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Review Article

Global Climatic Changes and Risks to Food Security a Narrative Review

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ABSTRACT

A narrative review was conducted investigate the association of global climatic changes on food security, leading to malnutrition among women and children posed by environmental risks, using well-regarded databases such as Google Scholar, Pub Med, and Springer Link. Employing key terms like "climatic changes," "food security," "public health concern," "Global," and "Pakistan," the identification of relevant articles was followed. Through a particular selection process, where 20 studies were carefully chosen from an initial pool (January 2019 to 2023).

The synthesis of these selected studies revealed evident correlations between climate variables (temperature, rainfall, humidity, and sunshine) and their distinct impact on crop production. Environmental risks emerged as difficult challenges to global food distribution systems, contributing significantly to an increase in disease burdens. Developing nations, particularly in regions such as Pakistan, confront difficult hurdles in food production, distribution, and nutrition, resulting in prevalent health challenges. These findings highlight the urgent commanding to fortify food systems, enhance infrastructure, and formulate policies geared towards fortifying global food security.

Despite improvements in understanding the link between climatic changes and food security, determined research gaps persist. The continuing challenge lies in quantifying the complicated effect of change of climate on human health and the security of food. Additional studies were imperative to accomplish a comprehensive assessment of these effects at both global and local levels.

Keywords: Climatic Change, Food Security, Global Environmental Changes (GEC), Malnutrition.

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INTRODUCTION

Climate change is a major contributor towards food security which has drastic effects on the most vulnerable population of the world i.e., women, children, or people belonging to lower strata of society.[1] Various direct and indirect impacts of climate change, like a sudden hike in food prices, uncontrolled influx in urban population due to displacement and migration, and subsequent inability of the local administration to provide food and shelter may give rise to risks towards local and/or regional conflicts.[2]

Food security is a complicated phenomenon that is not restricted to geographical boundaries, economy or literacy. About 16% of the world's population is suffering from hunger despite adequate food production worldwide due to disproportionate distribution.[3] Global environmental changes (GEC) comprising of weather changes, loss of animal and plant species, freshwater scarcity, deforestation, endangered marine life, ocean toxicity and soil degradation have adversely affected human health. All these factors also contribute to non-communicable diseases which make up a large burden globally; through various pathways including impacts on food, agriculture and nutrition.[4]

According to the Food and Agriculture Organization (FAO), an additional 35 to 122 million people are at risk of food insecurity as a result of the shift in climate. The projected world population of 10 billion by 2050 will further adding to the challenges posed to the UN SDGs of ending hunger by 2030.[5]

Pakistan being a country having various climatic zones is also faced with impacts of extreme climate change causing increased flooding with resultant loss of life, land, crop, livestock, housing and other infrastructure.[6] In order to understand the complex food system, a sustainable approach has been adopted from the framework which was formulated by FAO in 2018 for demonstrating food systems named as "food system wheel". Through this, stakeholders from all sectors can assess various agendas, systems and framework for accomplishing the goal of food security, nutrition and decline in poverty. The food system wheel has provided a holistic view of the sustainability of food systems by inculcating three aspects i.e., economics (provisions of benefits), social

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(food and health) and environment (saving the earth and natural resources).[7]

According to WHO, extreme climatic changes may cause increase in malnutrition and disease spread leading to rise in morbidity and mortality by 2030. Strategies, plans and activities need to be put in place at local and national levels to cope up with these changes, keeping health as top focus. An integrated approach having stakeholders on board at all level including the governing bodies and non-governmental organizations to strengthen the healthcare systems to ensure sustained population health globally.[8,9]

The global populace is heading towards greater challenges as earth's climate is transforming markedly, wreaking havoc with human health and needs. There lies an uncertainty of potential effects of climate on food, nutrition, health and mortality outcomes due to complex interlinking of these factors.[10-11]

