

Pardeep Singh · Bendangwapang Ao ·
Nabajyoti Deka · Chander Mohan ·
Chhetan Chhoidub *Editors*

Food Security in a Developing World

Status, Challenges, and Opportunities

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 Springer

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ISBN 978-3-031-57282-1 ISBN 978-3-031-57283-8 (eBook)
<https://doi.org/10.1007/978-3-031-57283-8>

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Preface

The war against hunger is truly mankind's war of liberation.
—John F. Kennedy

Food security has been one of the most discussed topics around the world. With a global total population of the world estimated to be around 8 billion, it is indeed a matter of concern for us as academicians to inquire deeply about the subject. As per World Bank data 2023 states that around 700 million people live in extreme poverty, these statistics are really alarming, and we, as global citizens, should take a stand in making transformational changes that make a better society. The challenge we all have to face is how we are supposed to feed a massive population with the question of sustainability. It is indeed a major problem of the unforeseen future. The wave of unsustainable practices like deforestation, climate change, land degradation, etc. suffice to food insecurities. We also forget the other important drivers of food security, like the political, social, and economic aspects. The stability of these aspects results in a bright prospect of a sustainable system. There are many actors and networks associated with the food systems. When all these systems interact collaboratively without disruption, we can assume a smooth passage for food security.

The book *Food Security in a Developing World: Status, Challenges, and Opportunities* is an attempt to investigate an interdisciplinary approach to understanding the structures of food security. The role of global institution, dimensions, challenges, and associated policy problems has been captured. This book will help readers to understand the many facets associated with food security. We hope the book will be a good fit for academicians, researchers, and policymakers to clear the doubtful complexities of food security in everyday activities. Being an interdisciplinary book, it should be a testament to making all individuals recognize and identify the significance it brings to curious learners.

We, the Editorial Team, would like to thank all the authors and academicians for all their noteworthy contributions to the book. The valuable time they spent on this book is highly appreciable and commendable. Finally, as researchers, we can only wish and hope that we all contribute to contributing works to make our world better.

New Delhi, India

Pardeep Singh
Bendangwapang Ao
Nabajyoti Deka
Chander Mohan
Chhetan Chhoidub

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The Historical Importance of Food Security: The Path to ‘Zero Hunger’



Awadhesh Kumar Jha

Abstract ‘Zero Hunger’ is one of the many United Nations Sustainable Development Goals goals, adopted in 2015. The aim is to end hunger on Earth by 2030. Eight years down the line from 2015, after more than half of the time gone, it becomes important to understand the progress of SDGs, particularly about hunger. Also important are the problems faced in these years in achieving zero hunger and the possible impediments to its success in the near to long-term future. The world problems such as climate change, food shortages, global pandemic-like COVID-19 and wars between nations—such as the Russia-Ukraine war, continue to roll back the progress made so far, and the future of zero hunger is bleak. In this regard, world leaders must ponder the issue at the highest level and review the success and future of a hunger-less world.

Keywords Food security · UNSDG · Zero hunger · FAO · NFHS

1 Introduction

The Rome Declaration on World Food Security at the World Food Summit (1996), under the aegis of United Nations Food and Agricultural Organization, describes Food Security as a condition when all people have physical and economic access to safe, sufficient and nutritious food to meet their dietary needs to lead an active and healthy life. Associated with this definition is the necessity of the availability of food, i.e., the supply side should be robust. Secondly the food should be available to each household at an affordable price. Thirdly, the available food should be nutritious. Fourthly the food supply to each household should be uninterrupted even after adverse weather, political instability or economic reasons (Rome Declaration on World Food Security, 1996).

Even after twenty-seven years of this declaration, the planet earth is not hundred percent food secure. Despite efforts made at multiple forums at the global level, we

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P. Singh et al. (eds.), *Food Security in a Developing World*,

https://doi.org/10.1007/978-3-031-57283-8_1

are many steps behind declaring oneself as hunger free race. Though the occurrence of famines has reduced in twenty-first century as compared to twentieth century, however it remains a major challenge for the world community to deal with. The lack of access to adequate food leads to malnutrition and deaths. Nearly 75 million people were killed by famines in twentieth century, and its occurrence in this century in regions of Africa, such as Sudan, Yemen, Nigeria, Somalia is still regular. Conflicts, natural disasters, climate change are factors that add up to the worsening food security in the world. The recent conflicts, climate change and the global pandemic COVID-19 has devastated the world's progress towards achieving low or zero hunger. The livelihood and incomes of the vulnerable section has devastated, food prices are on rise, access to basic social services has become limited. In such a scenario ensuring food security is indispensable.

The status of food security in any part of the world depends on availability, affordability, nutritious value and the continuous supply of food. According to the Global Hunger index, approximately 50 countries have higher or severe level of hunger in 2022 and most likely they will not be able to achieve low level of hunger by 2030, as envisaged under Sustainable Development Goals. The efforts to reduce hunger worldwide is witnessing a negative growth due to various reasons such as climate change, COVID-19 pandemic, Ukraine war etc. Thus, there is a need to invest in inclusive, sustainable and equitable food systems. The prevalence of hunger in 2022 was 18.2% as compared to that in 2014. The number of people with access to sufficient nutrition is increasing. In 2021, approximately 828 million people were undernourished who lacked access to sufficient calorie food (Resnick, 2022). The war in Ukraine has increased the fertilizers price, that could lead to worsening hunger index next year. It is high time that the zero-hunger goal by 2030 of SDGs needs to be reworked and adequate measures are taken in right time.

The history of the food security, famines and hunger is not satisfactory. Historically the world has seen a number of food crisis. During twentieth century all major developing nations of contemporary world had witnessed famines in one form or the other. It is estimated that in the twentieth century alone almost 100 million people died of famines. All major economies of today, had faced worst human crisis as famines. China witnessed famines in 1928–30, 1942–43 and 1958–61, killing almost 42 million people. Similarly, USSR lost over 10 million people in different famines and India lost approximately 3 million people in the Bengal famine of 1942–43 (Devereux, 2000). The attempt to eradicate hunger and address food shortages has also a long history. Food and Agriculture Organization (FAO) of the United Nations was created in June 1943, in response to the President Franklin D. Roosevelt's call for 'freedom from want' and to ensure that humanity be freed from hunger (Shaw, 2007, p. xi). Hunger became a public issue in America, after a television documentary that showed the acute food shortage among the Americans. Task force was made by the successive presidents of America and more studies began to come forth in both America and the world (Food Security and the Hunger in the United States, 2006). Gradually hunger and malnutrition became a world problem that needed urgent attention and thus the food summit was held in 1996.

