CLIMATE CHANGE AND FOOD SECURITY

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Abstract :

Climate change significantly threatens global Food Security by impacting food availability, access, and absorption. In countries like India, where agriculture is crucial for the people, rising temperatures, unpredictable rainfall, and extreme weather events destroy crop yields, reducing overall food production. This results in the unavailability of food and increases price volatility, making food less accessible to vulnerable communities. Beyond availability, access to food is restricted as rural populations entirely depend on farming, thereby facing declining incomes due to poor harvests. For urban populations, rising food prices driven by supply chain disruptions add strain on food accessibility to the people. Additionally, climate change worsens health issues, leading to diseases that impair the body's ability to absorb nutrients, further deteriorating food security. This research study focuses on identifying optimum solutions to address the challenges posed by climate change on food security. The strategies mentioned in the paper can strengthen resilience to climate shocks while maintaining agricultural productivity. It also showcases the importance of implementing policies prioritizing urban food security, public health, and infrastructure investment to ensure fair and reliable food distribution. Furthermore, increasing financial support for adaptation measures is crucial to help agriculture withstand future climate challenges. Thus, the study advocates for immediate and proactive actions to build resilient food systems that would be capable of sustaining production, ensuring food accessibility, and safeguarding public health in the context of a changing climate.

Keywords: Climate change, Food Security, Agricultural productivity, Sustainable practices, Food accessibility, Adaptation measures

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Introduction :

Climate change is considered one of the largest contributors to the threats present to the Food Security globally, reaching every segment of the food system, starting from production to distribution. For many years, it had been perceived that the improvement in the decrease in hunger had been going on; however, the Food and Agriculture Organization (FAO) highlighted that more than 800 million people were still experiencing chronic undernutrition, while around 161 million children were stunted while below the age of five years. Around half a billion people suffered from obesity, and two billion from micronutrient deficiency. This paradox uncovers the complexity within the global food systems.

The FAO projects that food production has to increase by 60% by 2050 to meet food demand triggered by population growth and changes in diets. However, climate change risks achieving this increase, mainly in vulnerable regions. Modifications in temperature, changes in rainfall patterns, as well as an increased frequency of extreme weather events directly impact agricultural yields and disrupt food systems. The Intergovernmental Panel on Climate Change

reports indicate four major risks delivered by climate change, which directly impact Food Security in the following ways:

- Loss of livelihoods and incomes of rural populations
- Degradation of marine and coastal ecosystems
- Loss of terrestrial and freshwater ecosystems
- General instability of the overall food system

Low agricultural productivity, further aggravated by climate change, has also been a critical challenge. Though India's economy has taken tremendous strides, cereal yields remain greatly more inferior to those in developed countries. Projections further indicate that with the significant strides in agricultural productivity, there would be relatively uncomplicated ease in meeting the future food demand of the country. Global warming, on the other hand, poses a range of wider risks for food security beyond agriculture. Increased sea levels and frequent extreme weather occurrences pose a risk to coastal regions and infrastructure, affecting supply chains and results in volatile food prices. Such an impact and the rising tension on natural resources therefore highlight the complex interdependencies within food systems.

Efforts to cope with such challenges must be placed at international, national, and local levels, with a commitment to mitigate climate change and adapt food systems to its impacts. Key actions toward Food Security in changing climate conditions include investments in agricultural practice improvement, resilient infrastructure, and smallholder producers. Finally, funds and expertise must be provided via international cooperation for susceptible regions to address the new climate realities.

Objectives of the Case Study :

- Evaluate Climate Change's Impact on Food Security
- Analyse Environmental and Agricultural Drivers
- Develop Climate Adaptation Strategies
- Enhance Rural Livelihoods and Strengthen Food Systems
- Encourage Multi-Stakeholder Collaboration
- Improve Food Security in Urban Areas

Literature Review :