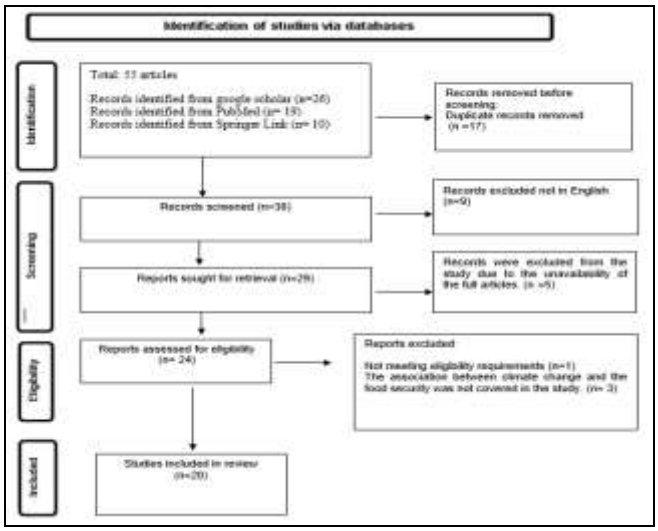

Figure: PRISMA Flowchart of the Searched, Identified, and Included Studies

This review was conducted to aid in assessing the current and future climatic change, and predicting its impact on food security. The challenges related to global food security, multiple climatic changes and human health have been assessed, and innovative interventions and strategies have been foreseen.

METHODOLOGY

This narrative review was conducted to provide frequently updated evidence regarding the global climatic changes on food security and its potential challenges leading to malnutrition. PRISMA reporting guidelines were followed, wherein 20 articles were selected for this review that were published between January 2019 to 2023. Articles focusing on climatic changes, food security, and malnutrition were searched. Original research, review articles, editorials and viewpoints were included in this review. Medline, PUBMED, database, and Google Scholar were searched through 2019-2023. We manually searched the databases and also checked the reference list of the searched studies. Only articles in the English language, and those about Pakistan and neighboring countries were selected. The study material was strategized to be searched through various combinations of keywords from the aforementioned databases, in the following orders: "Climatic change" "food security" or "malnutrition" or [Title/Abstract]" Malnutrition" or "Malnutrition among women, Malnutrition among children" or "Malnutrition among women & children " [Title/Abstract]

Consequences" or "Long-term effects" [Title/Abstract]

The studies with abstracts only and not the full-text versions were excluded. Research papers covering non-human studies including publications focusing on animal and plant experiments were also not included. The relevant studies based on abstracts and titles were identified and retrieved by study investigators. The complete content of these papers was thoroughly reviewed, and the most relevant articles were selected and compiled according to the eligibility criteria. Pertinent data mining was done and the details were organized in Table-I. The studies selected for this review included review articles, editorials, commentary or original research with cohort (both prospective and retrospective), case-control or cross-sectional design.

RESULTS

In total, 50 items were identified by using a research strategy, containing articles, blogs, reports via relevant databases (Pub Med, Google Scholar and Springer Link). After screening of titles and abstract for relevant information and uniqueness, 20 items were selected.

We found that climate variables of temperature, rainfall, humidity and sunshine had markedly affected the crop production.[12,13] In the face of higher environmental risks on agriculture, livestock and fisheries, challenges for equity-based dissemination of food, might become a major reason for increasing global burden of disease. Developing countries face multiple challenges in regards to food production, distribution and its nutritional capacity. This may lead

to various diseases and infirmities that can only be tackled by strengthening food systems, infrastructure and policies.[13,14] Human health has been known to be disturbed due to variations in climate like cyclones, flooding and drought causing drastic effects on agriculture, unhygienic conditions and disrupting the food systems giving rise to multiple diseases and infections like dengue, malaria and cholera specifically in developing countries like Pakistan.[15,16] Many emerging countries have increased their levels in