2 Sustainable Development Goals: Zero Hunger

The food security pertains to accessibility of food supply in an efficient manner (Chand, 2005, pp. 1055–1062). Associated with the food security is the sustainable development goals of United Nations. Also called global goals, it was adopted in 2015 by United Nations to end poverty, hunger, AIDS, discrimination against women and to achieve prosperity by 2030. There are 17 SDGs that are integrated to the extent that each goal is linked to another and it believes that actions to meet the challenges of any of the goals would have an impact on other goals. Thus, it advocated that the development must be socially, economically and environmentally sustainable (The SDGs in Action, UNDP Report, 2023). 'Zero Hunger' is the second of the seventeen SDGs, adopted by United Nations in 2015. It aims at eradicating hunger from this planet by 2030. We are into seventh year, after these goals were adopted, however the challenges remain significant. As per UN data, the number of chronically undernourished people in 2017 was 821 million. Over 90 million children in 2017 were dangerously underweight. Undernourishment and severe food insecurity in 2017 was a major concern in areas such as Africa and South America. In that year, Asia accounted for approximately two-third of worlds hungry. Nearly 22% children under five years of age were undernourished in the world. One-third of the women in the world in reproductive age were anaemic (Goal 2, Zero Hunger, The SDGs in Action, UNDP Report, 2023). These figures must have seen a new high during the global pandemic, COVID-19. Nations after nations failed to control the outbreak of the pandemic and the repercussions it had on the food security. The aim of UN is to achieve zero hunger and to remove all kinds of undernourishment, especially among the children, seems to be a tough task to achieve, as we have already crossed half-mark timeline.

The hunger data after the COVID pandemic shows that the aim of reducing hunger to zero is a distant dream. Instead of declining in the absolute numbers of hungry people as well as in their percentage in overall population, the undernourished people have increased significantly in 2020, due to pandemic and the related phenomena. As we can see from Fig. 1, it is clear that the undernourishment has increased from 8.4% in 2019 to 9.9% in 2020. Approximately 786 million people were undernourished in the world in 2020, out of which maximum number lived in Asia i.e., approximately 486 million people. The number of hungry people increased significantly, i.e., more than 800 hundred people faced hunger in 2020. Therefore, there is a need for a strong global action such as increasing food productivity, global cooperation to increase funding in the agriculture sector and leakproof distribution system to eradicate hunger by 2030.

Similarly, Fig. 2 tells us that the severe food insecurity was seen in the COVID period among the world's population. The world has witnessed a significant rise in the severe food insecurity in 2020. In 2020, approximately thirty percent of world population was facing food insecurity. Out of which 11.9% population faced severe food insecurity and approximately 18.5% population of the world felt moderate food security. Healthy diets are also becoming out of reach to the majority of the world's

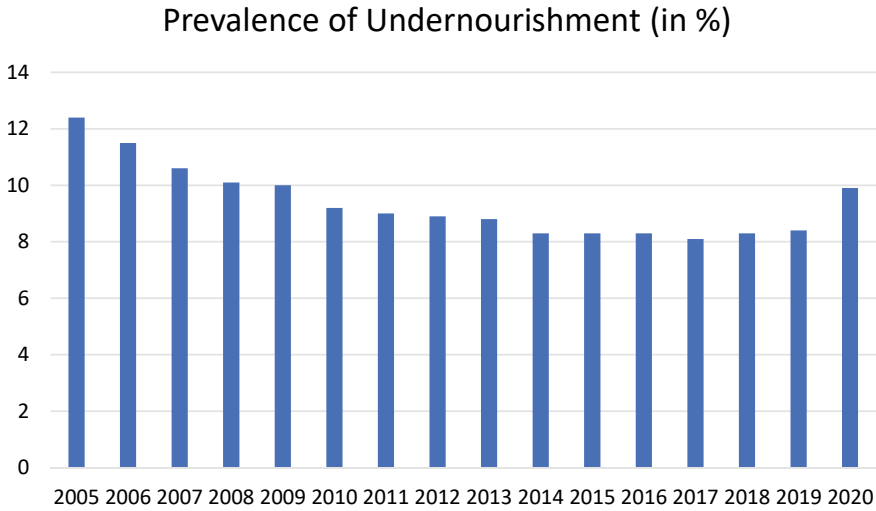


Fig. 1 Undernourishment in the world. *Source* Food and Agriculture Organization of the United Nations

population due to their higher price as well as due to income inequality. According to one estimate by FAO, approximately 3 billion people, almost half of the world’s population is feeling financial pressures to consume healthy diet. Food security is thus a serious concern, before the world could progress and also to achieve global goals for sustainability.

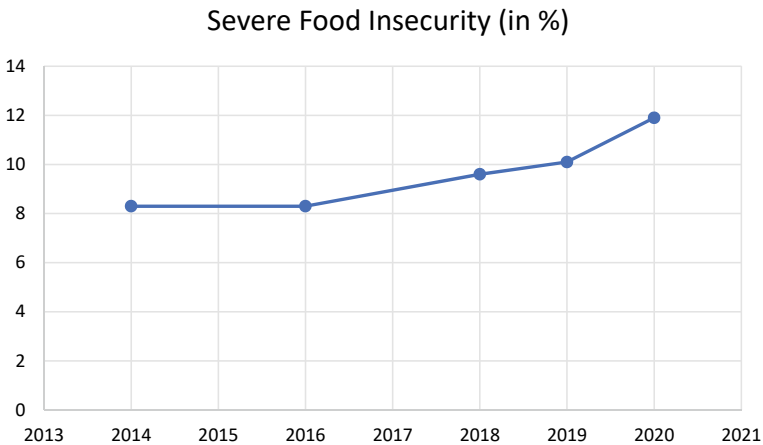


Fig. 2 Food insecurity in the world. *Source* Food and Agriculture Organization of the United Nations

There is a need for resurgence in international cooperation to enhance investment in technological innovations aimed at significant progression in agricultural productivity of developing and less developed nations. The United Nations must review the progress of SDGs in the wake of global crisis, the COVID-19. The developing and less developed nations, must look after their figures for undernourishment and malnutrition to rethink on the strategies to achieve SDGs by 2030. The focus of UN must have to be on Asia, where two-third of world's hunger resided in 2017. How Asian countries have performed in the years after 2017, needs to be assessed, more so in the pandemic and post pandemic period. This can be done through analysing the data of individual countries of Asia. Taking all Asian countries together would not be possible in one chapter, that's why it would be imperative to analyse data individually. One has to deal individually with Asian nations to arrive at any conclusion at the Asian level. The data suggests that if not addressed properly, the world would not be able to achieve the zero hunger aim by 2030, as approximately 670 million people may still be under severe food crisis. To add to this projection is the fact that most undernourished people lived in Asia (FAO Report, 2023). In such a scenario, countries like India becomes important as it constitute a significant portion of population as well as economy. There is a gender imbalance as well in this story of undernourishment and hunger population. It is estimated that, in 2021, approximately 31.9% of women were severely or moderately food insecure as compared to 27.6% of men (FAO Report, 2022). This is another task that has to be addressed.