- Raza et al. (2019) stated that the only way to lessen the harmful effects of climate change is climate-smart agriculture, because climate change has a dramatic impact on global crop production. The genetic engineering revolution can also help overcome the problem of food security against extreme environmental conditions through the crop production.
- Misra (2014) focused on assessing the availability of resources under different climate change scenarios. He also suggests that effective resource management and planning are crucial for maintaining a resilient food system in the face of environmental changes, ensuring consistent productivity and long-term food security.
- Vermeulen et al. (2012) conducted an extensive review of existing literature, emphasizing the importance of technological advancements in agriculture as a response to climate change. The study highlighted the potential of innovations like precision farming, enhanced irrigation systems, and biotechnological advances in improving food production efficiency.
- McKersie (2015) explored how genetic engineering can address food insecurity caused by climate change through both literature review and data collection. The study

highlighted how genetically modified crops, designed to withstand extreme conditions such as drought, heat, and salinity, can improve agricultural productivity in climates prone to extremes.

- El-Beltagy & Madkour (2012) reviewed literature on the importance of agricultural research and technology transfer in overcoming the challenges posed by climate change. The study emphasized the need for a new framework in agricultural research that focuses on sharing technological innovations, especially with developing countries.
- Ramos et al. (2021) review the Climate, Land, Energy, and Water Systems (CLEWs) framework, highlighting its evolution and advancements up until 2019. The CLEWs framework is designed to examine the interdependencies between these critical systems, aiding in the development of integrated strategies to manage resources effectively.
- Rasul and Sharma (2016) explore the water-energy-food (WEF) nexus as a comprehensive approach to addressing climate change adaptation. The paper highlights how coordinated strategies can improve resource efficiency, reduce trade-offs, and promote synergies, ultimately contributing to food security. The nexus approach is presented as a crucial adaptation strategy to mitigate the risks posed by climate change.

Climate change science - the status of climate change science today :

Climate change refers to long-term fluctuations in the Earth's climate system, characterized by shifts in temperature, precipitation patterns, and increased variability of weather events. According to the Intergovernmental Panel on Climate Change (IPCC), these changes can result from natural factors like volcanic eruptions and solar radiation fluctuations or human activities, with the latter being the dominant driver in recent decades. The IPCC's definition of climate change focuses on any noticeable shifts in the climate's average conditions or its variability over an extended period, typically spanning decades. These changes are measurable through statistical tests and can be attributed to both natural causes and anthropogenic (human-induced) factors. However, in the United Nations Framework Convention on Climate Change (UNFCCC), "climate change" refers explicitly to human-induced changes and natural climate variability. This distinction highlights the focus on the growing influence of human activities that alter the atmosphere's composition.

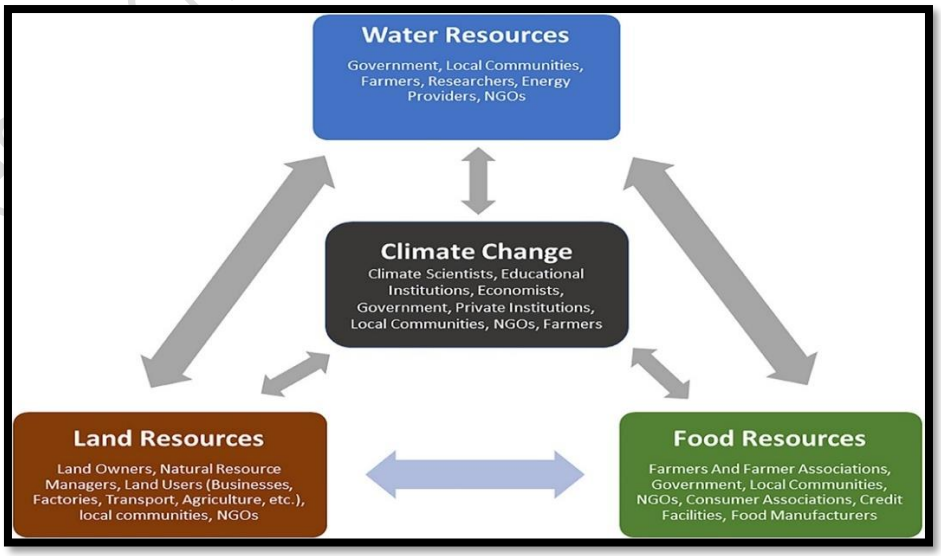

Fig.1: Flowchart representing factors responsible for the climate change and key stakeholders involved in regulating the resources

