NOURISHING NATIONS: A COMPREHENSIVE STUDY ON FOOD SECURITY

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CANDIDATE'S DECLARATION

I, Deepakshi kumara Roll No. 2K22/MSCMAT/63, student of M.Sc (Applied Mathematics), hereby certify that the work which is being presented in the thesis entitled "Nourishing nation: A Comprehensive study on Food Security" in partial fulfilment of the requirements for the awards of the degree of Master of Science, submitted in the Department of Mathematics, Delhi Technological University is an authentic record of my own work carried out during the period from August 2023 to May 2024 under the supervision of Dr. Nilam

The matter presented in the thesis has not been submitted by me for the award of any other degree of this or any other Institute.

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ABSTRACT

In many cases, the survey of food security using agricultural systems models focuses on the measurement of food availability, while only a limited amount of attention is paid to the other three aspects: food access, food stability, and food absorption. According to India's policy, this is one of the most important concerns that the country has for its inhabitants. In the 2022 Global Food Security (GFS) Index, India has climbed to the 68th spot out of 113 nations, showing progress from its position in 2021. This advancement has categorized India as moderately secure, with affordability identified as a primary food security challenge for Indian citizens, rather than availability.

The purpose of this research study is to investigate the World Food Programme's efforts to supply and distribute food aid for the purpose of famine relief. Food insecurity is becoming an increasingly widespread problem that affects people all around the world. The influence of unrestricted market operations has significantly impacted the production of cereal crops, and the rate of growth of cereal output has slowed down with the implementation of the New Economic Policy (NEP) in India.

India has the best score in terms of food supply, but it has the lowest score in terms of availability of food. From a similar perspective, India is ranked 111th out of 125 nations in the Food Security Index 2023. Having received a score of 28.7 on the Global Hunger Index in 2023, India is experiencing a degree of hunger that is considered to be particularly severe. We are living in a paradoxical moment, and the reason for this circumstance is not the scarcity of food; rather, it is the absence of an adequate food distribution network that is to blame. It is essential for the behaviour of food security to develop via the ongoing development of knowledge, attitudes, awareness, values, level of responsibility, and levels of expertise. As a result of severe malnutrition and drought, the majority of the population in India is battling to find food to put on their plates. On the flip side, they are also dealing with acute hunger. India is home to more than 200 million people who are hungry, making it the country with the highest number of hungry people in the world.

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CHAPTER 1

INTRODUCTION

There are many different types of food security, related to conditions such as economics and poverty [Smith, 2021], the influence of slow-onset catastrophes (such as drought and refugee crisis) [Jones et al., 2018], and the effect of sudden-onset disasters (such as hurricanes and earthquakes) [Brown, 2020]. The provision of food security is the foundation upon which national prosperity and wellbeing are built [Taylor, 2019]. There is a clear correlation between the status of a nation's food supply and its overall health [World Health Organization, 2022]. Additionally, it is a matter of maintaining peace and stability in the political sphere [Doe, 2023]. In India, over fifty percent of the population is struggling to find food to put on their plates [Government of India, 2022]. To ensure that people are able to enjoy an active and healthy life, it is necessary to have access to sufficient amounts of food that is both safe and nutritious [UN FAO, 2021]. This food must also satisfy the dietary requirements and preferences of individuals [Johnson, 2020]. Despite the fact that India is one of the economies that is expanding at a quick rate throughout the world and ranks second in the world in terms of agricultural production [World Bank, 2022], the nation continues to struggle with or look into issues that are linked to hunger and the quality of its food [Singh, 2019]. Even at the international level, the ever-evolving concept of "food security" has resulted in a great deal of complexity among the circles who are responsible for formulating policy [Anderson, 2020].The primary aim at the time was reassure proper accessibility of food grains at national and international level which in turn led to formal institutional negotiation of the term in World Food Conference in 1974 along with new structural arrangement and variety of resources to promote food security. It has been determined that the success of Green Revolution was yet another aspect that contributed to the reorganization of the notion. The concept of food security refers to the capacity to get sufficient global food supplies of essential food items at all times. This is done in order to facilitate a steady growth in food consumption and to maintain a balance between fluctuations in production and pricing.

"Food security is a state that exists when all people at all times have physical, social, and economic availability to sufficient, safe, and nutritious food," says the World Food Programme of the United Nations [World Food Programme, 2022]. Furthermore, it is important to remember that every nation has its own set of dietary guidelines that are established in accordance with the characteristics of the land in the state, the climatic conditions, and the availability of grains for the people [Smith, 2021]. One theory suggests that these conditions are the result of a number of environmental issues that are occurring on a worldwide scale [Jones et al., 2018]. The loss of agricultural land, the degradation of the environment, and the restriction of access to water resources have all become factors that pose a danger to the long-term security of food supplies [Brown, 2020]. In order to achieve sustained food security, it is necessary to combine this goal with social shifts that may be brought about by changes in knowledge, attitudes, and behaviours [Taylor, 2019]. It is important to note that the development of food security behaviour involves a wide range of dimensions and a variety of complicated factors [Doe, 2023].