3 The Global Pandemic, Undernourishment and Nutrition

During the global pandemic, COVID-19, the number of undernourished persons increased significantly. The food insecurity was at a high level and the governments after governments were failing to ensure minimum dietary requirements to its citizens in the wake of uncertainties, and associated steps taken to curb the growth of the pandemic. According to Food and Agriculture Organization of the United Nations, the number of people who suffered from hunger in 2021 was 10% of the total world's population. This figure was 9.3% in 2020 and 8% in 2019 (World Food and Agriculture-Statistical Yearbook, 2022). That means a rise of 2% from 2019 to 2021, the period when COVID-19 affected the most. The prevalence of undernourishment in Africa is alarming, as here the increase was more than two percent, i.e., there was an increase of 2.8%. In Asia, the rate of rise in undernourishment between 2020 and 21 was minimal, i.e., 0.5% only, from 8.6 to 9.1%. It is estimated that during 2019–21, there was an increase of 150 million people going hungry in the existing numbers, thus making it approximately 770 million people who suffered from hunger.

While the prevalence of undernourishment is second highest in Asia, after Africa, however more than fifty percent of world's hungry people resided in Asia. Between 2019 and 2011, 85 million people suffering from hunger were added to the exiting hunger population of Asia, thus making it to reach 425 million people. Prevalence of

undernourishment is a critical issue for the governments all over the world. During 2019–21, prevalence of undernourishment in Asia has increased from 7.2 to 8.3%. India also saw an increase in the percentage of undernourishment among its population from 13.3% in 2019 to 16.3% in 2021. The world's average is 7.8% in 2019 and 9.0% in 2021. In terms of the number of undernourished people in the world, it became 702.7 million in 2021 from 594.1 million in 2019. The same numbers in Asia were 387.5% in 2021 from 327.9 million in 2019. India has also seen an increase in the absolute numbers of undernourished people from 180.2 million in 2019 to 224.3 million in 2021. The data of Food and Agriculture Organisations published in 2022, tells us that stunting among children under five years of age has decreased significantly worldwide, from 33% in 2000 to 22% in 2020. Asia witnessed the highest drop in the percentage of stunted children under five, from 37% in 2000 to 21.8% in 2020 (World Food and Agriculture-Statistical Yearbook, 2022). In 2020, an estimated 22% of children under five years of age were stunted and 6.7% were wasted. This was made possible because of an increase in the breastfeeding of children under 6 months to 43.8% as compared to 37.1% in 2012.

4 Availability of Food and Its Access: A Case Study of India

India, being a responsible member of United Nations, is committed to achieve the seventeen sustainable Development Goals (SDGs). Adequate level of food grain stock is the primary concern of Indian government to ensure a national food security. It accumulates the food stock in succeeding years to feed its own population. Indian agriculture and its allied services have seen an average growth rate of 4.6% during 2016–2021, making it a net exporter of agricultural products. It is estimated that despite a decline in the sown area of Kharif production during 2022–23, the rice production is estimated at 104.9 million tonnes, higher than the average of 100.5 tonnes during 2016–21 (Economic Survey 2022–23, 2023, pp. 243–245). The affordability part of the food security is achieved through ensuring availability of food at the low cost to its citizen. This part is achieved by providing subsidies to the citizens through the Public Distribution System (PDS). The government fix the issue price for the PDS and bears the different between the cost of production and the selling price apart from bearing the cost of carrying the buffer stock as a measure of food security. This is done by the government organization, Food Corporation of India. Through this mechanism, the government of India is currently running the most extensive food security programme under National Food Security Act (NFSA) 2013, ensuring food availability to approximately 80 crore Indian populations. From January 1, 2023, free food grains are made available to about 81.35 crore beneficiaries under NFSA. It is estimated that approximately 2 lakh crore rupees is estimated to be spent in achieving this aim (Economic Survey 2022–23, 2023, p. 256) (Fig. 3).

Access to food at affordable price for a better health remains a critical issue for the policy makers in India. Both availability of food and access to food at affordable prices are interlinked. In production of food grains, India is continuously showing an upward

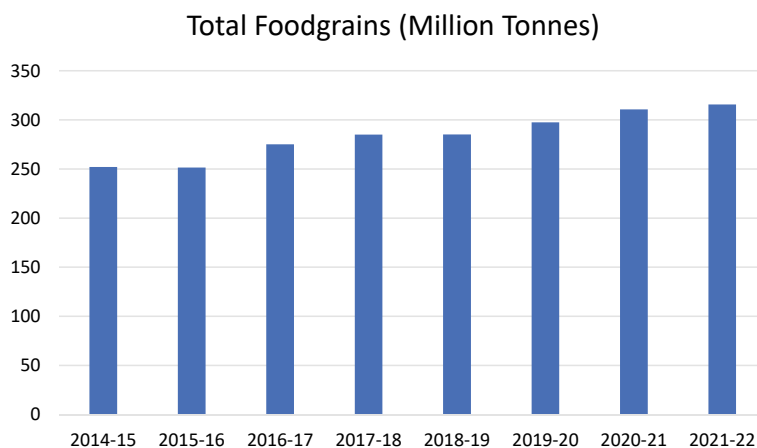


Fig. 3 Sustained increase in food grains production in India. *Source* Economic Survey, 2022–23, Government of India, p. 245

