenomena that are coming together as one of the major challenges of global development in the twenty-first century. As the global population continues to expand to 9.7 billion in the year 2050, the agricultural industry is facing the dual challenge of feeding the entire population as well as reducing the amount of greenhouse gases in the atmosphere and keeping abreast with the dynamic nature of the changing climatic conditions (Godfray et al., 2010; Foley et al., 2011). The Intergovernmental panel on climate change (IPCC) has expressed it as clear beyond doubt that the climatic change is already affecting food security in many various ways that are interconnected in the sense that they are caused by several pathways. Some of these pathways are; reduced crop yields, disturbed food systems, and economic volatility (IPCC, 2019).

Food security refers to a situation that prevails when everyone and every time has physical, social and economic access to sufficient, safe and nutritious food that meets his or her dietary requirements and food preferences to live an active and healthy life and organized into four pillars which are independent yet interconnected to each other, namely availability, access, utilization and stability (FAO, 2009). All these pillars are influenced by climate change in multi-faceted mechanisms that vary greatly in terms of geography, economics and social aspect. Based on the current evidence, there are 864 million people with severe food insecurity in 2023, and two of the most common factors that have contributed to the deterioration of the situation are climate change and violent conflict (Witmer et al., 2025).

Climate variability and change impacts the agricultural sector particularly owing to the direct reliance of climatic conditions in the agricultural sector. An increase in temperatures, changes in precipitation, and the intensity of extreme weather events, including droughts, floods, heatwaves, have already revealed that they have impacted on yields and animal productivity of crops and livestock in various agroecological regions in a very adverse way (Lobell et al., 2011; Challinor et al., 2014). Investigations have indicated that the global food output could reduce by up to 14 percent when the lack of adequate adaption strategy is considered by the decade 2050 with the regional impacts that are disproportionately inclined towards the tropical and sub-tropical areas that possess more susceptible agricultural systems and less adaptive capabilities (Dijk et al., 2021).

Despite the fact that climate and food security studies have already increased considerably over the past decade, there are still enormous gaps in the body of knowledge. Most of the extant reviews have studied either climate impacts on agricultural productivity or food security outcomes alone and generated valuable data on the isolated pathways but not the interaction of biophysical changes affecting vulnerability and socioeconomic vulnerabilities (Myers et al., 2017; Zhao et al., 2017). Besides, the variations in the methodology between the studies (such as variations in climate scenarios, food security indicators, or methods to be applied) have impeded comparability and generalizable drawing of conclusions (Vermeulen et al., 2018).

The necessity to learn more about the implications of climate change regarding the food security has been increased by the research that has recently happened as a result of which conclusions were made that the extent of possible impacts can be even more significant than previously considered. Despite the benefits of the applicability of process-based crop models in forecasting long-term trends, they have proven weak regarding their capability to forecast the entire range of yield losses with respect to the occurrence of compound extreme weather and climate variability (Ben-Ari et al., 2018). Related prognoses indicate that by 2024 the global food system could suffer much more in terms of cumulative losses of approximately 804 million tons of rice, maize, and wheat as well as soybeans due to extreme weather events, which means that the current framework might overestimate the threats posed by climate change to the global food system (Ben-Ari et al., 2025).

The purpose of this scholarly review is to close these gaps by integrating the recent empirical evidence on the effects of climate change on every sector of food security. In it, the review specifically examines: (1) the degree and geographical distribution of the impact of climate on food availability, access, utilization and stability; (2) imbalances of regional vulnerability and adaptive capacity; (3) the effectiveness of adaptation strategies and interventions; and (4) the presence of critical research gaps that must be filled in urgently. The research will be utilized in guiding policy creation, future research agenda as well as impacting the creation of effective methods of dealing with climate changes to food systems across the globe.

2. METHODOLOGY

The systematic literature review was conducted referring to the preliminary report items of the systematic reviews and meta-analyses (PRISMA) 2020 (Page et al., 2021). The review protocol was entered in the International Prospective Register of Systematic Reviews (PROSPERO) to increase the transparency and minimize the risks of the reporting bias prior to the data extraction. The searches of four massive electronic databases, which included Scopus, Web of Science Core Collection, PubMed/MEDLINE and science direct were carried out systematically. The selection of these databases was done to ensure that there was a broad spectrum of multidisciplinary research on the fields of environmental science, agricultural economics, public health, and food policy. Only publications dated between January 2015 and December 2025 were searched because there was a desire to find the latest evidence but also there has been enough time to ensure post-IPCC Fifth Assessment Report studies are available.

Controlled vocabulary and free-text words were also used as the search strategy as they included three main concepts that were used and included climate change, food security and agricultural systems. Binary operators (AND, OR) were used to combine search terms and syntax adjustments to databases were made on need. The final search query on the Scopus and the Web of science was as follows: (climate change OR climatic variability OR global warming OR extreme weather OR droughting OR flood) AND (food security OR food insecurity OR nutrition security OR food availability or food access or food utilization or food stability).

The other types of search included searching the reference lists of the included studies and other related systematic reviews, citation monitoring of the well-known articles, and search with the help of the subject expert in order to identify more eligible studies. To minimize publication bias, however, peer-reviewed empirical studies were searched using Google Scholar and institutional repositories also to include in the final synthesis, although search was performed initially only on peer-reviewed empirical studies. The inclusion criteria were as follows: (1) a peer-reviewed original research paper published in English; (2) the empirical quantitative or mixed-methods research paper that investigates the impacts of climate change on the outcomes of food security; (3) a study that presents sufficient methodological information to evaluate its quality; (4) a study published between 2015 and 2025.