Factors Responsible for Climate Change and Its Impact on Food Security :

Climate change is driven by various factors significantly affecting food security. The interconnectedness of water, land, and food (WLF) resources demonstrates how changes in one area can impact the others. Several environmental, agricultural, and human-induced factors contribute to climate change, which, in turn, threatens agricultural productivity, food availability, and water resources across the region. Key Factors Contributing to Climate Change are as follows:

1. Deforestation and Land Use Changes:

Deforestation has been uncontrolled worldwide. The expansion of agricultural land, livestock grazing, and fuelwood harvesting are the primary drivers of deforestation. The loss of forests reduces carbon sequestration, resulting in higher concentrations of atmospheric CO2 and accelerated global warming.

2. Improper Agricultural Practices:

Unsustainable agricultural practices, such as over-irrigation, improper use of pesticides, and monocropping, lead to soil degradation, water depletion, and pollution of water resources. This degradation contributes to the negative impact of climate change on agricultural productivity, as poor soil health and water scarcity reduce crop yields.

3. Water Depletion:

The depletion of water resources, especially in freshwater ecosystems, is a growing concern due to climate change. As surface water temperatures rise and rainfall becomes less predictable, the ability to maintain sustainable irrigation diminishes, threatening food production.

4. Climate Variables and Weather Extremes:

Changes in air and water temperatures, precipitation patterns, and storm intensity directly impact agricultural systems. This situation is hazardous in countries with single wet seasons, where irrigation during the dry season is essential but needs to be revised due to limited water resources.

Major Impact of Climate Change: Food Security :

The most significant consequence of climate change is its negative effect on food security. Climate change disrupts the availability, accessibility, and absorption of food by affecting agricultural productivity and the stability of food systems. Following are some of the major impacts:

1. Declining Crop Yields and Agricultural Productivity:

With increasing temperatures, decreasing precipitation, and more frequent extreme weather events, agricultural productivity is significantly threatened. This reduced output is driven by both water scarcity and soil fertility deterioration, leading to food unavailability.

2. Water Scarcity and Food Production:

Water is crucial for irrigation and livestock rearing. The depletion of freshwater ecosystems due to climate change reduces water availability for agricultural purposes, particularly during dry seasons. As water resources diminish, rural communities face challenges in producing enough food to meet their needs, further escalating food shortages.

3. Impact on Livestock and Fisheries:

Climate change also affects livestock rearing and fisheries, the two most important sources of food and income. Increasing temperatures and changes in precipitation patterns reduce pastureland biomass and drinking water for livestock, leading to a decline in livestock

productivity.

4. Rising Food Prices and Access to Food:

As climate change reduces food production, the increased scarcity of food leads to rising prices, making food less accessible, especially to vulnerable populations. Rural communities that depend on farming face declining incomes due to poor harvests, while higher food costs pressure urban populations.