trend. From producing approximately 250 million tonnes of food grains in 2014–15, India is now producing approximately 315 million tonnes of food grains in 2021–22, despite disruptions due to the global pandemic. The production of oilseeds and pulses have also increased from approximately 27 million tonnes and 17 million tonnes respectively in 2014–15 to 37 million tonnes and 27 million tonnes respectively in 2021–22. The reason for this increase in food grains production was the decision of the Government of India in 2018–19 to increase the Minimum Support Price (MSP) to at least one and half times the cost of production. Since then, at least twenty-two kharif and Rabi crops have seen year by year increase in their MSP, the price at which the Government buys food grains from the farmers both to maintain buffer stock and to feed people through Public Distribution System (PDS). For oilseeds and pulses, the government of India has fixed a relatively higher MSP, to ensure the nutritional requirements of its people. That proved an incentive to the farmers, who invested their capital in production of oils seeds and pulses. Add to it was the least complex credit disbursement to farmers through banks in India. The government has increased the credit line to the farmers under Kisan Credit Scheme. Farmers can easily access loans at cheaper rates to buy agricultural products and its related services. Moreover, the kisan credit scheme facility has been extended in 2028–19 to the fisheries and animal husbandry sector as well. All farmers of this sector have the access of a short-term loan up to three lakhs of rupees at just 4% interests. In 2021–22, a credit of more than 16.5 lakh crore rupees was given to the farmers of this sector and the aim of credit disbursement for 2022–23 is 18.5 lakh crore (Economic Survey 2022–23, 2023, pp. 246–247). To further increase the productivity, the Government of India started world’s largest Direct Benefit Transfer (DBT) scheme in 2018, an income support of six thousand rupees, to eligible farmers. It is transferred into their bank account directly (Report of PM Kisan Samman Nidhi, 2023). Approximately 12 crores farmers are

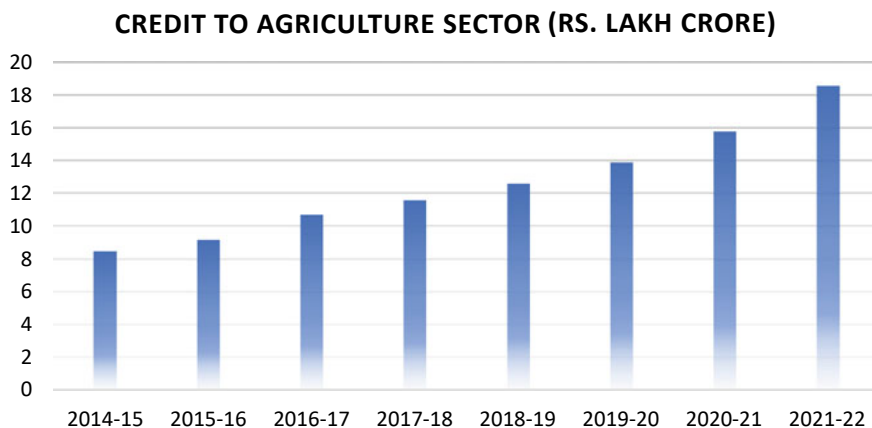


Fig. 4 Continued increase in institutional credit to agriculture sector (Rs. lakh crore). *Source* Economic Survey, 2022–23, Government of India, p. 247

benefited from this income scheme, consequently impacting the productivity of food grains (Fig. 4).

The accessibility of food grains to the citizens of India is a critical matter for policy makers. The ability to access food by its people is a major concern for Indian government. India came up with National Food Security Act, in 2013 to ensure hassle free access of food grains to its citizens. This is done by government through buying food grains at MSP from the farmers and distributing them to the poor/vulnerable section at an affordable price. Apart from buying for distribution, the government keeps part of the food grains in their stock to stabilize food prices in the open market, as and when required. Till 2022, the government of India has provided coarse grains, wheat and rice at the price of rupees one, two and three respectively to approx. 75% of rural and 50% of urban population. During COVID-19, the global pandemic, the government had given an additional five kg of food grains per person per family under PM Garib Kalyan Yojana. From January 1, 2023, it was decided to provide food grains free of any cost to approximately 81.35 crore Indian population. The challenges in the agriculture sector, however remain critical. There is a need to increase investment in this sector, as this sector is linked directly with the employment and growth of the country.

5 Food Security and the Health Survey: Drawing Linkages

The government of India released the key findings of the fifth round of National Family Health Survey 2019–21, in March 2022. The released data is a ready compendium to understand India's progress in meeting the goals of Sustainable Development Goals. The data pertaining to nutritional status of Indian families,

tells us that 35.5% of children under five years are stunted i.e., short for their age (National Family Health Survey, NFHS-5, 2021). Stunting is assessed through height for age, which is a measure of linear growth retardation and cumulative growth deficit (National Family Health Survey, NFHS-5, India Report, 2021). Stunting is caused due to undernourishment and intake of low nutritional food. Though the government of India has reduced the percentage of stunted children under five years of age from 38.4% in 2015–16 to 35.5% in 2019–21, however both the rate of decrease as well as the absolute numbers are not satisfactory. The government of India needs to work on a war footing basis to reduce the absolute numbers of stunted children through various policies and interventions in the lives of common people. A decrease of three percent in the percentage of stunted children in four years is not encouraging and this needs to be addressed decisively so that zero hunger as one goal of SDGs is achieved in time.

The same report, National Family Health Survey 2019–21, tells us that the children under five years of age who are wasted has decreased from 21% in 2016 to 19.3% in 2021. Wasting of children is a condition in which weight for height is measured (National Family Health Survey, NFHS-5, 2021). It measures the body mass with respect to body height and is also an indicator of nutritional status amongst the children (National Family Health Survey, NFHS-5, India Report, 2021). Similarly, the percentage of underweight children at all India level is also significantly high. Though it has reduced from 35.8% in 2016 to 32.1% in 2021, however this decrease in percentage of underweight children is still high and needs to be addressed at the local level on a pan-Indian scale. Underweight is a clear indication of acute and chronic undernutrition among the children.

Stunting, wasting and being underweight are three important measures to understand undernutrition amongst children. The pattern of undernutrition among children clearly tells us that girl child is less nourished as compared to the boy child. One reason for prevalence of stunting, wasting and underweight among children is the less Body Mass Index (BMI) of pregnant mother. Secondly stunting is higher among children of rural areas as compared to those of urban areas. In rural areas the percentage of stunted children is staggering high, i.e., 37% as compared to 30% in urban areas. Education of mother also plays a role, as per the data available in India. Mothers with twelve or more years of schooling had less percentage of stunted children, i.e., 26% as compared to mother who had no schooling and whose corresponding figure of stunted children is 46%. Similarly for underweight children, the schooling of mother has an impact. Mothers with no schooling gives birth to 42% of underweight children as compared to mothers with twelve years of or more of schooling, as they gave birth to only 23% underweight children. Meghalaya, a state in India has the highest percentage of stunted children (47%), followed by Bihar (43%), Uttar Pradesh (40%) and Jharkhand (40%). Bihar also has the credit of having the highest percentage of underweight children (41%). Maharashtra topped the list in the highest number of wasted children (26%) (National Family Health Survey, NFHS-5, India Report, 2021).

What comes out of the above data is that priority must be on the nutrition of the pregnant women, during pregnancy and afterwards, both in rural and urban areas.