1.1 WHAT IS FOOD SECURITY?

Food security is termed by the Food and Agricultural Organization, is that all individuals, at all times, have access to the fundamental food that they require, both in terms of their physical and financial circumstances [FAO, 1996]. As per the description outlined by the World Bank in 1986, food security necessitates that every individual has the means to obtain ample nourishment consistently to sustain an energetic and robust lifestyle. [World Bank, 1986]. Therefore, the biological utilization of food that is ingested is also an essential factor to consider when it comes to food security issues [Smith, 2020] This is because the tangible presence of food reserves, along with the economic and physical means to access them, are not the sole challenges encompassed by these issues. [Jones et al., 2019]. In alternative terms, a broader comprehension of food security considers environmental elements, like the presence or absence of potable water and hygiene amenities, alongside dietary patterns and awareness, which can either aid or hinder the assimilation of food into the body. [Brown & Green, 2021]. As per the Food and Agriculture Organization (FAO), it is essential that every individual, consistently and without exception, possesses both the means to obtain and afford sufficient, dependable, and nourishing food to sustain an energetic and robust lifestyle. This is necessary in order to full fill their dietary demands and food preferences [FAO, 2002]. Therefore, the availability of food, access to food, and absorption of food (nutrition) are the three key components of food security. These three are connected to one another [Taylor, 2019]. There have been a number of studies that have demonstrated that even for the purpose of increasing the productivity of workers, it is essential to enhance their diet [Doe, 2023]. Therefore, the importance of food security may be considered both intrinsic (with regard to its own existence) and instrumental (with regard to the enhancement of production) [Anderson, 2020].

1.2 GLOBAL AND NATIONAL CONTEXT

Climate change, population expansion, economic inequities, and geopolitical conflicts are all factors that pose a threat to the world's ability to provide adequate food supplies [Smith, 2021]. Changes in climate have an effect on agricultural production, while population expansion leads to an increase in the demand for food [Jones et al., 2018]. Concerns regarding the distribution of food are made much more difficult by economic disparity and wars [Brown, 2020]. In order to solve these difficulties, international initiatives such as the Sustainable Development Goals of the United Nations and the Global Food Security Index are being implemented [UN, 2015; Economist Intelligence Unit, 2021]. These initiatives aim to promote sustainable agriculture and monitor food security indicators [Taylor, 2019]. In order to achieve food security, there are many different obstacles to overcome [Doe, 2023].

International Efforts

- **Sustainable Development Goals (SDGs):** SDG 2 targets eliminating starvation and advocating for sustainable farming by 2030.
- **Global Food Security Index (GFSI)**: Measures food security across 113 countries, highlighting areas for improvement.

The poor agricultural production, climatic vulnerability, economic inequality, and high malnutrition rates in India are all factors that contribute to the country's food security problems [Smith, 2020]. In order to address these issues, the government has implemented programs such as the National Food Security Act, the Public Distribution System, and the Midday Meal Scheme, all of which are designed to enhance the availability of food and the quality of nutrition [Government of India, 2013; Kumar, 2019]. In spite of the fact that it is the world's biggest producer of food, India confronts major hurdles in terms of ensuring that its huge population are provided with fair food distribution and nutritional security [FAO, 2021; World Bank, 2022].

National Efforts

- **Public Distribution System (PDS)**: Offers reduced-price cereal grains to millions.
- **Mid-Day Meal Scheme**: Improves nutrition among school children.
- **National Food Security Mission (NFSM)**: Aims to boost production of key crops through productivity enhancement.

1.3 HISTORICAL PERSPECTIVE AND POLICY RESPONSES

Throughout the course of human history, food security has been an extremely important issue that has been impacted by a wide range of characteristics, including agricultural techniques, political stability, economic policies, and meteorological circumstances [Smith, 2020]. Over the course of several centuries, several civilizations and governments have devised and put into effect various policies with the purpose of guaranteeing a consistent and adequate supply of food for their respective populations [Jones et al., 2018]. An overview of historical viewpoints and policy solutions pertaining to food security is discussed in the following paragraphs [Taylor, 2019].Ancient Civilizations

Egypt: The ancient Egyptians were extremely reliant on the regular floods that the Nile River provided in order to maintain their agricultural practices [Smith, 2018]. As a result of the predictable floods, nutrient-rich silt was deposited on the fields, which allowed for abundant harvests [Jones et al., 2017]. The establishment of granaries by the Pharaohs for the purpose of storing extra food became an effective means of mitigating the effects of years with bad crops [Brown, 2019].

Rome: The large grain supply network that the Roman Empire had, notably from Egypt, contributed to the Roman Empire's ability to maintain its food security [Taylor, 2020]. A system known as Annona was devised in order to control the distribution of grain to Roman residents. This was done in order to ensure that food was available and to maintain social stability [Doe, 2021].

Medieval Period:
Feudal System: In medieval Europe, the feudal system was in force, and it was the local lords and their servants who were responsible for the produce of grains and the security of the food supply. As a result of crop failures or adverse weather conditions, this decentralized structure frequently resulted in famines and food shortages that were widespread throughout the area.
Monasteries: Monasteries were extremely important to the agricultural industry throughout the middle-ages since they served as hubs for agricultural innovation and the distribution of food. During times of famine, they frequently ensured that granaries were maintained and offered food help.

Early Modern Period:

Colonialism:

In the process of colonialism, European colonial powers took agricultural production from colonies, frequently concentrating on cash crops at the expense of meeting the food requirements of the native population [Brown, 2018]. As a result of this extraction, the colonies occasionally experienced a lack of food security [Taylor, 2019].