Table: Evidence Table

Year of publication	Methodology			Findings	Conclusion
	Study Setting	Study design	Risk Factors		
[5] 2022	Pakistan	Review article	Climate variability, resource limitations, and unequal development risk food security and worsen vulnerability in climate-affected regions.	Climate change's negative impacts on food production, stressing the urgent need for sustainable, resilient solutions.	Climate change's challenges to global food security and the need for research and policies to address its impact. It stresses sustainable, climate-resilient food production for security in changing climates.
[6] 2023	Low/Middle-income countries	Systematic Review	Climate extremes, limited nutritious food access, and social discrimination impact vulnerable populations.	Severe climate change risks jeopardize food security, impacting vulnerable populations and extending beyond food systems.	Adaptation options and governance actions to mitigate climate risks for future food security and nutrition.
[7] 2019	Pakistan	Descriptive study	In the 21st century, climate change exacerbates economic inequality, agriculture dependence, and vulnerability to droughts and floods.	Climate change threatens human development and welfare in South Asia, home to 40% of the world's poorest, with 1.5 billion people living on less than $1.25 per day. Malnourishment is a growing concern due to economic inequality and climate-related disruptions in agriculture, such as shifting rainfall and severe droughts, notably in India and Pakistan.	Climate change threats to South Asia's development and welfare, urging preventive measures to protect resources and future generations. It reveals climate change's adverse effects on agriculture, poverty, and malnourishment.
[9] 2021	India and the United States	Nested case studies	Wealth gap in the United States and high population of food insecure people in India.	Different challenges and solutions to food security in the two countries due to varying agricultural and food security policies	Emphasis on agricultural production in developing regions and food access in the Global North to address food insecurity and global hunger.
[10] 2019	Netherlands	Predictive Modelling	Climate variables and agrichemical usage were identified as risk factors contributing to contamination levels in the feed.	A Bayesian Network (BN) model achieved 90.3% accuracy in predicting feed contamination, influenced by climate and agrichemical variables on different crops.	The study demonstrates that data-driven Bayesian Networks can effectively capture complex interactions and provide high-accuracy predictions for food safety hazards in dairy cow feed, with potential applications in other areas of food safety.
[11] 2020	Germany	Systematic Review	Elevated temperatures, shifts in drought and flood occurrence, in addition warming water temperatures attitude significant risks to agriculture, fisheries, and livestock.	Climate change negatively affects farming, animal husbandry, and fishing, threatening food safety and availability.	Emphasizes the significance of allowing for climate change concerning the main factor for agricultural production and adopting mitigation strategies to ensure food security.
[12] 2022	China	Global Trade Analysis Project (GTAP) model	Climate change, Extreme temperatures, Agricultural insurance, Education, Urbanization, Agricultural research Investment in agricultural, infrastructure and Natural disasters	The study reveals that agricultural insurance positively influences food security, while climate change, particularly extreme temperatures, significantly impacts food security and crop yields.	The significance of agricultural insurance in mitigating the outcomes of climate change on food insecurity and provides policy implications for promoting sustainable agricultural development in China.
[13] 2022	Iran	LARS-WG model	Reduced water availability and crop production, affecting the economic and environmental aspects of the agricultural system.	Water availability will decrease by about 13.79–15.45%, and crop production, especially rain fed wheat, will experience significant declines, around 59.95%, in response to climate scenarios.	Adverse consequences of drastic changes in climate on water resources and agricultural production in arid regions. The research can provide valuable insights for policymakers to develop effective strategies to mitigate these impacts and ensure agricultural sustainability.
[14] 2020	India	Longitudinal Study	The study considers factors like caste, religion, sex, and income decile groups as time-invariant characteristics and age as a deterministic predictor for food security transitions.	Around 50.4% of rural households and 46.1% of urban households faced chronic food insecurity, with 39.8% of rural and 42.2% of urban areas remaining food secure.	The study provides valuable insights into food insecurity dynamics in India, helping in effective policy design for addressing food security challenges.
[16] 2021	India	Field-based study	Class-specific climate change adaptation, variations in adaptive practices based on land ownership and livelihood options.	Climate change adaptation is class-dependent, with distinct capacities and practices across classes. Community-based adaptation was overlooked, emphasizing the necessity of comprehending the class dynamics of climate change for effective village-level strategies.	The study calls for a deeper understanding of the part of the class in impact of the climate change adaptation for developing successful community-based adaptation models at the village level.
[18] 2019	Florida	multi-model Study	Probable impacts on the rising temperature, changes in rainfall, and nitrogen availability could negate the advantages of increased atmospheric CO2 intensity on the global wheat grain and protein yield.	Genotypes adapted on the warmer temperatures might increase global wheat yield by approximately 7% and the protein yield by around 2%, however, grain protein concentration may be reduced by minus 1.1 % indicating a comparative change of minus 8.6%.	The Environmental change modifications that value grain yield was not always positive for grain condition, placing further pressure on global wheat production.