Until the nutritional concerns of women are addressed, the stunting among children cannot be reduced. Secondly the government must focus on the education of the women and make special arrangements to ensure that they complete at least twelve years of their education. So that the mother can assess the nutritional requirements of her baby and is more cautious to the growth of her child. Since the schooling of a mother has a direct impact on both the stunting and underweight of her child, it should also be the priority of the government. Thirdly, the states of India which are on the top ten of the lists in all the three measures of nutrition, i.e., Stunting, wasted and underweight needs to reassess their nutritional schemes to be able to reach out to the neediest persons. The surprise part of the data pertains to those states of India which are otherwise developing fast and are frontiers of India's development but tops the list in stunting and wasting. The reason for the same needs to be analysed, as to what went wrong with these model states which otherwise is the bright star of India's developmental galaxy but lacking behind in providing adequate nutrition to pregnant women in dire need of nutrition and the stunted and wasted children. So, there are couple of interrelated priorities of the government which needs to be brought into the mainstream policy to be able to defeat the menace of undernutrition and underweight both among the women and her child. One has to look into these details from the data available to ascertain where is the stumbling block in achieving zero hunger in India. The Government of India should increase its budgetary allocations to food security, to achieve affordable availability of healthy diets to its population and to achieve zero hunger by 2030, which is difficult to achieve not only for India but for the world as well due to progress made so far and the uncertainties lying ahead. Undernutrition among women, and in particular the pregnant women is a concern that needs to be assessed and addressed on a priority basis.

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The Need for Food Security Under Changing Climate Scenario



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Abstract Global food security is an issue, especially in light of the scenario of a changing climate. The production, accessibility, and availability of food are anticipated to be significantly impacted by climate change, thus making the world's population more vulnerable to food insecurity. In this situation, it is important to prioritise food security for sustainable development. Under the scenario of a changing climate, this chapter provides an overview of the need for food security while highlighting the potential and problems for food production and distribution. It examines the consequences for food security as well as how climate change affects the growth of crops, animals, fisheries, and aquaculture. The essay also outlines various institutional and policy measures that will be necessary to solve the problems. In order to guarantee that food systems are robust and sustainable in the face of climate change, the chapter emphasises the significance of a coordinated and integrated approach to food security and climate change adaptation. The effects of climate change on agriculture have been more pronounced in recent years. Global food production systems are being impacted by increasing temperatures, shifting rainfall patterns, and increasingly frequent extreme weather events like floods and droughts. For instance,

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increasing temperatures in certain areas are lowering the yields of important crops like wheat, maize, and rice, while shifting rainfall patterns in other areas are making it more challenging to cultivate crops.

Keywords Food security · Climate change · Agriculture · Sustainable development

1 Introduction

Climate change has a substantial influence on livestock productivity because it may alter animal access to water and food through changes in temperature and rainfall patterns. Climate change can also worsen the spread of diseases and pests, which can have a considerable impact on cattle productivity. Aquaculture and fishing are both susceptible to climate change's effects. The survival of fish and other marine creatures may be impacted by changes in ocean chemistry and the loss of fish habitats caused by warming oceans. People whose food and livelihoods depend on fisheries and aquaculture may be significantly impacted by this. It is necessary to implement climate-smart agriculture practises that can assist farmers in order to handle these concerns. This includes methods that can improve soil health, boost yields, and lower greenhouse gas emissions, such as agroforestry, conservation agriculture, and integrated pest control. The Food and Agriculture Organisation of the United Nations asserts (FAO, 2009) that "food security exists when everyone, at all times, has physical, social, and financial access to enough, safely prepared food to meet their needs." Dietary needs and food choices for living an active and healthy life. The foundation of food security is made up of four components, according to the Committee on World Food Security (2012), Ericksen (2008), FAO et al. (2013), and the United Nations System High Level Task Force on Global Food Security (2011): food availability (i.e., sufficient quantities of food produced and supplied on a consistent basis); food access (i.e., physical access and affordability); food use (i.e., proper use of food based on basic nutrition knowledge); and stab The concept of food security (FS) has received a lot of attention in the discussion of sustainable development. In actuality, the first Millennium Development Goal (MDG) was to "Eradicate extreme poverty and hunger," as stated by the United Nations (2015a). In more recent years, the second Sustainable Development Goal (SDG) "Zero Hunger" was created with the goals of "putting an end to hunger, achieving food security and improved nutrition, and promoting sustainable agriculture" (United Nations, 2015b). However, despite the efforts made over the last few decades, food insecurity continues to be a significant issue in many countries, especially rising ones. In actuality, over 820 million people throughout the world suffered hunger in 2018, predominantly in Africa, Latin America, and Asia, according to the FAO and allied organisations' 2019 report on the State of Food Security and Nutrition in the World (FAO et al., 2019).

A sign that the global food system is malfunctioning is food insecurity. El Bilali (2018, 2019) and El Bilali et al. (2018), in which a number of elements are experiencing a unique confluence. In fact, FAO (2016) claims that due to its effects on agriculture, climate change will have a considerable impact on all facets of food security. Agriculture is a crucial avenue by which food security is influenced, even while other factors, such as adverse weather events that reduce urban inhabitants' wages and hence limit their access to food, will also have an impact. The land and water resources required for agricultural production are impacted by climate change. A sign that the global food system is malfunctioning is food insecurity (El Bilali et al., 2018).

In addition, promoting sustainable food systems that prioritize local food production, reduce food waste, and ensure equitable access to food can also help to address the challenge of food security under the changing climate scenario. This requires the involvement of multiple stakeholders, including governments, civil society organizations, and the private sector. Finally, strengthening social protection programs can help to mitigate the impacts of climate change on vulnerable populations, including smallholder farmers and urban poor. This includes measures such as cash transfers, food vouchers, and insurance schemes, which can help to ensure that people have access to food even in times of crisis. Overall, addressing the challenge of food security under the changing climate scenario requires a coordinated and integrated approach that brings together multiple stakeholders and addresses the root causes of food insecurity. By doing so, we can ensure that food systems are resilient and sustainable, even in the face of the changing climate.

Climate change is anticipated to extend its impact far beyond the realm of food production and sourcing, permeating entire value chains and food systems. Scientific investigations suggest that elevated temperatures and prolonged exposure to heightened CO₂ concentrations may result in diminished nutrient content, such as zinc, iron, and proteins, in crucial food crops. These environmental shifts could also instigate alterations in essential quality parameters, including dry matter, sugar content, citric and malic acid, organic acids, and antioxidant compounds (Dong et al., 2018; Högy & Fangmeier, 2009; Moretti et al., 2010; Myers et al., 2014). Moreover, there is a heightened risk of increased occurrences of foodborne pathogens and mycotoxins (Battilani et al., 2016; Tirado et al., 2010). Figure 1 shown Emissions are measured in carbon dioxide-equivalents. This means non-CO₂ gases are weighted by the amount of warming they cause over a 100-year timescale.