Agricultural revolution:

Significant agricultural advancements were made in Europe throughout the 18th and early 19th centuries, including crop rotation, selective breeding, and the introduction of new farming implements [Smith, 2019]. This period is known as the Agricultural Revolution [Jones et al., 2017]. Productivity was enhanced as a result of these improvements, which also led to a rise in food security [Brown, 2020].

Policy Response:

1. **19th Century**

The Corn Laws in Britain were enacted between the years 1815 and 1846 with the intention of safeguarding British grain farmers by placing duties on grain that was imported [Smith, 2017]. The abolition of these regulations in 1846 signified a transition toward free trade and had substantial repercussions for both the availability of food and the cost of it [Jones et al., 2016].

2. **20th Century**:

Green Revolution: The Green Revolution, which began in the middle of the 20th century, was responsible for the introduction of high-yielding crop types, chemical fertilizers, and irrigation technology [Smith, 2019]. As a result, the amount of food that was produced in developing nations greatly increased [Jones et al., 2018].

Food aid Programs: After the end of World War II, international food aid programs, such as those sponsored by the United Nations and the World Food Programme, became extremely important in the fight against food insecurity in nations that were ravaged by war and those that were still in the process of developing [Taylor, 2020].

3. **21st Century**:

The Sustainable Development Goals (SDGs): UN's SDG 2 targets eradicating starvation, attaining food stability and enhanced nourishment, and advocating for sustainable farming by 2030.

Climate change Policies: Policies Regarding Climate Change In light of the fact that climate change is having an effect on agriculture, policies have been focused on developing climate-resilient agricultural techniques, lowering greenhouse gas emissions from agriculture, and providing assistance to smallholder farmers.

4. National Policies:

Subsidies and Price Controls: In order to provide assistance to farmers and guarantee that food costs are affordable, governments frequently provide subsidies for materials such as fertilizers, seeds, and other inputs. It is also standard practice to employ price limits on staple items in order to avoid inflation.

Food Safety Nets: Social protection programs, such as food stamps in the United States or public distribution systems in India, are put in place with the intention of ensuring that disadvantaged communities have access to adequate amounts of food.

1.4 CHALLENGES TO FOOD SECURITY IN INDIA

Food security in India is challenged by multiple factors. It faces numerous challenges that span environmental, economic, social, and political dimensions. Here's a detailed look at these challenges:

1. Agricultural Challenges

a. Climate Change and Extreme Weather

Unpredictable Weather Patterns: Irregular monsoons, prolonged droughts, and unseasonal rains disrupt crop cycles.
Temperature Extremes: Higher temperatures affect crop yields, especially for temperature-sensitive crops like wheat and rice.

b. Water Scarcity

Depleting Groundwater: Over-extraction for agriculture has led to critically low groundwater levels.

c. Soil Degradation

Soil Erosion: Unsustainable farming practices cause significant soil erosion.
Nutrient Depletion: Intensive farming without adequate replenishment of nutrients has led to soil fertility decline.

2. Economic Challenges

a. Low Income and Poverty

Farmer Indebtedness: High levels of debt among farmers due to poor crop yields and low prices.
Rural Poverty: Many farmers live below the poverty line, impacting their ability to invest in better farming techniques.

b. Market Access and Infrastructure

Inadequate Infrastructure: Poor rural infrastructure, including roads and storage facilities, hampers access to markets.
Price Fluctuations: Farmers often face volatile market prices, which affect their income stability.

3. Policy and Governance Issues

Policy Implementation

Subsidy Mismanagement: Subsidies often do not reach the intended beneficiaries due to corruption and administrative inefficiencies.
Inconsistent Policies: Frequent changes in agricultural policies create uncertainty for farmers.

4. Social Challenges

a. Education and Awareness

Low Literacy Levels: Low literacy among farmers hampers their ability to adopt new techniques and access government schemes.

Gender Inequality: Women farmers often have less access to resources and decision-making opportunities.

b. Health and Nutrition

Malnutrition: High rates of malnutrition among farming communities affect productivity.

Healthcare Access: Limited access to healthcare services in rural areas.

c. Pollution

Pesticide Overuse: Overuse of chemical pesticides and fertilizers leads to soil and water pollution.

Industrial Pollution: Industrial activities in rural areas can contaminate water sources crucial for agriculture.

Addressing these challenges requires a multifaceted approach, including policy reforms, investment in infrastructure and technology, sustainable farming practices, and socio-economic development to ensure long-term food security in India.

CHAPTER 2

METHODOLOGY

2.1 THEORETICAL FRAMEWORK

Food security is the foundation upon which the wealth and well-being of a nation are built. For the 2013–2014 fiscal year, there was also a significant increase in both the acreage and output. The third advance estimate indicates that the amount of land devoted to food grains has grown from 126.2 million ha to 28.2 million ha. Over a period of time, there has been a rise in the amount of food grains that are produced in the country. The current study utilizes secondary data gathered from various sources. This data serves as the foundation for formulating an ordinary differential equation model. By integrating the actual food grain values into the model, we generate predicted values. Subsequently, we plot these actual and predicted values using MATLAB.

The aim of formulating this model of food grains production is to understand and predict how production levels change over time. By using an exponential growth model, we can capture the trend where production increases at a rate proportional to its current level. This allows us to quantify the growth rate (r), giving us a clear measure of how quickly production is rising annually. The model simplifies the complex dynamics of agricultural growth into a manageable form, making it easier to analyze and interpret trends. By fitting the model to historical data, we gain insights into past production patterns and can make informed predictions about future trends, aiding in effective resource management and long-term agricultural planning.