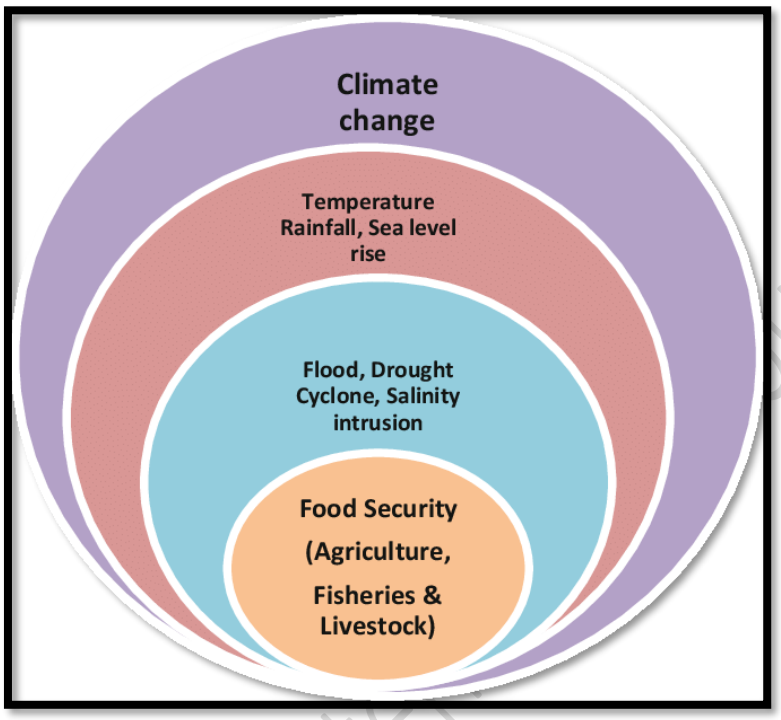

Fig.2: Effects of Climate Change on Food Security

Economic & Social Consequences :

Climate change brings considerable economic and social repercussions, particularly for food security, as it directly impacts agricultural output and the livelihoods of those dependent on farming activities. One of the most immediate effects is the decline in agricultural incomes. As crop yields diminish, farmers may be forced to sell off assets like livestock to cope with financial losses, reducing their ability to reinvest in future farming activities. This not only lowers profitability at the farm level but also destabilizes the broader economy, especially in regions where agriculture plays a central role.

Rising agricultural commodity prices are another significant outcome of climate change, driven by reduced food supply. These higher prices disproportionately affect low-income households, which allocate a significant portion of their income toward food. As a result, poverty and food insecurity increase, making it harder for vulnerable populations to access nutritious food. Nationally, countries heavily reliant on agriculture for a large share of their GDP experience economic instability as climate-related shocks slow growth, discourage investments, and alter traditional trade dynamics.

The social impacts on rural communities are also severe. Lower farm incomes limit families' ability to afford vital services such as healthcare and education, worsening the cycle of poverty. Small-scale farmers, already vulnerable, face greater risks due to their limited capacity to recover from climate-induced shocks. Sectors such as fisheries are also affected, as changing climatic conditions threaten jobs and income, particularly in regions like West Africa, leading to widespread economic and social upheaval.

On a global scale, the consequences of climate change extend beyond local economies, as extreme weather events in key agricultural regions disrupt food markets, leading to price fluctuations and altering trade patterns. These disruptions can slow down agricultural development, particularly in poorer nations, where attracting investments and building resilient food systems becomes increasingly difficult. Farmers and countries with the least capacity to adapt are the most affected, further intensifying the challenges related to food security.

Fig.3: Water Scarcity and its Economic and Social Consequences

Climate change and Food Security Nexus Framework :

To effectively showcase the impact of climate change on food security, a comprehensive framework or model that captures the multidimensional interactions between climate variables, agricultural systems, and socio-economic factors is required. One such model could be the Climate-Food Security Nexus Framework, which integrates key dimensions of climate change and food security.

The Climate-Food Security Nexus Framework is a conceptual approach that illustrates the intricate links between climate change and food security. It outlines how climate change influences food security through multiple channels, such as shifts in agricultural productivity, food supply, accessibility, and the stability of livelihoods. The framework emphasizes the multifaceted relationship between environmental, economic, and social factors, serving as a tool for developing strategies to reduce the adverse impacts of climate change on food systems.