The repercussions of climate change extend further to storage, marketing, and retail systems, demanding adaptation in response to rising temperatures and the challenges posed by less durable and more frequently flooded roads, as well as damaged port infrastructure (Nicholls & Cazenave, 2010; Shi et al., 2015). Complications arise in the transportation sector as electrical grid failures, triggered by hydroelectric dams running dry or overwhelming demand, can impact retail shops and consumers alike (Portier et al., 2013). Additionally, concerns about the consumption of food emerge, with studies indicating potential contamination of drinking water supplies and an increase in the prevalence of respiratory diseases and diarrhea, particularly in semiarid areas (Signorelli et al., 2016).

Green House Gas emissions per kilogram (Poore & Nemecek, 2018)

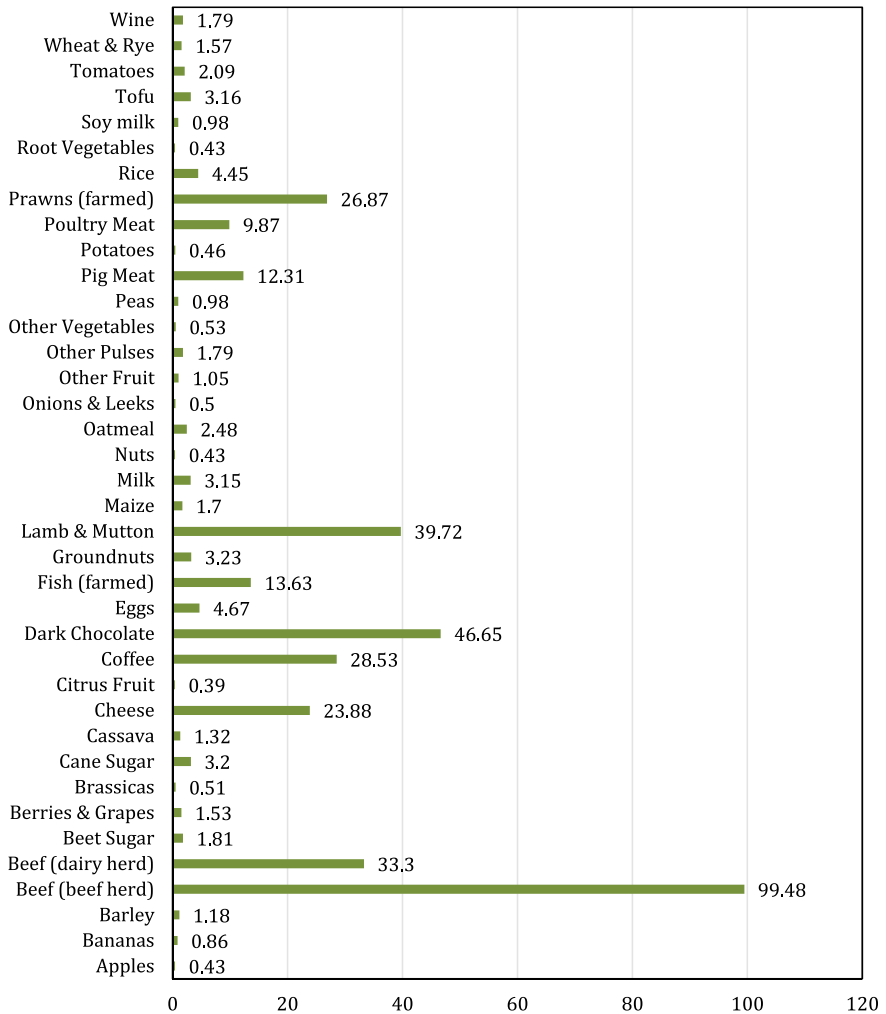


Fig. 1 Greenhouse gas emissions per kilogram (Poore & Nemecek, 2018)

Vulnerability to these challenges is heightened for already susceptible populations due to the anticipated impact of climate change and an enhanced understanding of the enduring consequences of malnutrition (Alderman et al., 2006; Martins et al., 2011). The discourse on food security has evolved, acknowledging the intricate nature of the issues involved. Initially centered around commodity trade, tariffs, barriers, food processing, and calorie availability post-World War II, contemporary discussions on food security incorporate multifaceted definitions that address the complexity

of threats posed by climate change. These definitions emphasize the multifaceted nature of food security, considering factors like availability, accessibility, utilization, and stability of food over time, impacting people's physical, social, and economic development.

The challenges posed by climate change necessitate a shift in development interventions from merely focusing on food production to integrated approaches targeting entire food systems (FAO-WHO, 2014; Mbow et al., 2019; Oliver et al., 2018). This paradigm shift requires increasingly complex and collaborative approaches among experts from diverse fields.

In the realm of contemporary development thinking, a relatively recent concept gaining prominence is that of resilience. Resilience is now commonly employed in academic literature and international development contexts as an approach to address adverse shocks and promote sustainable development (Serfilippi & Ramnath, 2018). Researchers note that resilience and vulnerability studies can inform the principles of sustainable food systems, offering valuable insights into framing responses to food emergencies and development challenges (Prosperi et al., 2016; Vonthron et al., 2016). The integrative nature of resilience bridges research areas that were traditionally treated in isolation, such as gender, social protection, health and nutrition, climate change, energy, and infrastructure (Béné & Haque, 2021). Recognized for its potential to support a systems approach, resilience acknowledges the interconnectedness of human capabilities and natural systems (Xu et al., 2015).

2 Climate Change Impacts on Availability of Food

Changes in temperature and precipitation patterns, which directly affect crop yields and the viability of agricultural zones, are the main ways that climate change has an impact on the availability of food. The supply networks and methods of food production throughout the world are significantly impacted by these consequences. Climate change will alter how food is used, which will have an influence on how well-nourished the population is, particularly the poor and vulnerable. In particular, water scarcity (caused by droughts) affects water quality and hygiene practises, especially in arid and semi-arid regions, which could increase the burden of diseases (like diarrhoea), especially among the poor children. For example, higher temperatures can favour the development of pathogens. In fact, vulnerable populations including children, women, and elderly people may be more affected by the effects of hunger brought on by global warming (Belesova et al., 2019; Sorgho et al., 2016).