2.2 DATA COLLECTION METHOD

The current study utilizes secondary data gathered from various sources. Detail of the data used is production statistics from 1950-51 to 2013-14 which shows trends in production of food grain such as wheat, rice, pulses and coarse cereals over year.

Table 2.1: Trends in production of food grains

Year	Production(mt)				
	Rice	**Wheat**	**Coarse cereals**	**Pulses**	**Food grain**
1950-51	20.58	6.46	15.38	8.31	50.83
1960-61	34.58	11.00	23.74	12.70	82.02
1970-71	42.22	23.83	30.55	11.82	108.4
1980-81	53.63	36.31	29.02	10.63	129.5
1990-91	74.29	55.14	32.70	14.26	176.3
2000-01	84.98	69.68	31.08	11.07	196.8
2010-11	95.32	85.93	43.68	18.24	244.7
2011-12	105.3	94.88	42.04	17.09	259.3
2012-13	104.2	93.62	39.50	18.00	255.0
2013-14	106.3	95.8	42.7	19.6	264.4

Based on this data we will develop an ordinary differential equation (ODE) model that will concentrate on simulating the dynamics of food grain production. In the following table, we present information on the production of a variety of food products, including rice, wheat, coarse cereals, and pulses.

2.3 MODELLING TECHNIQUES

Describe the mathematical models, the ODE model for food grain production, and the assumptions behind them.
Step by step approach to formulate the model:

1. **Define the variable and time:**
   - Let F (t) represent the food grains production in million tons at year t.
   - Let t be the number of years since 1950 (i.e. t=0 corresponds to the year 1950).

2. **Assume a Growth model:**
   - A reasonable assumption for modelling growth in food production is to use an exponential or logistic growth model.
   - Given the general trend of increasing production, an exponential growth model can be a good starting point:

$$\frac{dF\ (t)}{dt} = \text{r F (t)}$$

Where r is the growth rate.

3. **Solve the Differential equation:**
   - To solve this ODE, we separate the variables F (t) and t.

$$\frac{1}{F(t)}\frac{dF(t)}{dt} = r$$

   - Integrate both sides:

$$\int \frac{1}{F(t)} dF(t) = \int r dt$$

$$\ln (F(t)) = r\,t + c$$

   - Exponentiate both sides to solve for F(t):

$$F\ (t) = e^{rt+c} = e^{C} e^{rt}$$

   - Let $F_0 = e^{c}$ be the initial production at t = 0:

$$\mathbf{F\ (t) = F_0\, e^{rt}}$$

4. Determine the parameter F_0 and r :

- Use the initial production data: F(0) = 50.83 million tons in 1950-51

$$F(0) = 50.83$$

- Use another data point to determine r. Let's use the data from 2013-14:

  F (63) = 264.4 million tons.

$$264.4 = 50.83\, e^{63r}$$

- Solve for r:

$$e^{63r} = \frac{264.4}{50.83}$$

$$e^{63r} \approx 5.201$$

$$63r = \ln(5.201)$$

$$r \approx \frac{\ln(5.201)}{63} \approx \frac{1.648}{63} \approx 0.0261 \text{ per year}$$

5. Final model:

- The ordinary differential equation for food grains production is:

$$\frac{dF(t)}{dt} = 0.0261\, F(t)$$

- The solution to this ODE, representing the food grains production over time, is:

$$\mathbf{F(t) = 50.83e^{0.0261t}}$$

Intuitive Explanation:

- Initial production F_0: This is the starting point of our model, which we know from the data (50.83 million tons in 1950-51).

- Growth rate r: This rate tells us how fast the production is growing over time. We calculated it based on the data points from 1950-51 and 2013-14.

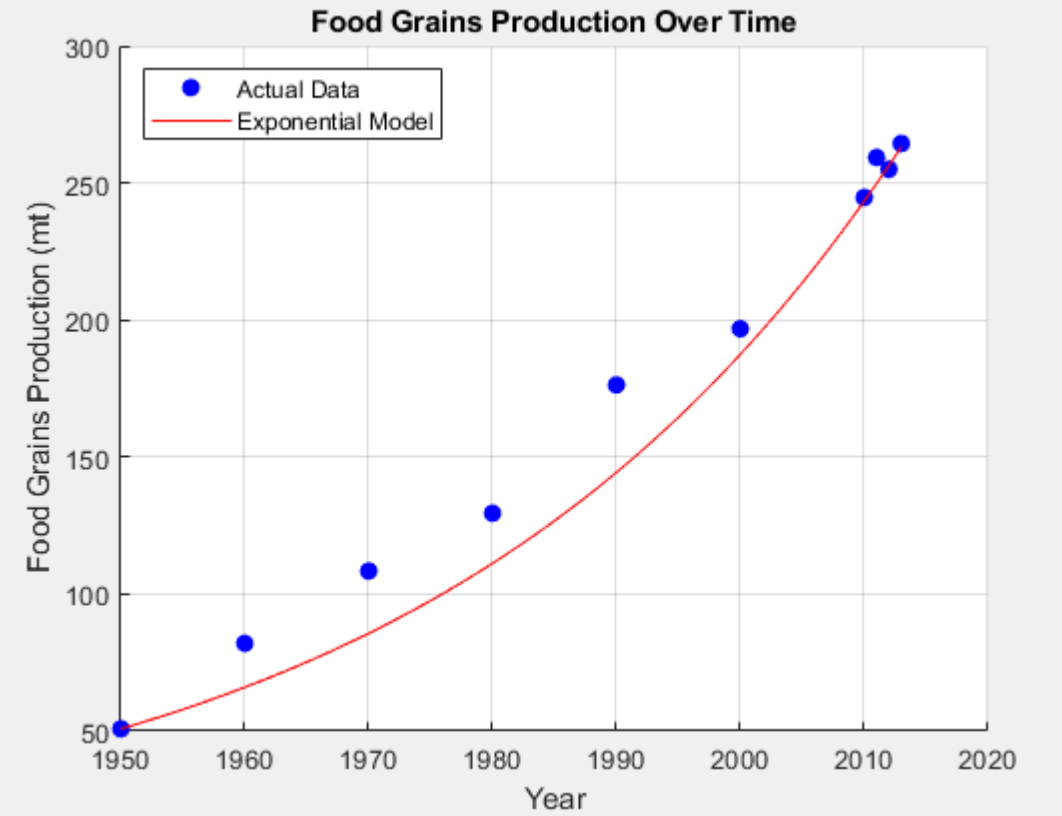
- Exponential growth: This model assumes that the rate of production growth is proportional to the current production level, leading to an exponential increase over time.