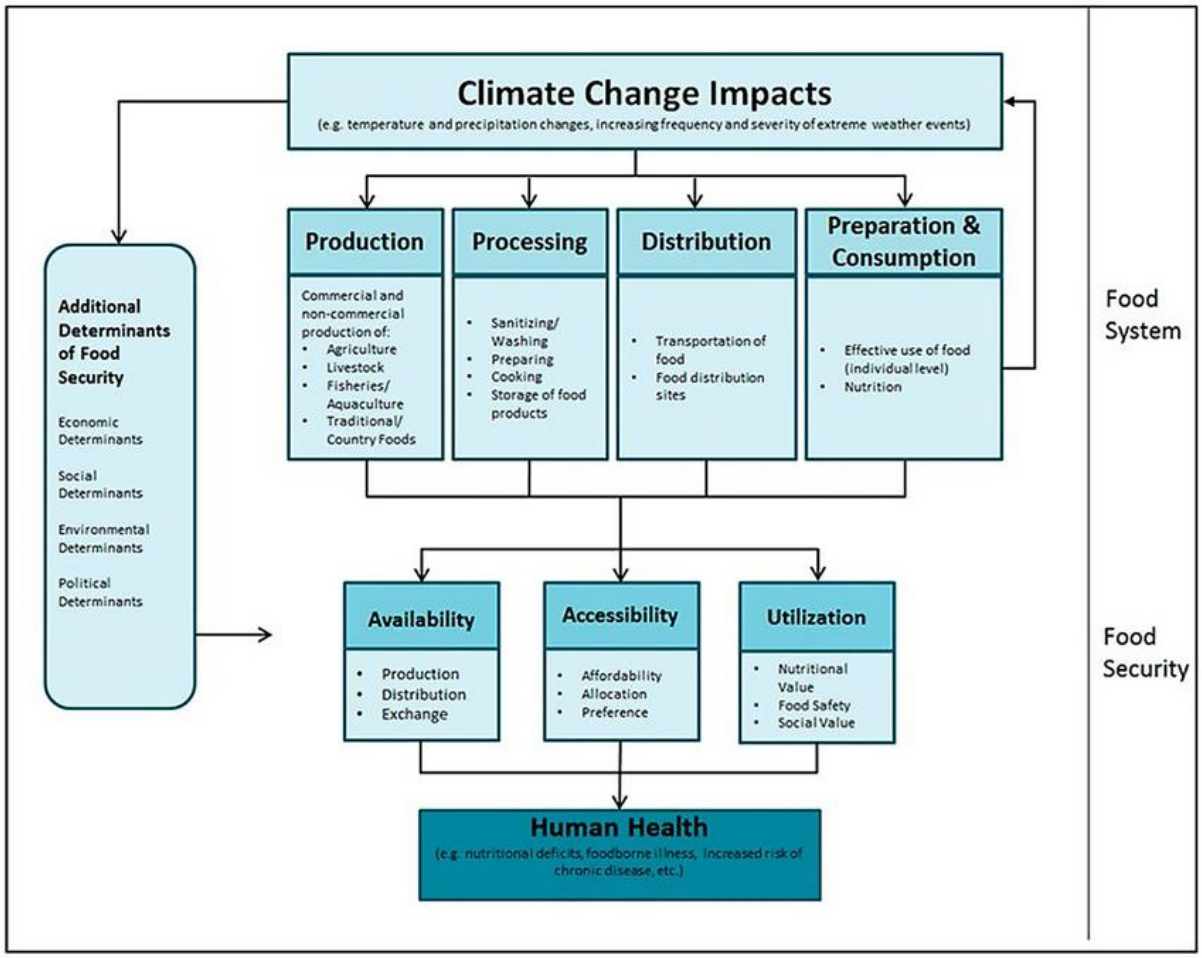

Fig.4: Food Security, Climate change and Human Health Nexus Framework

Climate-Food Security Nexus Framework can be explained by taking real-life example of the drought-prone region of Marathwada in the state of Maharashtra. This region demonstrates how climate change impacts food security through multiple dimensions as mentioned below:

1. **Climate Variables and Drivers:**

Marathwada has experienced erratic patterns of rainfall and increasing temperatures during the past few decades, with frequent drought conditions. These climatic factors have drastically cut down the supply of water, which is a prime resource for the region's primarily agricultural economy.

2. **Agricultural Production Systems:**

In Marathwada, agriculture greatly depends on monsoon rain. Erratic rainfall led to declining crop yields, especially for critical crops such as sorghum, wheat, and pulses. Livestock farming is also a critical livelihood whose productivity has been affected by fodder and water shortages. The decline in crop and livestock productivity immediately affects food availability.

3. **Food Accessibility & Availability:**

The decline in agricultural production has led to less food availability to producers and consumers in Marathwada. Food availability is scarce among small and marginal farmers, who rely on the produce they grow for consumption. Since agricultural yields have dropped, prices have increased, and it has become out of reach for needy families to source healthy food.

4. **Livelihoods and Income**:

Livestock activities and farm income are mainly financed by agricultural activities.