2.1 Effects of Temperature Change on Agricultural Yields

Climate change-related temperature increases have the potential to negatively impact crop growth and production. Increased agricultural water demand and evaporation

brought on by high temperatures can result in water stress and decreased yields. Heat stress at crucial growth phases can also result in fruit and blossom abortion, affecting crop productivity as a whole. Furthermore, rising temperatures may encourage the spread of pests and diseases, further reducing food production.

2.2 Changes in Precipitation Patterns' Effects on Agricultural Yields

Crop yields are impacted by shifting precipitation patterns because of changes in rainfall timing, intensity, and distribution brought on by climate change. Excessive rainfall or periods of high precipitation can result in waterlogging, nutrient leaching, and soil erosion, all of which are detrimental to crop development. On the other hand, prolonged dry spells and droughts can cause water shortages, soil moisture loss, and crop failure. These changes in precipitation patterns make it difficult for farmers to control irrigation, which has an effect on agricultural productivity and yields.

2.3 Changes in the Appropriateness of Certain Areas for Growing Crops

The geographic distribution of acceptable agricultural zones can alter as climatic conditions change. A lack of proper temperature and precipitation conditions may cause areas that were formerly fruitful for particular crops to become less viable. On the other hand, certain areas may see more prospects for agricultural production as a result of warmer climates and extended growing seasons. However, these changes frequently need modifications to agricultural methods, infrastructure, and crop selection, which can be difficult to adapt to and may result in increased expenditures.

2.4 Consequences for the World's Food Supply Chains

Global food production and supply systems are affected significantly by climate change's effects on crop yields and agricultural appropriateness. Reduced agricultural yields in some areas might result in less food being available and possible price rises. Food insecurity can increase as a result of crop failures and supply disruptions, which can also threaten the stability of the world's food markets. Furthermore, modifications to agricultural zones may have an impact on trade patterns and need changes to supply chain logistics and distribution systems.

The creation and use of resilient agricultural practises, such as the adoption of climate-smart tactics, crop diversification, and enhanced water management, are necessary to adapt to the effects of climate change on food availability. To reduce the effects of climate change on food availability and guarantee global food security, it is essential to strengthen international collaboration, information exchange, and investment in sustainable agriculture.

3 Climate Change Impacts on Access to Food

The impacts of climate change on the availability of food are significant, primarily manifested through changing temperatures and precipitation patterns, which directly influence crop yields and the suitability of agricultural zones. These effects have wide-ranging implications for global food production and supply chains. Food access will decrease as a result of climate change's detrimental effects on food prices and rural livelihoods. Food costs would rise as a result of shortages in the food supply brought on by the adverse effects of CC on yields and output. Millions of low-income individuals who reside in regions with high rates of hunger and poverty, such as South Asia (Bandara & Cai, 2014) and SSA (Tamako & Thamaga-Chitja, 2017), will be impacted by price increases for food.

3.1 Impact of Climate Change on Disadvantaged Communities' Access to Food and Livelihoods

Vulnerable populations, such as small-scale farmers, rural communities, and marginalised groups, are disproportionately impacted by climate change. Extreme weather conditions, such as droughts, floods, and storms, can ruin livestock, crops, and way of life, making it harder for these communities to generate or buy food. Food insecurity increases as a result of the decreasing accessibility and availability of food.

3.2 Market Dynamics and Disruptions in the Food Delivery Systems

The availability and accessibility of food may be impacted by changes in market dynamics and food delivery networks brought on by climate change. Transporting food from food production regions to markets can be difficult due to disruptions in transportation infrastructure caused by extreme weather events and shifting climatic trends. Food shortages may result from this, especially in isolated or vulnerable

areas that depend significantly on outside food supplies. Supply chain disruptions and changes in market dynamics can also increase price volatility and food price spikes, making it harder for disadvantaged communities to get food.

3.3 Affordability and Affordability Changes in Food

Food affordability may alter as a result of climate change effects such as crop failures, decreased agricultural output, and rising production prices. Greater food prices, especially for those with little financial means, can be brought on by lower yields and greater input costs, making it more challenging for people and households to afford a sufficient and nourishing diet. As a result, vulnerable populations could turn to fewer varied and worse food alternatives, which would be detrimental to their general health and nutrition.

A multifaceted strategy is needed to address how climate change is affecting people's access to food. It entails putting in place agricultural practices that are climate-resilient, promoting sustainable livelihoods, and making investments in social safety nets to safeguard vulnerable communities. Food accessibility and availability may be improved through strengthening local and regional food systems, expanding market infrastructure, and improving storage and distribution networks. For people most impacted by climate change, increasing income-generating possibilities, social protection programmes, and targeted initiatives can help make food more affordable.

4 Climate Change Has Significant Impacts on Food Stability

The Capability to Ensure Consistent Access to Food Over Time Climate change has a huge influence on the utilisation of food. The following bullet points provide a succinct summary of how climate change affects food stability. The stability of food supply, access, and usage will be impacted by climatic variability and the increasingly frequent and severe extreme climate events. Changes in seasonality, variations in ecosystem production, elevated hazards, and a less predictable food supply are expected to contribute to this (FAO, 2016). This will be a significant issue, especially for SIDS and landlocked nations, which are more susceptible to interruptions in the commerce and food supply. Barnett (2011) illustrates that "climate change will adversely affect food systems in the region, including the supply of food from agriculture and fisheries, the ability of countries to import food, systems for the distribution of food, and the ability of households to purchase and utilise food" with reference to the South Pacific islands. According to HLPE (2014), CC will have an

impact on every component and activity of the food system, with far-reaching consequences for FS at the international, national, and local levels (Myers et al., 2017; Schnitter & Berry, 2019).

4.1 Severe Weather Events Are Happening More Frequently and More Intensely

Droughts, floods, storms, and heat waves are just a few examples of severe weather occurrences that have become more frequent and intense as a result of climate change. These occurrences have the potential to seriously harm agricultural systems, including crop losses, infrastructure devastation, and disruption of farming methods. It can be difficult to fulfil the needs of expanding populations when there are such interruptions in the food supply.

4.2 Changes to Food Storage, Preservation, and Post-harvest Management Procedures

Changes to food storage, preservation, and post-harvest management procedures: Climate change might impair food stability by jeopardizing these procedures. The rotting and degradation of harvested crops can be accelerated by higher temperatures and variations in humidity, shortening their shelf life. Climate change can also result in an increase in insect infestations, mold development, and mycotoxin contamination. These difficulties put food stability at risk and compromise its long-term preservation and storage.