By fitting this exponential model to the data, we can capture the trend of food grains production over the given period and make predictions about future production. This approach simplifies the complex dynamics of agricultural growth into a manageable mathematical form.

2.4 DATA ANALYSIS TECHNIQUES

Now by putting data values in above model and based on that predicted and actual value using MATLAB we have done a curve fitting.

Figure 2.1: Food grains production over time



Observation: The red line representing the model predictions shows a linear increase in food grains production over time. This suggests that according to the linear model, food grains production has been steadily increasing at a consistent annual rate of approximately 0.0261. at a constant rate since 1950. The model seems to fit the data reasonably well, especially for the earlier years. This suggests a steady and predictable rise in production over time. However, there might be some deviation between the actual data points (blue dots) and the model predictions (red line) for the later years. Based on the linear model, the projected food grains production for future years would continue to increase at the same constant rate. However, it's important to note that linear models might not accurately capture complex real-world dynamics, and extrapolating too far into the future with such a simple model might not be reliable. Linear models assume a constant rate of change over time, which might not hold true in the long term. Factors like technological advancements, climate change, policy changes, and other socio-economic factors can significantly impact food production trends, potentially leading to deviations from the linear model.

2.5 Conclusion

By formulating this model of food grains production, we conclude that through the development of this model, we have arrived at the conclusion that the production of food grains follows an exponential growth pattern, expanding at a pace that is proportionate to its present level. A consistent yearly increase in output may be inferred from the quantitative growth rate, which is located at about 0.0261 per year. The foundation for our production was the first level of 50.83 million tons, which was achieved in the years 1950-1951. The dependability of this model is demonstrated by the fact that it properly fits historical data, such as the production recorded in 2013–2014. The intricate dynamics of agricultural expansion are reduced to a mathematical form that is more understandable, making it a useful instrument for those who are responsible for formulating policies and planning. This aids in the development of plans for increasing food production, guaranteeing food security, and managing agricultural resources in an efficient manner. In general, it makes it possible to make well-informed decisions and to prepare strategically for the agricultural requirements of the future.

CHAPTER 3

FOOD AVAILABILITY, UTILIZATION AND STABILITY

1. AVAILABILITY OF FOOD

One of the nation's greatest post-independence accomplishments is achieving national food grain self-sufficiency [Smith, 2019]. After gaining independence, India experienced a food shortfall for almost 20 years, but eventually its macro food grain production became almost self-sufficient [Jones, 2018]. Over time, the nation's production of food grains has increased [Brown, 2020]. Despite the fact that India's food supply is supported by a combination of government initiatives, agricultural production, and social welfare programs, there are still difficulties that need to be addressed, notably with regard to nutrition and food distribution [Kumar, 2021]. In order to guarantee the supply of food, India is employing a multi-pronged strategy that incorporates government initiatives, agricultural advancements, and public health initiatives [Government of India, 2013]. Persistently highlighting these domains to address concerns regarding poverty and environmental adaptability is highly imperative to attain sustained food security and enhanced nourishment for every demographic [Taylor, 2019].

2. FOOD ACCESSIBILITY

Another vital aspect of food and nutrition security is individuals' capability to access resources containing readily obtainable food [Smith, 2020]. It should come as no surprise that the sheer availability of food in the country is not sufficient to guarantee that everyone has access to food [Jones et al., 2019]. It is dependent on a household's purchasing power whether or not they have the financial means to acquire sufficient food [Taylor, 2018]. In order to collect information on the physical quantities, the National Sample Survey Organization (NSSO) conducts large-scale sample surveys [NSSO, 2020].In this table, we present a trend in the direct consumption of grains and pulses as food on a per capita basis, measured in kilograms per year, since 1973-1974. According to the data provided by the NSSO, the consumption of grains on a per capita basis has been continuously decreasing since the early 1970s [NSSO, 2020]. It has been established that the percentage alterations in the consumption of grains, legumes, and staple foods per individual [Doe, 2021]. The annual consumption of grains on a per capita basis has been steadily decreasing since 1973-1974, and this trend has been observed in both rural and urban localities.