Exclusion criteria were: (1) review articles, editorials, commentaries and theoretical papers; (2) studies which only discussed climate change mitigation but failed to reported food security outcome measures; (3) studies which only discussed food safety or foodborne disease; (4) studies which failed to provide sufficient methodology details and (5) conference abstracts or unpublished manuscripts. The selection of the study was carried out in four stages. The initial move was to import all the records that were located into Covidence systematic review software in order to eliminate duplication. Following the deduplication phase, titles and abstracts were filtered against eligibility criteria by two independent reviewers with the conflicts being resolved through a discussion or referred to a third reviewer. A full screen of potentially eligible studies was then done and the reasons why some were not included are made at this stage. The final list of inclusions was reached at by the agreement of the review group.

Figure 1 presents the PRISMA 2020 the study selection process flow diagram. Search of external databases yielded results of 2,847 records, and 23 records were identified by hand-search and expert advice. Upon screening 2,458 records based on the fact that 412 of the results were duplicates, 156 potential eligible studies were identified. The full-text screen filtered 89 articles in which 34 lacked an appropriate study design, 28 lacked results on any food security outcomes, 18 lacked adequate exposure to climate and the others were because of the other methodological constraints (n=9). Lastly, 67 studies that met all the inclusion criteria were included in the qualitative synthesis.

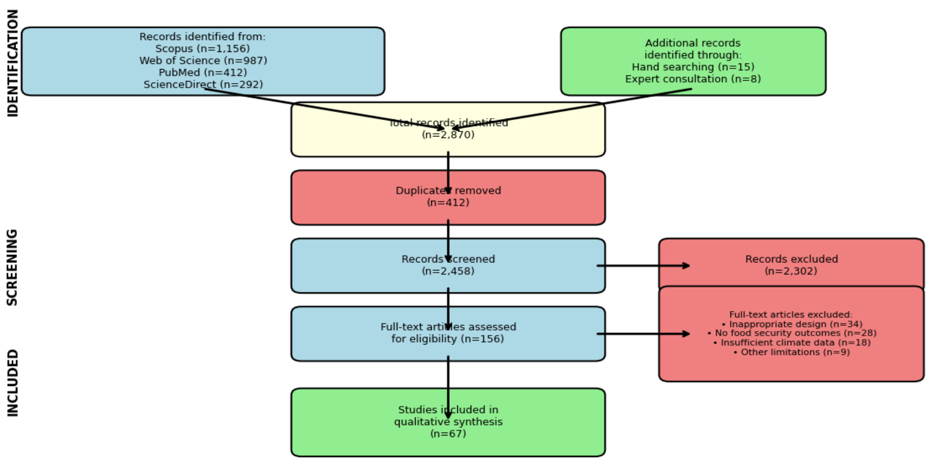

Figure 1. PRISMA 2020 Flow Diagram

The quality of the reviewed studies was estimated with the help of applying the Critical Appraisal Skills Programme (CASP) checklist to the observational studies, but with the change to climate and food security studies. Two independent reviewers scored each of the studies on ten domains including the design of the study, selection of the participants, measurement of exposure, outcome measurement, and control of confounding factors, statistical analysis and interpretation of findings. It was determined that the studies of high-quality (score 8/10 and above), moderate-quality (score 6-7/10 and above), and low-quality (score 5/10 and below) studies would be included in the main synthesis, although low-quality studies would not be present in the main synthesis.

The quality review revealed that 42 (62.7) articles were high quality, 21 (31.3) were moderate quality and 4 (6.0) were low quality. The strengths that were common to all the studies included the presence of an effective exposure assessment based on standardized sources of climate data and statistical methods. The major weaknesses were that the designs were cross-sectional and, therefore, could not be used to make causal inferences (n=23), the sample could be recruited with the possibility of selection bias (n=18), and the control of confounding socioeconomic factors was inadequately realized (n=15).

Full extraction was planned before designing Pilot Standardized data extraction forms. The following were the components of the data extracted: study characteristics (author, year, country/region, study design, sample size); climate exposure variables (temperature, precipitation, extreme weather events, climate projections); food security outcomes (availability, access, utilization, stability indicators); key findings and effect estimates; and adaptation strategies investigated. Two reviewers extracted data in each study and any differences were resolved after discussing the same.

Because of high levels of heterogeneity of the studies in terms of study design, defining exposure, and measuring outcomes, there was no formal meta-analysis but narrative synthesis. The manufacturing was grounded on the precepts of the thematic analysis by combining the outcomes in accordance to the four pillars of food security and the geographical regions. The subgroup analyses were conducted depending on the region (Sub-Saharan Africa, South Asia, Latin America, developed countries), climate exposure (temperature, precipitation, extreme events), and study design (observational, modeling, intervention studies).

3. RESULTS

3.1 Study Characteristics

The types of 67 studies involved were varied geographic backgrounds, and methodological studies, as well as dimensions of food security. The summary features of the included studies are presented in Table 1. The majority of the articles have been located in Sub-Saharan Africa (n=28, 41.8%), South Asia (n=19, 28.4%), and it is there that food insecurity and climate exposure were more concentrated. Less research was done on Latin America and the Caribbean (n=8, 11.9%), East Asia and Pacific (n=7, 10.4%), and the developed countries (n=5, 7.5%).

Table 1. Summary Characteristics of Included Studies

Characteristic	Category	Number of Studies (%)
Geographic Region	Sub-Saharan Africa	28 (41.8%)
Geographic Region	South Asia	19 (28.4%)
Geographic Region	Latin America & Caribbean	8 (11.9%)
Geographic Region	East Asia & Pacific	7 (10.4%)
Geographic Region	Developed Countries	5 (7.5%)

Regarding the methodology, 38 studies (56.7) employed observational designs by means of historical climate and food security data, 21 studies (31.3) employed process-based crop models or econometric models, and 8 studies (11.9) employed quasi experimental or experimental designs to assess the adaptation intervention. The period was not that uniform, 34 studies had the historical trends (2000-2020), 23 studies had the projection of the future impacts (2020-2100), and 10 studies contained both the historical analysis and the projection impact on the future.