4.3 Effects on Food Reserves, Food Assistance Programmes, and Disaster Response Systems

Food reserves, food aid programmes, and emergency response systems may all be put under stress by climate change. Extreme weather conditions may reduce food stocks, creating shortages at pressing times. Additionally, the provision of food aid to impacted communities may be hampered by logistical and transportation difficulties brought on by climate-related disasters. In the face of growing climate-related issues, emergency response agencies may find it difficult to adequately manage food poverty.

Proactive efforts are needed to address how climate change is affecting the stability of the food supply. These include adopting agricultural practises that are climate-resilient, such as drought-resistant plants and enhanced water management methods. Increasing infrastructure for post-harvest management, storage, and preservation can

help cut down on food losses and increase the amount of food that is available. The creation of strong early warning systems, emergency action plans, and flexible social safety nets can improve our capacity to respond to future food crises caused by the effects of climate change.

5 Adaptation Strategies for Enhancing Food Security

When it comes to improving food security in the face of climate change, adaptation methods are essential. Although there is a bidirectional relationship between CC and FS, the research focuses far more on the effects of CC on food security. Islam and Wong (2017) make the following claim in this regard: “It seems that research on climate change and food in/security has often been one-sided, with climate change being identified as the cause of food insecurity and not how the systems in place to ensure food security have exacerbated the issue of climate change.” Through GHG emissions, agriculture is a significant cause of CC and one of its most severely impacted industries (FAO, 2016; HLPE, 2012). About one-fifth of global GHG emissions are attributable to agriculture, forestry, and other land uses (AFOLU) (FAO, 2016). In fact, according to Torquebiau (2017), “Agriculture is probably the most climate-dependent human activity and is both a victim of and a cause of climate change, while it can also be a solution to the climate change crisis.” FS and CC reduction are combined through sustainable intensification, which is portrayed in this context as a win–win solution (Ayantunde et al., 2020; Descheemaeker et al., 2016; van Loon et al., 2019).

Plant-based alternatives to animal-sourced foods encompass various categories, ranging from minimally processed options like pulses and nuts to traditional plant-based foods with historical usage, such as mock duck made from seitan, and staples like tofu, natto, falafel, and tempeh. Additionally, there are emerging forms of highly processed plant-based analogues designed to replicate the taste and texture of meat or other animal-sourced foods. Each category presents distinct sustainability and health considerations. The issues surrounding plant-based foods and diets exhibit some differences, though substantial overlap exists. Figure 2 illustrates several ongoing debates in this domain, reflecting the diverse perspectives and concerns associated with the consumption of plant-based alternatives.

van Loon et al. (2019) draws the following conclusion with regard to cereal cropping in SSA: “Intensification scenarios are clearly superior to expansion scenarios in terms of climate change mitigation.” The major adaptation techniques are explained in the following points.

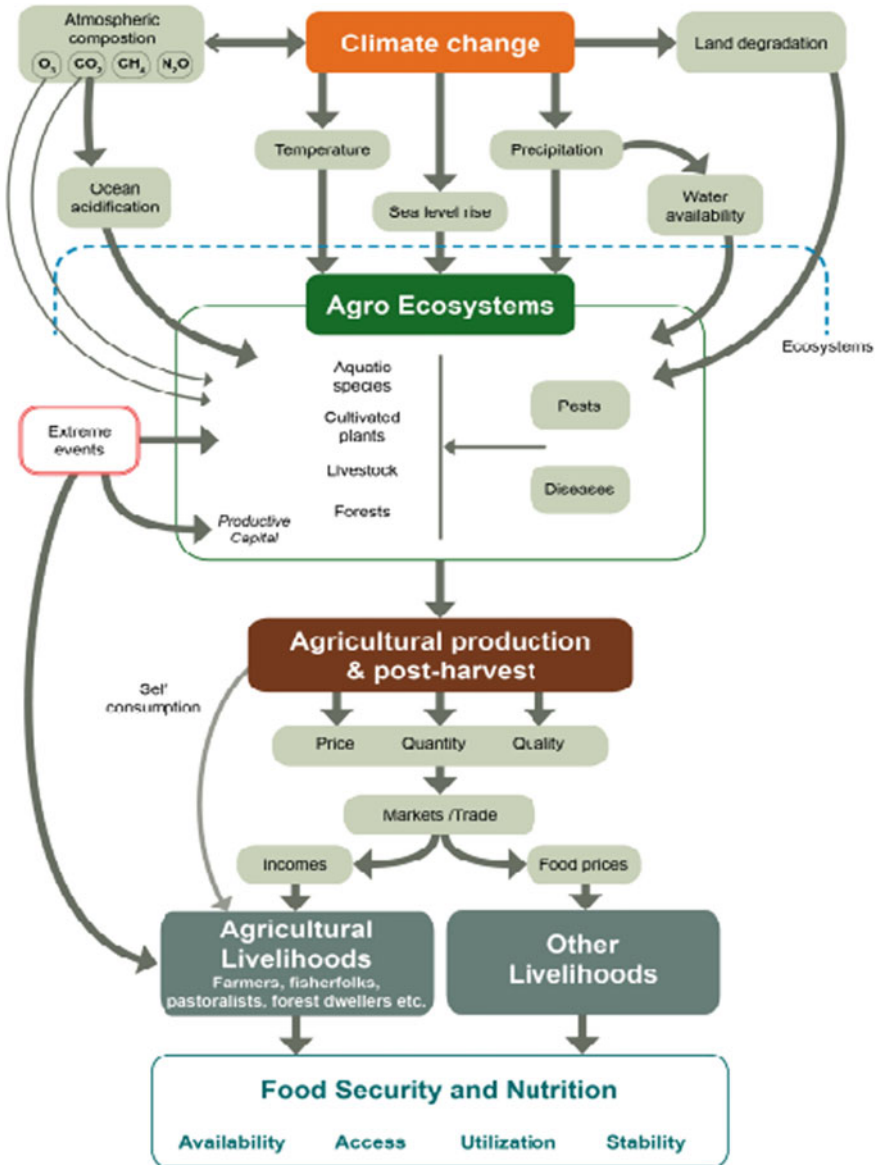


Fig. 2 Illustrates the interconnected consequences of climate change on food security and nutrition. Various physical, biological, and biophysical changes affect ecosystems and agroecosystems, leading to repercussions on agricultural production. These consequences manifest in terms of quantity, quality, and price, subsequently influencing the income of farming households and the purchasing power of non-farming households. All aspects of food security and nutrition, encompassing quantity, quality, availability, and accessibility, are significantly impacted by these cascading effects. *Source* FAO (2016)