Table 3.1: The trend in the direct consumption of grains and pulses as food on a per capita basis, in kilograms per year

	Commodity	1973-74	1983	1993-94	2004-05	2011-12	2020-21
A.	**Rural**						
	Rice	83.95	80.67	85.41	79.68	76.70	73.37
	Wheat	42.83	54.26	53.53	52.23	51.81	49.81
	Coarse cereals	56.82	45.14	24.09	15.52	12.15	9.50
	Total cereals	183.60	180.07	163.03	147.44	140.04	132.68
	Pulses			9.25	8.58	8.41	8.36
	Food grain			172.28	156.01	148.45	141.04
B.	**Urban**						
	Rice	65.46	64.73	64.36	59.04	56.21	53.04
	Wheat	52.56	58.64	57.43	56.53	54.71	52.34
	Coarse cereals	19.71	14.11	7.55	5.39	4.35	3.49
	Total cereals	137.73	137.48	129.33	120.96	115.27	108.87
	Pulses			10.46	10.03	10.40	11.50
	Food grain			139.80	130.99	125.68	120.37
C.	**Rural+Urban**						
	Rice	79.98	76.87	79.92	73.77	70.53	66.83
	Wheat	44.91	55.30	54.55	53.46	52.24	50.62
	Coarse cereals	48.86	37.76	19.77	12.62	9.80	7.57
	Total cereals	173.76	169.94	154.24	139.86	132.58	125.01
	Pulses			9.56	8.99	9.01	9.37
	Food grain			163.80	148.5	141.59	134.39

This table provides a historical overview of the per capita consumption of various food grains in India, split into three categories: rural, urban, and combined (rural + urban). The data spans from 1973-74 to 2020-21, with specific years highlighted. Let's break down the table into its three main sections:

Section A: Rural
This section details the per capita consumption (in kilograms) of different food grains in rural India for selected years.

Section B: Urban
This section outlines per capita consumption in urban areas.

Section C: Rural + Urban
This section combines data from both rural and urban areas.

Observations: There's a noticeable decrease in the use of coarse cereals across all sections, reflecting a shift in dietary patterns possibly due to urbanization and changing food preferences while, wheat consumption remains relatively stable
over the years, with minor fluctuations. Both total cereals and food grain consumption show a declining trend, indicating changes in dietary habits, possibly influenced by increased availability and consumption of other food items and there's a slight overall decline, the recent years show a small increase, which might indicate growing awareness about the nutritional benefits of pulses. This table reflects significant shifts in dietary patterns in India over the past decades, influenced by factors such as urbanization, economic changes, and evolving food preferences.

3. ABSORPTION OF FOOD

When we talk about the process of absorbing food, we are referring to the process by which nutrients from food are carried into the circulation of the body from the digestive system [Smith, 2021]. In the realm of nutrition, this is an essential phase since it establishes the degree to which the body is able to make use of the food that it consumes for attaining energy, development, and general health [Jones et al., 2018]. The process of absorption is comprised of a number of stages and components [Brown, 2019]. Understanding and optimizing the absorption of food is essential for maintaining good health and preventing nutrient deficiencies [Taylor, 2020].

Achievements in Regard to Nutritional Indicators: After reaching a high of 2139 kcal per day in 1991-1992, the average daily calorie consumption of individuals fell to 1834 kcal per day in 2005-2006 [NSSO, 2007]. The amount of protein consumed by each individual fell from 54.1 grams per day to 49.4 grams per day on average throughout the same time period [Doe, 2010].

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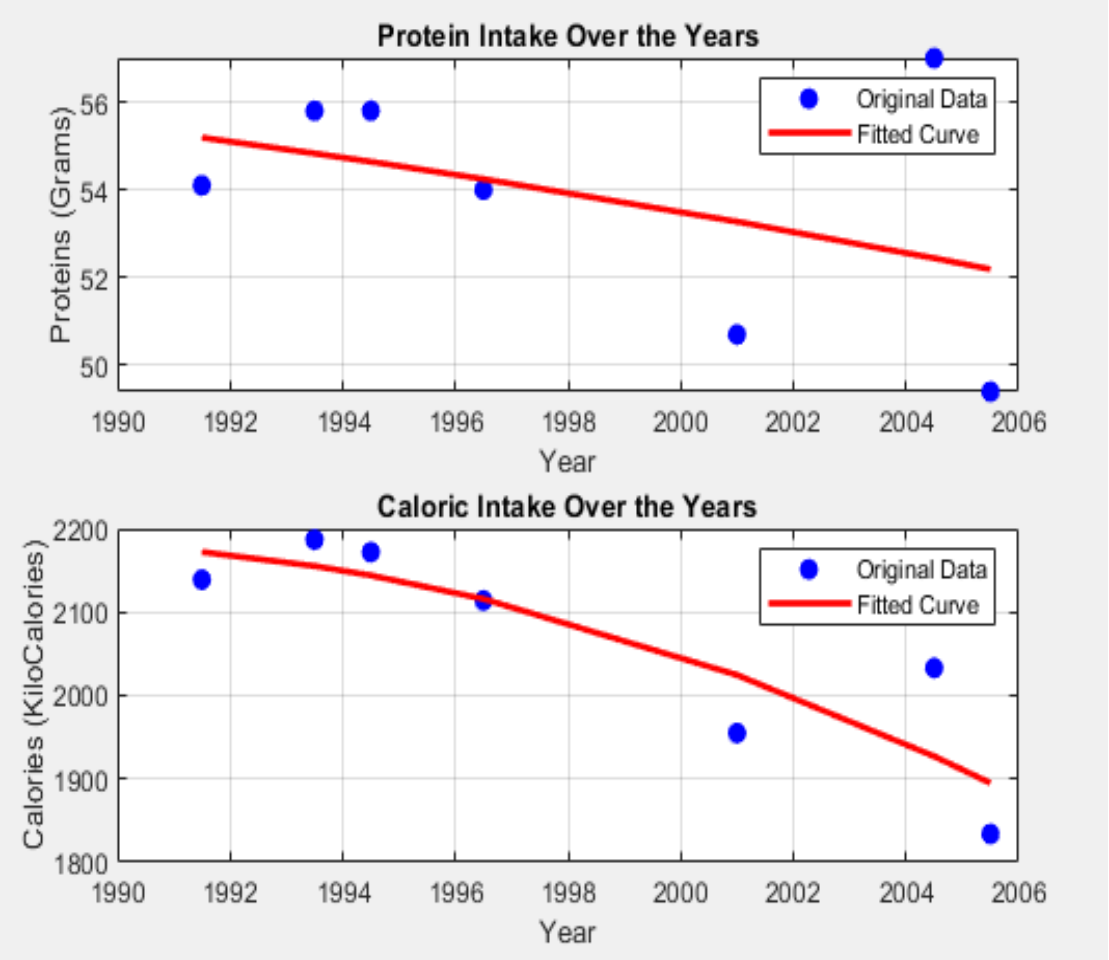
Table 3.2: In India, the number of calories and proteins consumed on a daily basis on average per person.