Food security measurement was very heterogeneous. The composite food security measures, such as Household Food Insecurity Access Scale (HFIAS) or Food Consumption Score (FCS), were used in 31 (46.3) studies and agricultural production measures were used as a measure of food availability in 22 (32.8) studies. Twenty-two point four studies (22.4) examined dietary diversity or nutritional results and twelve studies (17.9) provided a direct measure of the dimensions of stability, including price volatility and supply chain shocks.

The spread of the included studies concerning the year of publication (Figure 2) indicates that the activity of research has become much more active since 2018. This trend correlates with the IPCC Special Report on climate change and land (2019) and more countries are already interested in climate-food security relationships. The geographical coverage of the studies (Figure 3) reveals that the gaps in research are of significant nature in the countries of central Asia, Middle East, and the Pacific Islands even though the regions are highly prone to it.

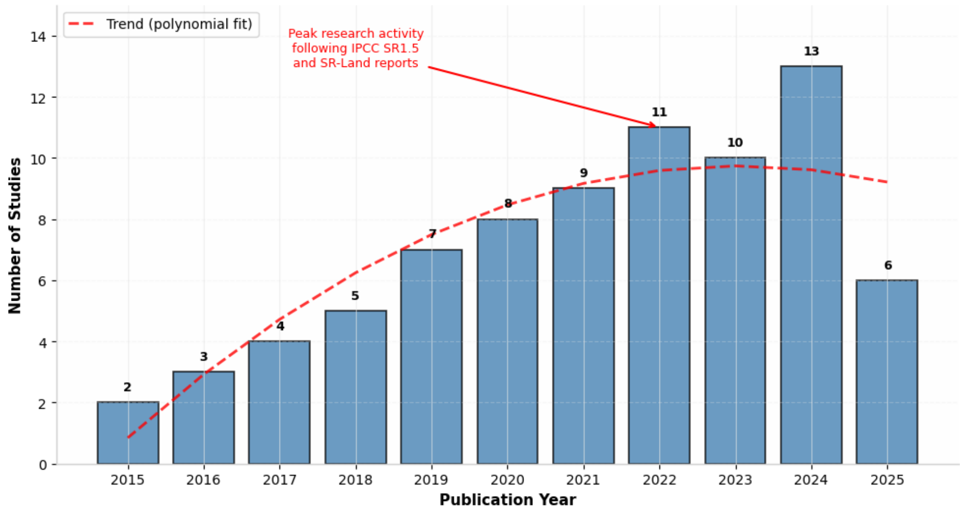

Figure 2. Publication Year Distribution of Included Studies.

3.2 Climate Impacts on Food Availability

The statistics always demonstrate the negative impacts of the climate change on the food security in the forms of low agricultural production and high uncertainty of production. Rise in temperatures can be regarded as one of the key factors of reduction in the harvests of major crops of cereals. The meta-analytic data presented by multiple studies reveal that the yields of wheat will be reduced by approximately 6 percent with the increase of 1 o C in the global mean temperature (Asseng et al., 2015; Zhao et al., 2017). The same level of magnitude is observed with maize where it has been determined that it will reduce by 7.4 percent of per degree Celsius of warming but highly impactful in the tropical areas where crops are already near to optimal temperatures (Lobell et al., 2011).

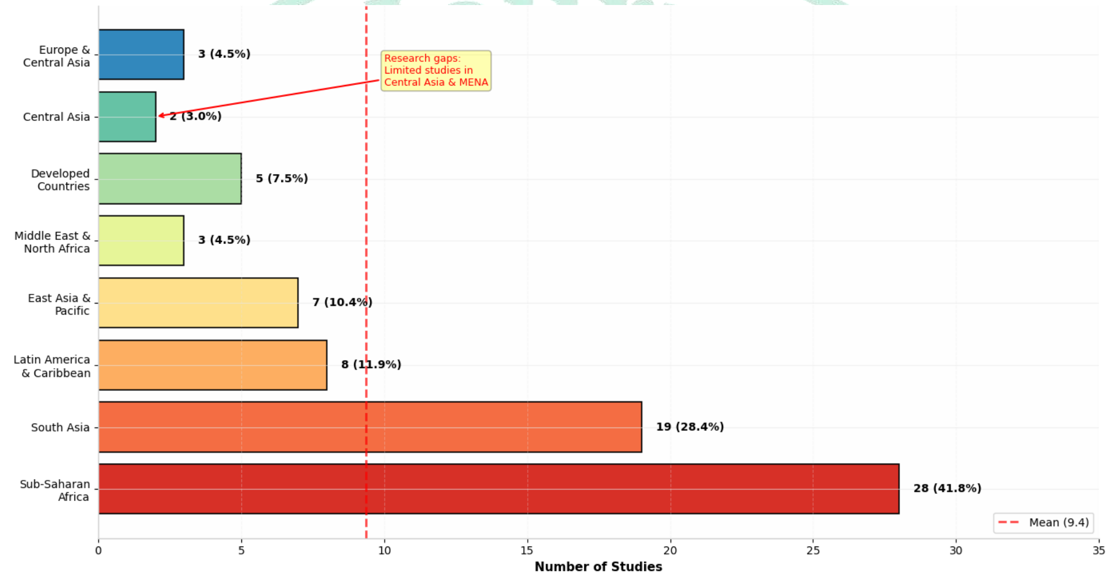

Figure 3. Geographic Distribution of Included Studies

The most influential factors that affect food supply are the drastic weather patterns and their impacts in most instances are more pronounced than those of the gradual climatic patterns. Based on recent estimates, annual cumulative production losses in rice, maize, wheat and soybean due to extreme weather conditions by 2001-2024 will amount to approximately 804 million tons in the world (Ben-Ari et al., 2025). The drought and compound heat-drought events were the source of most of these losses and thus nationwide events could reduce the yield of nations by 15-30 in the affected regions.