[19] 2019	Kiribati	Narrative review	Limited land availability, population pressures, and vulnerability to ocean height rise direct to low-lying topography.	Environment change noticeably impacts food security and health in Kiribati, requiring effective policies and cultural perspectives for mitigation.	Recognizes the pressing concern of climate change in Kiribati, highlighting the need for further research and action to address the worsening problem.
[20] 2019	Ethiopia	Systematic Review	Lack of irrigation and farmland, water scarcity from drought and floods, strict soil erosion, farm animal dispossession, household magnitude, and knowledge were identified as risk factors impacting food security in the face of drought.	The reducing meal quantity, seeking cash and grain, off-farm and non-farm jobs, food aid, livestock vending, and participation in food-for-work programs.	Research emphasizes the importance of coping strategies for building resilience and improving health conditions for food-insecure households in drought-affected regions of Ethiopia.
[21] 2019	Canada	Systematic Review	Liabilities inside the Canadian food system to climate change, leading to potential risks to human health.	The main activities in the food chain are vulnerable to climate change, impacting food security and human health outcomes.	The research proposes an analytical framework to address the environmental change, food security, and human health link, aiding public health officials and stakeholders in preparing for future health risks and informing adaptation efforts.
[22] 2020	Spain	Systematic Review	The major risk factor is the projected improve the occurrence and difficulty of droughts directly to change in the climate, leading to potential adverse effects on health systems if proper modification procedures was not detected.	The complex nature of drought phenomena emphasizes the need to quantify and understand the health risks associated with drought occurrence.	The study aims to raise awareness among healthcare providers and services regarding the association between scarcity indicators and individual health, ultimately helping to inform future strategies and responses to drought-related health risks.
[23] 2021	Vietnam	Cross-Sectional Survey	Adverse climatic stresses in Vietnam, including temperature increases, droughts, flooding, saltwater intrusion, and sea-level rise.	Climate change adaptations vary depending on the specific climatic stress individuals are responding to, with droughts and floods having the strongest effect at the household level and adaptations at the agricultural level being influenced more by the impacts of the stress.	The study provides valuable insights for designing effective climate change policies by understanding individual adaptations to specific climatic stresses and identifying gaps that require public responses
[24] 2019	rural and urban areas of the iLembe district, South Africa	Cross-Sectional Survey	food insecurity variations and household characteristics in both urban and rural populations in the iLembe district, South Africa.	South Africa, faced food insecurity (72.9%) with similar coping strategies in urban and rural areas. Urban households had better access to piped water and diet diversity, while rural households relied on natural resources and stored food differently.	The study highlights the prevalence of food insecurity in both urban and rural households, with similar coping strategies despite location differences. Food security interventions should consider location-specific factors to address household food insecurity effectively.
[25] 2022	Austria Europe	Comprehensive Analysis	The study identifies climate change as a primary risk factor, exacerbated by pandemics, causing disruptions in food systems and posing threats to global food security, diet quality, and human health.	Climate change disrupts food systems, affecting soil fertility, crop yield, nutrient content, and pest resistance, leading to challenges in food security and malnutrition. The emergence of pandemics like Covid-19 further complicates these interactions.	The study underscores the urgent need for sustainable and resilient food systems, incorporating climate-smart agriculture and contextual ecosystem functions to ensure diverse, nutritious, and environmentally aligned diets amidst the challenges of climate change and pandemics. Developing robust tools and indicators is crucial to measure the complex interplay between food systems, climate change, and human health.
[26] 2023	Italy	Narrative Review	Ineffective kid-feeding methods, food uncertainty, poverty, constrained health access, and food system industrialization are identified as risk factors for child malnutrition and its interaction with climate change.	Lack of child feeding practices, food availability poverty, and inadequate health access are foremost causes of malnutrition. Food system industrial development and globalisation promote to a double burden of malnutrition, combining undernutrition with overweight/obesity and climate-related harms. Environment change and the COVID 19 plague exacerbate kid malnutrition and impact essential causes and socio-economic factors.	Existing interventions should be expanded to address undernutrition, over nutrition, and climate change through schooling, farming, food classifications, and community safety nets, requiring collaborative efforts among stakeholders to improve global sustainable nutrition.
[27] 2020	Ethiopia	Mixed Methods	Climate Variability, Change, and Extremes Shift in Rainfall Timing and Patterns Dependence on Markets and In-Kind Contributions Potential Impacts on Food Access and Prices Physical Access to Markets and Climate-Related Disasters Climate Impacts on Livelihoods	Relationship Between Climatic Variability and Food Security Indicators Long-Term Historical Data Analysis Results Baseline Assessment of Vulnerability to Future Risks Impact of Climate Change on Agricultural Practices Household Strategies for Coping with Climate-Induced Challenges	Implications for Food Security and Livelihoods Recommendations for Adaptation Considerations for Future Research Please note that the text provided is limited, and the suggested headings are based on the information available. You may need to adjust or expand the headings based on the full content of your study.