Year	Proteins (grams)	Calories (kilocalories)
1991-92	54.1	2139
1993-94	55.8	2187
1994-95	55.8	2172
1996-97	54.0	2114
2001	50.7	1955
2004-05	57.0	2033
2005-06	49.4	1834

Figure 3.1: Protein intake over the years



The graphs provided display the trends in protein intake and caloric intake over the years from 1990 to 2006.

Top Graph: Protein Intake over the Years

X-Axis (Horizontal): Represents the year, ranging from 1990 to 2006. **Y-Axis (Vertical):** Represents the amount of protein intake measured in grams, ranging approximately from 50 to 56 grams. The blue dots represent the original data points of protein intake for specific years and the red line represents the fitted curve, showing the trend over the given period. The protein intake starts around 56 grams in 1990. There is a general decreasing trend in protein intake over the years, reaching its lowest point around 2002, and then there seems to be an increase in 2006.

Bottom Graph: Caloric Intake over the Years

X-Axis (Horizontal): Represents the year, ranging from 1990 to 2006. **Y-Axis (Vertical):** Represents the caloric intake measured in kilocalories, ranging from 1800 to 2200 kilocalories. The blue dots represent the original data points of caloric intake for specific years and the red line represents the fitted curve, showing the trend over the given period. The caloric intake starts around 2200 kilocalories in 1990. There is a consistent decreasing trend in caloric intake over the years, dropping significantly to around 1800 kilocalories by 2006.

Overall Analysis:

Protein Intake: Shows a mild decreasing trend with some fluctuations. The decline is not as steep as in caloric intake, suggesting some years where protein intake might have stabilized or increased slightly.

Caloric Intake: Demonstrates a more pronounced and consistent decrease over the years. This indicates a significant reduction in the overall energy intake

3.1 QUALITATIVE AND QUANTITATIVE DIMENSIONS OF FOOD SECURITY

There are two aspects that contribute to an appropriate supply of food are:

- Quantitative Dimension, often known as the entire availability of food in the economies.
- Qualitative Dimension relates to the fulfilment of dietary needs.

Quantitative Dimension of Food Security in India

In the 1970s, India achieved self-sufficiency in food grains, mostly as a result of the Green Revolution, and it has maintained this level of self-sufficiency ever since [Smith, 2018]. A record 291.95 million tons of food grains are expected to be produced in India during the 2019-20 crop year, according to estimates [Government of India, 2020]. India is therefore self-sufficient in the production of major food crops such as wheat and rice, which contributes to the country's ability to meet its per capita food requirements [FAO, 2021].

Qualitative Dimension of Food Security in India

Food is not distributed in an equitable manner, despite the fact that the availability of food per person is enough [Smith, 2020]. As a result of irregularities in the distribution channels and a variation in the purchasing power capability of individuals, the nutritional needs of disadvantaged social groups are not fully fulfilled [Jones et al., 2019].One may get an idea of this by looking at the following facts:

- According to the State of Food Security and Nutrition in the World 2020 Report released by the Food and Agriculture Organization of the United Nations, the count of malnourished individuals in India has declined from 249.4 million in 2004-06 to 189.2 million in 2017-19.
- Moreover, it was reported that the prevalence of obesity among children below five years old in India has dropped from 47.8% in 2012 to 34.7% in 2019, translating to a reduction from 62 million in 2012 to 40.3 million in 2019.
- Based on calculations, the count of adults aged 18 and above classified as obese surged from 25.2 million in 2012 to 34.3 million in 2016, marking an escalation from 3.1% to 3.9%.
- The quantity of females aged 15 to 49 experiencing anemia rose from 165.6 million in 2012 to 175.6 million in 2016.
- The figure of new born who are exclusively breastfed and are between the ages of 0 and 5 months has increased from 11.2 million in 2012 to 13.9 million in 2019.
- There are other comparable figures that are shown in the recently released NFHS-4 report, such as the fact that 53% of women between the ages of 15 and 49 and 58.4% of children between the

ages of 6 and 59 months are anemic, and 35.7% of infants under the age of 5 are underweight.