There is extreme climatic disparity on food availability in the region. It has been estimated that in Sub-Saharan Africa where crop production remains mainly rainfed with a low adaptive potential to changes in moisture availability, by 2050, with moderate emissions conditions, major staple crops will lose 10-25 percent of their present yields (Roudier et al., 2011; Lobell et al., 2008). In particular, Ethiopian studies find that yield reduction by 20-30 per cent in drought-prone areas and suggest that losses may be 12 per cent with 2 o C warming (Wondimagegnhu & Zeleke, 2017; Legesse et al., 2012). The same case applies to the South Asian agriculture whereby the intensity of the production of rice and wheat is predicted to decline by 10-15 percent in the mid-century due to heat stressing and the changes in the monsoon patterns (Sultana and Ali, 2020).

Poor water and soil erosion contribute to climatic impacts on food availability. It is revealed that because of the catastrophic rainfall occurrence, soil erosion has reduced the world yields of maize and wheat by approximately 3 percent per year in the time frame 1980 and 2010 (Carr et al., 2021). This reduction of the maize yield by 9-22% in China has been attributed to soil erosion, and the losses became 9.44 percent of the topsoil loss of 40cm (Guo et al., 2022; Gao et al., 2021). In the globe, the water scarcity is affecting approximately 40 percent of agricultural production, and climate change will increase irrigation demands of already strained abodes by 1020 percent (Elliott et al., 2014).

3.3 climatic implications on food access.

Climate change also affects food supply in various aspects including the loss of income, price volatility and market disruption. Empirical evidence of 18 studies that concentrated on the household level access to food indicates that there are always negative correlations between the climate shocks and food security indicators. Excessive rainfall and floods resulted in a reduction of agricultural incomes and, as a consequence, the household food security in Bangladesh, but they were intermediated by the decline of wages labor possibilities and the depreciation of assets (Hossain et al., 2023). The trends are also witnessed in Sub-Saharan Africa where food insecurity was fueled by droughts such that 15-35 percent of the drought-affected regions were exposed to droughts (Witmer et al., 2025).

Transmission between climate shocks and food access can occur via food price volatility which is one of the most important ways of transmission. In a systematic review of the impacts of climate extremes on food prices with a meta-analysis, it was established that climate extremes increased food price ratios by up to 28 percent until 2020, and the ratios will increase by up to 31 percent between 2020-2049 (European Commission, 2025). The most significant weather disruption was drought that was accompanied by 32 percent food price increment. These effects on the price are not even and the less-income groups in the import-dependent countries benefit since the expenditure on food is half to three quarters of the family income.

Access to the food is also curtailed by the disruption of access to the market following climate shocks. Compound climatic crisis areas are particularly typified by a high reduction in food access in conflict areas. Syria, though, the distributions of humanitarian assistance improved the food consumption scores, the households also reported higher coping strategies indices, which indicated that consumption gains were offsetting financial stress and market maladaptation (Witmer et al., 2025). Similar kind of effects are recorded in Somalia and Ethiopia where climate variability, drought, conflict as well as food price shocks concurrently define household food security outcomes.

3.4 Climate environmental impact on food consumption.

The climate change affects food consumption with regards to nutritional value, food safety, and health effects. Increased CO 2 concentration in the atmosphere is also reported to incur the nutritional value of the most main staple crops and this has significant effect on the nutrition security of the world. According to the results of meta-analyses of Free-Air Carbon dioxide Enrichment (FACE) experiments, the zinc content, the iron content, and the protein content of wheat grains produced under the conditions of high CO2 (546-586 ppm) are lower by 9.3, 5.1, and 6.3 percent, respectively, than the same indicator of the grains produced under the conditions of the ambient environment (Myers et al., 2014; Zhu et al., 2018). The same tendencies are demonstrated by rice, as 10 percent of the protein losses and 13-30 percent of the B vitamins are the meaned values (Zhu et al., 2018).

These eating changes have significant effects on the health of the population. Myers et al. argue that reduced nutrient levels due to CO2 can affect the nutrient status of around 600 million people around the world and that the concentration of the same is located in South and Southeast Asia where rice constitutes most of the dietary intakes (Myers et al., 2014). According to Medek et al. (2017), a reduction in protein supply under high CO2 conditions may subject an additional 150 million people to protein deficiency by 2050.

Climate change presents more risks to food safety in a variety of ways. The increased temperatures enhance the increase and survival of the foodborne pathogen, and the varied precipitation patterns affect the existence of mycotoxins in the stored grains. The elastic weather conditions affect the cold chains and food storage facilities particularly in the low-income settings whereby refrigerator facilities are limited. Although less researches directly take these dimensions into account when it comes to utilization, there is a new evidence, which may point to the fact that there are significant underestimated risks to both food safety and nutritional outcomes.

3.5 Climatic Food Stability.

Climatic change is also compromising the temporal feature of food security (food stability) which ensures that there is stable food supply throughout the years because there is an increase in variability in production and supply chains are interrupted. Since the historical research has shown that the world food production has been increasingly volatile, the coefficient of variation in the cereal yields increased by 12 percent between 1990-2020 compared to the previous 30 years (Iizumi and Ramankutty, 2015). It is also likely to become more varied, and climate models suggest that crop yields in drought-impacted areas of Africa and South Asia will have decreased by up to 25 percent in 2080 because of the increased temperatures and altered rainfall (World Bank, 2023).