context to global climatic changes and depletion of resources for instance Pakistan has raised up to two points. To preserve the diminishing resources and prevent natural climatic catastrophes, the government needs to gear up their administrative powers for the future of Pakistan. It is projected that by the year 2050 there will be 529000 deaths worldwide due to climatic changes, dietary and weight disturbances with higher prevalence in South and East Asia. Such high numbers of estimated mortality can be decreased by 29-71 % through mitigation and adoption of climate stabilization pathways.[17,18] Numerous factors that need to be prioritized include food security, mental health, safety concerns and health hazards for interventions and planning. Strategies and intervention have been highlighted to enhance awareness and promotion for reserving water resources and mitigation of environmental pollution.

DISCUSSION

Climate changes and climate sensitive outcomes for health and food is a complicated phenomenon which is interlinked and varied by factors like seasonality, geographical regions, crop production, burden of disease and infection, migration, which will be difficult situation to sustain by low- and middle-income countries.[8,18]

Although multiple researches have been conducted to predict the exact influence of climatic changes globally, data is still insufficient to give a clear picture of countries having varied agro-ecological regions, such as Pakistan. Hence, evidence-based researches confined to various ecological belts should be carried out.[7]

Greenhouse gas emission (GHG) and natural calamities have a combined effect on food security and malnutrition. According to WHO, these consequences will be most prominent in developing countries, affecting 50% or more population globally. In order to decrease these GHG, adaptation will be made by switching low GHG diets, but at the cost of nutritional quality, food security and safety.[19]

A study states that the implication of climate changes in South Asia would likely hamper the efforts of reducing malnutrition in children, especially due to food insecurity, which might be halted by decreasing the greenhouse gas emission and development of socioeconomic conditions.[5]

Food security is highly vulnerable to growing environmental changes with strong influence on health, in which undernutrition will be the most eminent consequence of climatic variability. South Asia in this context will face 62% of stunting and east and southern Africa 55 % by 2050.[19]