Crop failures, especially during periods of drought, results in decreased agricultural income among the farmers in Marathwada. This migration reduces food production and increases food insecurity in the rural areas.

5. **Nutrition and Health:**

The present nutritional condition of the people of Marathwada has declined because of food scarcity and rising prices. Its low-income family members have to skip other nutritious diets like vegetables, fruits, and protein-rich pulses, increasing malnutrition rates. These are affecting mainly the vulnerable population groups like children and pregnant women as higher stunting and wasting cases are reported.

Fig.5: Decline in agricultural production due to Climate Change

This example from Marathwada shows how climate change-through erratic rainfall and warmer temperatures-creates big challenges to food security in terms of reduced agricultural productivity that threatens the livelihoods and aggravates nutritional outcomes. The adaptation measures reflect the need to bring the Climate-Food Security Nexus Framework, integrating environmental and socio-economic aspects into one.

Strategic Recommendations to tackle the issues :

In order to handle the climate change and secure food availability, it is crucial to implement strategies that focus on both environmental preservation and strengthening social resilience. The improvement of agriculture techniques, better management of water supply, and the construction of climate-resilient infrastructure would all contribute to the alleviation of these problems and progress toward a more sustainable food system. A few key recommendations follow:

1. **Develop Climate-Resilient Agriculture Practices**: Promote climate-adapted, localized farming techniques, including water-saving irrigation and diversified crops. Investing in water conservation and building up stocks in resilient crop varieties and livestock breeds will strengthen the productivity of agriculture under climatic change.
2. **Implement Proactive Disaster Risk Reduction:** Focus on preventive measures rather than being a reactive response. Proactive Disaster Risk Reduction strategies are also cost-effective as they reduce potential damages and increase recovery from climate-related disasters.
3. **Sustainable Natural Resource Management**: Promote the sustainable management of forests, fisheries, and land to develop ecological resilience. Techniques like reforestation, integrated pest management, and responsible fishing practices should be encouraged to preserve ecosystem health.

4. **Invest more in resilient agriculture**: More public and private investments in developing climate-resilient agricultural systems would be needed. The investments should focus on research, reclamation of lands, water management, and extension services that could build up the adaptation capacity of rural communities.
5. **Improvement Market Stability and Information Systems:** Firm agricultural market information systems must be built to reduce price volatility and ensure security in food supply. Timely and high-quality crop production, availability, and trade data can stabilize the markets and shield the most vulnerable regions from climate change shocks.
6. **Develop Investment in Public Health Systems:** Investment in public health systems is crucial in addressing climate-related health risks, especially in vulnerable areas such as slum areas of cities and tribal regions. In this regard, public health programs should focus on climate-driven diseases like malaria and diarrhoea and still develop overall health systems resilient to climate change.
7. **Strengthening Livelihood and Social Safety Nets:** NREGA and similar initiatives should continue to support rural livelihoods in the face of climate change; work will be guaranteed in areas like water conservation and resource management to realize income stability and food security.
8. **Urban Food Security**: Revamp public distribution systems to make healthy food products more accessible. Some exemplary models need to be emulated from states like Tamil Nadu to improve access and nutrition among urban populations.
9. **Climate-Resilient Infrastructure**: Investment in climate-resilient infrastructure should be made to mitigate the risks and dangers of climate change, particularly flooding in cities. Improved sanitation, flood control, and disease prevention infrastructure reduce health impacts through extreme events.

Fig.6: Use of Advanced technology and AI to reduce the impact of Climatic change on agricultural crops

Conclusion :

Climate change represents a significant threat to the world's food system, creating substantial challenges for sensitive regions with agriculture as their base livelihood. All these interlinked changes impacts on agricultural productivity, access to food, and nutrition call for urgent and integrated action. The requirements for proactive efforts toward climate-resilient agricultural practices, disaster risk reduction, and investments in sustainable natural resource management ultimately ensure long-term food security. Support smallholder farmers, better market information systems, and strengthen public health and social safety nets to build

resilience. The governments, the private sector, and international organizations must collaborate effectively to foster adaptive capacities, ensure food availability, and promote sustainable development against climate change.

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