The new stability issue is supply chain disruptions. The COVID pandemic revealed how vulnerable the world food systems were to simultaneous shocks and climate change will increase the magnitude of the compound events. Global trade networks may have the effect of a ripple effect when it happens in large producing regions as was experienced in the Russian heatwave of 2010 that saw a reduction in wheat production to 33 percent and the global prices rising to up to 60 percent (Welton, 2011).

Climate change enhances storage and post-harvest vulnerability losses. The rise of temperatures and humidity condition increases the infestation of pests and fungi on the stored grains and the losses of pests, in their turn, due to the rise in temperatures are estimated at 10-25 percent per 1 C of temperature increase (Deutsch et al., 2018). The developing world smallholder farmers with poor storage facilities and structures controlled by climatic conditions are highly susceptible to these stability threats.

3.6 Strategy and effectiveness Adaptation Strategy.

The publications being analyzed have examined different measures of adaptation like technological measures to institutional measures. A strategy that has been studied the most is Climate-Smart Agriculture (CSA) and the evidence shows that this type of strategy has a significant potential in terms of risks reduction and productivity increase. The research of Bijarniya et al. (2020) showed that CSA activities in rice-wheat crops increased production by 10.5 percent and profitability by 29.4 percent and reduced greenhouse gas emission by 43 percent. In their research, Ahmed and colleagues found out that food security enhanced 28-56 per cent depending on the vigor with which the Ethiopian smallholders embraced CSA.

There is a particular possibility to overcome the issue of water scarcity with the help of the crop varieties resistant to drought and more effective irrigation systems. High efficiency irrigation technologies increased the cotton results in water-limited regions by 69.99 percent and crop survival by 55.27 percent (Jia et al., 2023). However, the cost of adoption has been expensive and lack of financial support, inadequate infrastructure and lack of quality extension support are some of the factors that lower the adoption particularly among poor resource smallholders (Bryan et al., 2009).

The adaptive benefits manifest in the form of diversification strategies, diversification of crops on farms and off-farm livelihood. The volatility of income in climate-sensitive regions was reduced by 15-30 percent by crop diversification without leading to a change in nutritional variety (Waha et al., 2018). Diversification of livelihoods like introducing drought-resistant animals like the camels into pastoral production provided immunity against the climate catastrophes in the East African drylands (Wako et al., 2017).

Even though the strategies of adaptation have been determined to be working, there is an implementation gap. Only 34 percent of the number of included studies had reported high adoption of recommended practices with financial barriers being the most frequent barriers to adoption at 67 percent. The institutional and governance challenges that act as constraints to adaptive capacity issues include insecure tenure to land, poor access to the market, and ineffective access to climate information (Adimassu et al., 2025).

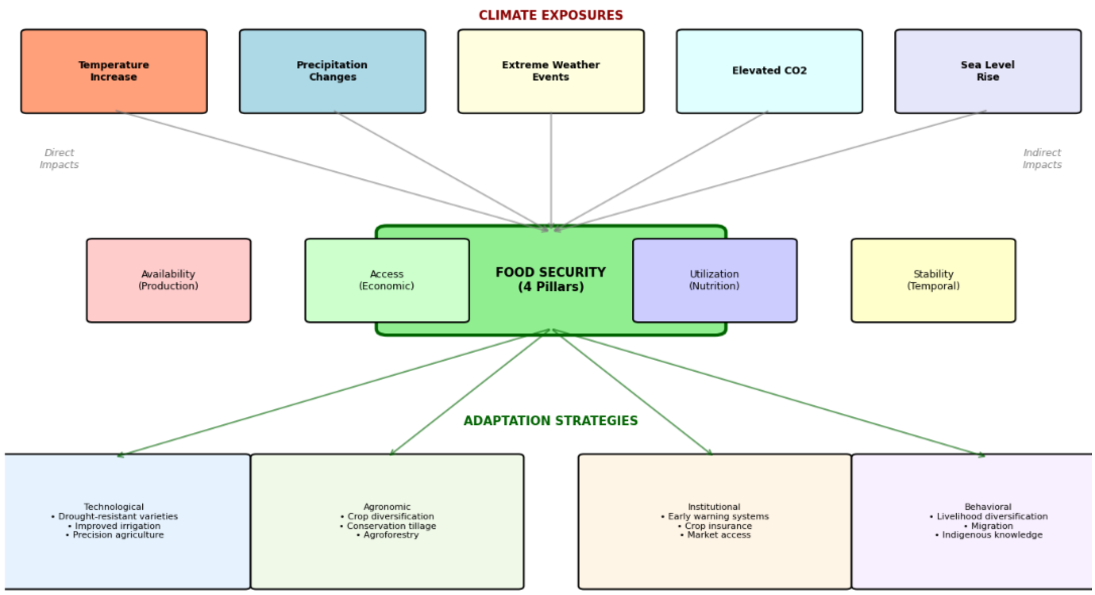

Figure 4. Thematic Categorization Framework

3.7 Methodological Trends and Research Gaps

There are also some trends that are raised by evaluation of methodology techniques. Climate impact assessment at a large scale is increasingly being conducted in the form of remote sensing and geospatial analysis with 236 (34.3) studies having utilized satellite-based climate or agricultural data. Yield and climate risk prediction Models are currently being trained on machine learning, but are not yet popular, primarily because of the size of the resource requirements in those fields. Process-based crop models still dominate future prediction studies, but fresh hints of a systematic understatement of the impacts of extreme weather have been noted (Ben-Ari et al., 2025).