The key findings of the study emphasize that severe climate change risks not only imperil food security and nutrition for vulnerable populations but also unleash cascading effects that extend far beyond the boundaries of food systems. In South Asia, where a significant portion of the world's poorest individuals reside, change in climate causes a substantial hazard to individual development and welfare. This region, home to 1.5 billion people living on less than $1.25 per day, grapples with malnourishment compounded by economic inequality and climate-induced disruptions to agriculture, such as altered rainfall patterns and severe droughts, particularly in India and Pakistan. The study highlights distinct challenges and solutions related to food security within these countries, shaped by varying agricultural and food security policies.[20]

Annually, about one-third of worldwide food production is lost or wasted mainly due to pests or fungal infestation in developing countries or due to domestic food wastage in developed world, respectively.[9,17]

An alarming situation created by climatic variations and catastrophes like floods and cyclones, destroyed land and corroding irrigation systems for agriculture, further bringing upon an added burden of disease and infirmity, further ruining the economy. Pakistan had been facing climatic changes through rise in temperature, melting of glaciers, tropical cyclones and floods inflicted diseases and infection like cholera.[20]

Pakistan being an agricultural country, is dependent on climatic conditions, especially for wheat production. These extremes of weather have a negative impact on food security. So vigorous actions, plans and strategies need to be formulated for increasing capacity, awareness and information of the modified and improved ways of agriculture and impeding climate changes.[6]

Health outcomes inflicted by climatic changes are diverse due to variations in geographical locations and risk factors in context of dietary habits, for example consuming less quantity of fruits and vegetables. China and India have had highest prevalence for climate-related mortality. Public health needs to be addressed by developing and adapting programs with

objectives to mitigate and control dietary and weight-related causes for impaired health.[12,22]

The impact of climate change on developing countries is particularly concerning for vulnerable communities, especially women and children. Moreover, food systems are accountable for a substantial portion of green-house vapor emissions, and shifting towards sustainable diets could help mitigate climate change and reduce health costs.[23,24,29]

A substantial relation exists between climatic trends like scarcity of water, food insecurity and land deterioration, and dietary habits. Integrated management and guideline are required by experts from multiple sectors for informing and educating dietary habits for example preference of meat over vegetables or excess intake impeding towards wastage of food.[25-29]

An integrated approach was devised comprising of five domains for prioritizing decisions, policies, action plan, programs and challenges at local and national level for climate related changes and impacts.[26,28]

There is an emergent need to revisit policies pertaining to climate change affecting water, health and agricultural sectors by the relevant ministries working under Government of Pakistan. Novel techniques and strategies should be considered for plantation of heat resistant, flood / drought tolerant and water efficient crops and grasses for water conservation alongside construction of dams to increase water storage capacity addressing both drought and flood related issues.[27,30]

LIMITATIONS OF STUDY

This review has excluded grey literature and blogs or publication other than English databases that held important information pertaining to the topic but might carry lower weightage in comparison to other items. Extensive literature is available, but due to time constraints the articles reviewed were limited. Substantial scientific knowledge on climatic changes and agriculture that need further critical analysis in future for developing specific interconnections. Some important studies with appropriate relevance to the topic were not included due to lack of access to full text version of articles. Selection of the articles was by author, producing potential bias.

CONCLUSION

Addressing the connection between climatic changes, food security, and public health is crucial, with limited current studies focusing on the complicated linkages. A comprehensive examination is needed to quantify the effect of change in climate on human health and food safety across various ecological regions. The approaching challenges require substantial investment in public health to empower societies to combat malnutrition. Establishing global collaborations and associations is commanding to mitigate anticipated food and water scarcity. Long-term planning is vital, emphasizing the application of health for all and hunger reduction, aligning with revealing programs, action plans, and protective strategies. Community involvement is key, to enhancing awareness and preserving natural resources amid environmental challenges. Stakeholders across sectors, including education, technology, health, and government, must not only communicate and plan, but actively implement and demonstrate results for sustained efforts spanning decades.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

NS & STA: Data acquisition, data analysis, critical review, approval of the final version to be published.

SAR & MJ: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

NA: Conception, data acquisition, drafting the manuscript, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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