Research gaps are very many, and they are of primary concern in a number of ways. The studies on the effect of climate and their adaptations over years are lacking in longitudinal studies, and 78 percent of the sampled studies were of cross-section designs. The compound and cascading risk assessment is not performed; the majority of research studies have researched individual components of climate hazards and not the interaction and sequence of events. Central Asia and North African countries are especially research gaps even though the areas are particularly vulnerable. The Pacific Island countries are particularly research gaps despite the high vulnerability there. The adaptation strategies involving indigenous systems of knowledge and community-based adaptation strategies are not well studied as compared to technological solutions.

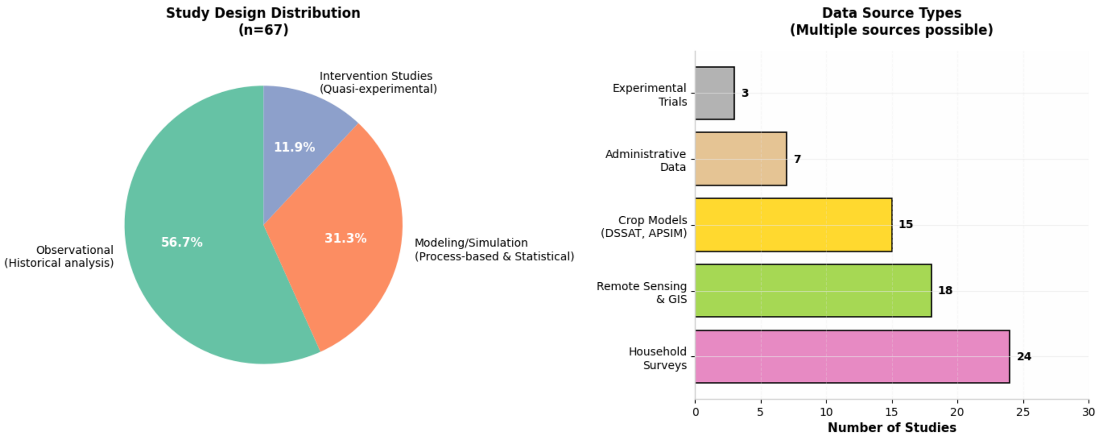

Figure 5. Methodological Distribution of Included Studies

Table 2 and Table 3 present methods of comparison by providing results of the study in accordance with the study types and the main findings respectively in accordance with the dimension of the food security. The thematic framework of categorization that can be created as the outcome of the synthesis is illustrated in Figure 4 and splits the effects into biophysical, socioeconomic vulnerabilities, and adaptation response. As shown in figure 5, the distribution of the types of methodology used in included studies was as follows: quantitative methods and geographic concentration dominate in the Sub-Saharan Africa and South Asia.

Table 2. Methodological Comparison Across Study Types

Study Type	Number (%)	Strengths	Limitations
Observational Studies	38 (56.7%)	Real-world historical data, large datasets, regional representation	Limited causal inference, confounding variables
Modeling Studies	21 (31.3%)	Future projections, scenario analysis, climate simulations	May underestimate extreme events, model uncertainty
Intervention Studies	8 (11.9%)	Direct adaptation evaluation, quasi-experimental rigor	Limited geographic scope, short-term evaluation

Figure 6 details the results of risk of bias assessment and depicts, as a rule, moderate risk at the level of studies with specific concerns in the area of confounding control and exposure measurement in observational studies. Figure 7 provides the conceptual framework to summarize the effects of climate change on the food security in both direct and indirect pathways, and Figure 8 sums up the research gaps identified in the study in geographic, methodological, and thematic aspects.

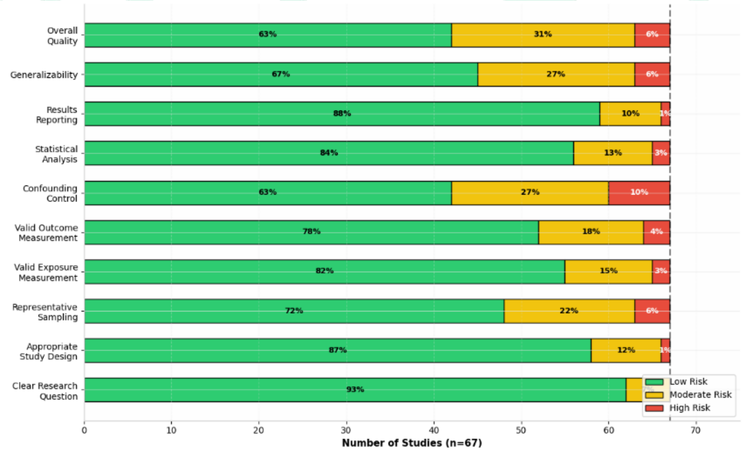

Figure 6. Risk of Bias Assessment Summary

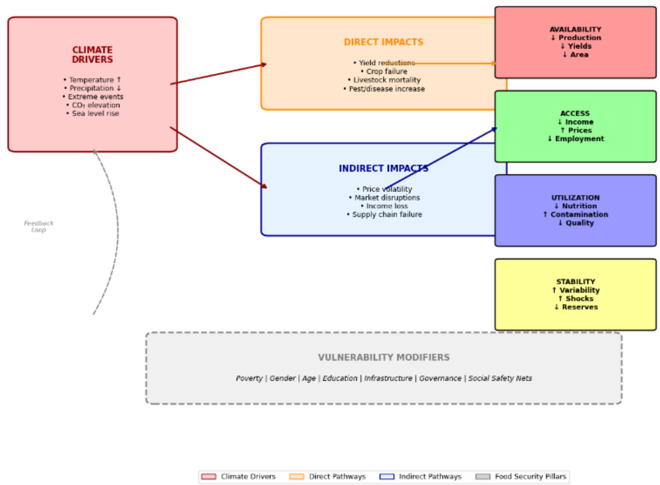

Figure 7. Conceptual Framework of Climate Change Impacts on Food Security

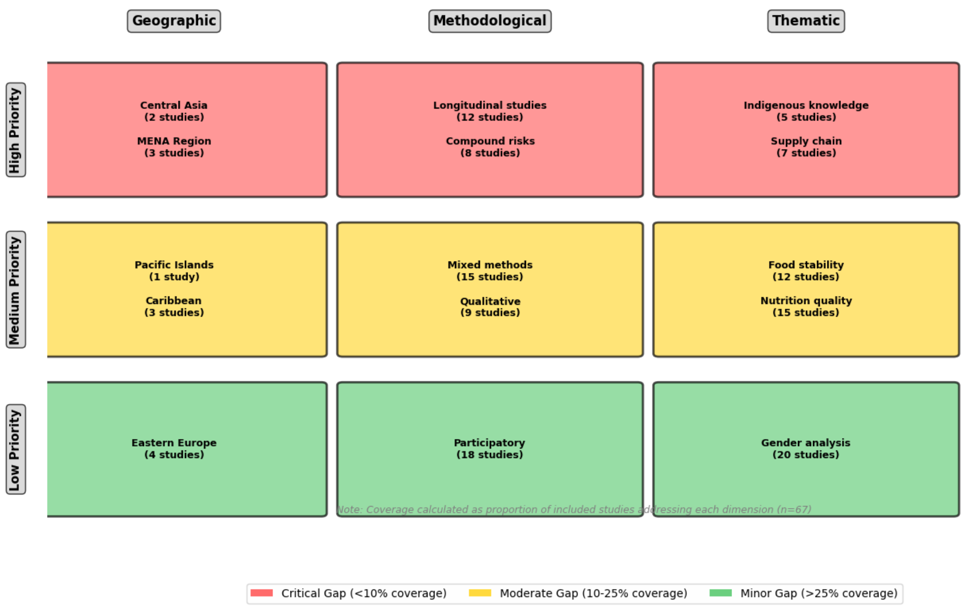

Figure 8. Research Gap Synthesis Diagram

Table 3. Synthesized Climate Change Impacts Across Food Security Dimensions

Food Security Pillar	Key Climate Impacts	Quantitative Evidence
Availability	Reduced crop yields, extreme weather losses, soil degradation	Wheat yield -6% per 1°C warming; 804 million tons lost (2001–2024)
Access	Income loss, food price volatility, market disruption	Food prices ↑ up to 32% after drought events
Utilization	Reduced nutritional quality, increased food safety risks	Protein -10%, Zinc -9.3%, Iron -5.1% under elevated CO_2
Stability	Production variability, supply chain disruptions, storage losses	Cereal yield variability ↑ 12% (1990–2020)

4. DISCUSSION

This is a systematic review of the existing literature on climate change and its consequences on the global food security, which reveals that 67 studies all obtained a negative effect of climate change on all 4 pillars of food security with a significant disparity on the vulnerability and adaptive capacity in the regions. The outcomes confirm the previous assessment by the IPCC and FAO and offer the updated quantitative estimates of the extent of impacts and introduce significant gaps within the current adaptation endeavors.

This information indicates that the existing effects of climate change are already enormous and directly affect food availability in the form of low yields and increased variability in production which are prone to increase in future as the warming levels rise. The magnitude of quantifiable and estimated impacts such as the 6 percent reduction in wheat yields per degree Celsius of global warming and the losses accrued in 804million tons of cereals due to the harsh weather conditions show that climate change is an existential risk to food security in the world with even bigger impacts than had been previously anticipated. These findings go hand in hand with recent assessments, which show that process-based models are systematically inaccurate in the estimation of hazards of climate because they do not entirely represent extreme events of compounds and the variability of yield (Ben-Ari et al., 2025).

One of the themes that come out is the issue of regional disparities whereby the Sub-Saharan Africa and South Asia are overly exposed to risks due to the fact that exposure is high, sensitivity is high and the adaptive capacity is low. Poor infrastructure, the geographical concentration of rainfed agriculture, and poverty conditions in the regions precondition the hotspots of vulnerability where the direct coincidence of the climate outcomes with the food insecurity outcomes takes place. Such a distribution of regions justifies climate justice factors of food security since the most vulnerable to climate change impacts on food systems in the past are the ones that contribute the least to climate change (Hasegawa et al., 2018).

The evaluation reveals that the climate change has a complex and cross-cutting channel that extends beyond the decrease in production in the food security scenario. Climate risks come in through a myriad of channels because of impacts on food access in terms of revenue loss and price fluctuations, use in terms of loss of nutritional value and stability in terms of increase in variability and supply chain influence. This multidimensionality means that to come up with strategies of adaptation, care should be taken to ensure that the whole range of food security is taken care of and not just concentration on productivity improvement.

The possibilities of the risk's reduction are enormous provided by the strategies of adaptation, and Climate-Smart Agriculture and the improved water management may be regarded as particularly promising. However, the gap between the effectiveness demonstrated and its actual application is enormous with its financial, institutional and informational limitations. This disparity in implementation is a serious problem of climate policy since there exist technical solutions that are not reaching the vulnerable populations that are most in need of help in adjustment (Lipper et al., 2014).

The review presents both future directions and current restrictions in climate and food security research methodologically. The remote sensing and machine learning are increasing, and this situation opens prospects in the field of enhanced monitoring and forecasting, but longitudinal and quasi-experimental designs are not used. Cross-sectional researches are prevalent, which makes it impossible to cause and learn about the processes of dynamic adaptation. The future of the research is the longitudinal designs, compound risk assessment, and mixed-method research that will involve biophysical and socioeconomic scrutiny.

The policy and practice implications of the gaps in the identified research should be considered important. The geographical remoteness of Central Asia, Middle East and Pacific Islands subjects the vulnerable population to absence of evidence-based adjustment mechanisms. The absence of the representation of the indigenous knowledge and community-based solutions might bias the adaptation strategies to the technological solution, which happens to be not as sustainable and as fitting to the local practices as the locally-grown ones. Cascades of food system failures are more prone to be caused by climate shocks due to the absence of consideration of food stability and risks in the supply chains.

Ideally, the findings of the research affirm the growing level of consciousness that food security is actually bound to the environmental systems in complicated sense that cannot be simplified into certain effects-cause relationships. Conventionally, the food security literature has been based on economic accessibility and social protection this review demonstrates that increasing biophysical effects stipulated by climate change are reducing the viability of economic-only solutions to food security. This means that there exists need to incorporate theoretical methods in the fields of political economy, agroecology and climatic science (Ericksen, 2008).

Practically, the results of the review render several policy suggestions. Firstly, the adaptation investments must be targeted at the vulnerable population and regions, particularly on the smallholder farmers of the Sub Saharan Africa and South Asia. Second, the food security pillars must be considered at the same time since the areas of improvement of the strategy should integrate the parameters of the markets access, the nutritional quality, and the stability with the improvement in the productivity. Third, institutional and governance modifications including increased land tenure security, climate information services, and social protection mechanisms should be added to supplement the technological adaptation solutions. Fourth, the urgency to cut down emissions is that, despite the critical role of adaptation in dealing with the impact of climate on food systems in excess of 2o C of warming, there is a necessity to cut down on emissions (Campbell et al., 2014).

These are the weaknesses of this review that should be considered. Even though all the search strategies are comprehensive, the probability of publication bias exists whereby research articles that demonstrate high levels of evidence of the climate effects are given preference over articles with no evidence and those with mixed evidence. The heterogeneity of the study designs, definitions of exposure and outcome measures impaired the process of quantitative synthesis and meta-analysis. In most of the studies, quality assessment revealed a medium risk of bias particularly on the confounding control aspect of observational studies. The focus on peer-reviewed English literature may exclusion of the articles which are not related to English and grey literature.

5. LIMITATIONS OF THE REVIEW

Various factors restrict the inferences that have been made in this system review. The databases are a limitation to the systematic review though 4 major databases were searched, there is always a chance of unreadable journals, institutional database or non-English literature. The methodological rigor, which has been attained as a result of the sole use of peer-reviewed literature, does not eliminate the probability of a gray literature that could hold some potentially significant contextual information, including government documents and evaluations of the NGO.

The other significant weakness of the review is the language bias as the search was done in English-language articles. As the consequences of climatic on food security are in the non-English-speaking regions, there could have been no value evidence. The limitations of the studies employed to incorporate the research include the sampling bias employed in the studies, overrepresentation of Sub-Saharan Africa and South Asia, and underrepresentation of other areas vulnerable to the study, which limit the generalizability of the results to the global food systems.

The existing evidence is also likely to be biased in terms of publication since those studies that reported a significant impact of climate get published selectively as compared to those that reported no significant impacts or found a combination of effects. Though it offers current relevance, the time limit of 2015-2025 excludes the research activity of previous years that attained fundamental correlations of climate and food security. The varying definition of studies, outcome measures, and ways to analyze them, limited the process of quantitative synthesis and may bias patterns, which would otherwise have been obvious with the conditions of standardized methods of measurements.

The quality assessment revealed that most of the studies included have moderate risk of bias particularly in relation to confounding control and selection bias and exposure measures. The evidence base was primarily grounded on cross-sectional designs limiting the possibility to make a causal inference and understand the dynamics of time. The methodological weaknesses above suggest that the estimates of the effects could be considered as correlations, but not causal relationships.

6. CONCLUSION

This is a systematic literature review, which provides a wide range of evidence, which indicates that climatic change poses severe and multifaceted threats to the world food security in all four pillars availability, access, utilization, and stability. The summary of 67 empirical studies gives homogenous adverse impacts with a skewed impact on susceptible individuals in Sub-Saharan Africa and South Asia. Quantitative estimates indicate that there are drastic yield losses of major cereals with a 6 percent reduction in the yield of wheat per degree Celsius of warming and extreme weather incidences with a cumulative loss of 804 million tons of major crops over the past 20 years.

This review has demonstrated that climate impacts go beyond the simple loss of production to affect food availability economically, food use in nutritional loss and food stability in variability increased and supply chain disruptions. The adaptation plans particularly Climate-Smart Agriculture and improved water management hold great potentials of reduction of the climatic risks but has a lot of barriers to implementation including financial constraints, inappropriate infrastructure, and institutional provisions.

The main benefits of the review include a recent quantitative synthesis of the climate impacts, hotspots of regional inequalities and vulnerabilities, assessment of adaptation effectiveness and knowledge gaps mapping. The outcomes demonstrate the need to unite efforts to reduce the emissions, invest in the adaptation, and change the food system in such a way that food security will be ensured in the situation of climate change.

The identified research gaps should be filled as soon as possible, including longitudinal study of the outcomes of adaptation, risk evaluation of compounds, geographical expansion to underserved regions, and integration of indigenous knowledge systems. Future research must involve the implementation science which involves the investigation on how to deal with the barriers to adoption, and how to scale up effective adoption methods to the vulnerable populations across the globe.

The case presented is sufficient to call on the policymakers, practitioners and researchers to act. Climate change is not a distant threat to the food security but a crisis that, as a union, must be resolved at once. Without drastic modifications of the adaptation investment and mitigation of emissions, as well as the effects of the latter, the Sustainable Development Goal of Zero Hunger will never be feasible, and the implications of its failures are extensive and go beyond national and international health stability, and equity. The time frame of action is assuming a shorter and shorter form and the time to place climate resilience as an agenda in the planning of the food system is a matter of urgent concern among the international community.

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