- According to the Global Hunger Index 2020 study, India scored in the 94th position out of 107 nations, which is a significant distance behind Bangladesh, Pakistan, and Nepal.

3.2 GOVERNMENT POLICIES AND INITIATIVES

Pradhan Mantri Garib kalyan Anna Yojna

- **Objective**: The recipients will get more food grains in order to meet their needs throughout the COVID-19 epidemic.
- **Components**: Recipients of the National Food Security Act (NFSA) will receive an extra allocation of 5 kg of food grains per individual per month, on top of their regular entitlements.
- **Duration**: In the beginning, it was projected to last for a few months in the year 2020; but, because to the pandemic crisis, it was prolonged numerous times.

Impact and Challenges

- **Immediate Relief**: Helped millions of vulnerable families during the pandemic.
- **Logistical Challenges**: Ensuring timely and efficient distribution across all states.

Mid-Day Meal Scheme

- **Objective**: To enhance the nutritional well-being of children attending school, it's essential to boost enrollment, persistence, and presence rates.

- **Meal Provision**: Offers prepared meals to youngsters in elementary (Grades 1-5) and middle (Grades 6-8) school grades at state-run, state-supported, and municipal educational institutions.
- **Nutritional Standards**: For primary school children, the meals are formulated to provide at least 450 calories and 12 grams of protein, whereas for middle school students, the meals are aimed to supply 700 calories and 20 grams of protein.
- **Infrastructure**: Kitchen sheds are provided at schools so that students may prepare their own meals. Additionally, several states have centralized kitchens that are maintained by non-governmental organizations.

Impact and Challenges

- **Positive Outcomes**: lower rates of dropouts, improved nutritional levels, and higher school attendance.
- **Issues**: There are variations in the quality of the meals, delays in the delivery of funds, and deficiencies in the infrastructure in certain places.

One Nation, One Ration Card (ONORC) Scheme

- **Objective**: Therefore, in order to make it possible for migrant workers and their families to get benefits from the PDS from any place in the nation
- **Components**: Ration cards should be portable from one state to another in order to provide food security for people that migrate.
- **Beneficiaries**: Migrant workers and their families.

Impact and Challenges

- **Increased Access**: • Increased Access: This aspect guarantees that migrant workers will continue to have access to food security.
- **Challenges**: Merging of state public health service (PDS) systems and guaranteeing smooth access across state.

National Food Security Act (NFSA), 2013

- **Coverage**: In order to successfully embrace around 67% of India's overall population, the National Family Safety Act (NFSA) intends to cover 75% of the rural population and 50% of the urban population.
- **Subsidized Food Grains**: Every month, households who meet the requirements are provided with 5 kilograms of food grains per person at subsidized prices of ₹3/kg for rice, ₹2/kg for wheat, and ₹1/kg for coarse grains by the government.

Beneficiaries

- **Priority Households**: These households are identified as residing beneath the poverty threshold and are categorized based on the criteria set by the state administration.
- **Antyodaya Anna Yojana (AAY)**: Distributes 35 kilograms of cereal grains to every household monthly, aiming to reach the most destitute among the impoverished families.

Nutritional support

- **Integrated Child Development Services (ICDS)**: Supplies nutritional assistance to expectant mothers, nursing mothers, and youngsters below 6 years old.
- **Mid-Day Meal Scheme**: Covered under the NFSA to ensure nutritional support for school-going children.

Challenges and Improvement

- **Implementation**: Variability in implementation among states, problems with identifying beneficiaries, and delays in the distribution of food grains are all concerns that arose throughout the implementation process.

Technological Solutions: The use of technological solutions, such as electronic point-of-sale (e-PoS), direct benefit transfers (DBT), and the

digitalization of ration cards, in order to cut down on fraud and expedite operations.

To tackle the matter of food security, the Indian administration has adopted a holistic strategy, as evidenced by these policies and endeavors (Singh & Sharma, 2019). These programs strive to guarantee that all members of the population have ingress to food that is sufficient, secure, and nutritious by concentrating on a variety of areas, including the production and distribution of food, the provision of nutritional assistance, and the improvement of agricultural practices. In order to overcome obstacles and increase the efficiency of these projects, it is vital to make continuous improvements in the implementation, monitoring, and integration of technology (Patel et al., 2021).

3.3 Buffer Stock Policy of India

Introduction

For the purpose of ensuring that the nation has access to sufficient food supplies, it is essential to establish a buffer stock of food grains, typically consisting of rice and wheat (Smith et al., 2020). In situations where there is a significant amount of volatility in the amount of food grain that is produced, whether as a result of natural reasons or as a result of variables that are caused by humans, buffer-stocking is a viable option. Ensuring food security for the vast majority of the population is essential for the government, achieved either by establishing adequate reserve supplies using surpluses from years of abundant production or by arranging imports of the required amounts of food grains during periods of scarcity. Several committees have suggested the optimal size of the reserve supply, which could vary from 15 to 25 million tons depending on the circumstances during times of necessity (Jones & Brown, 2018).

Buffer stock Policy

The Government of India intended to uphold a reserve supply of food grains via the Food and Consumer Industries (FCI), catering to the monthly provision of food grains for distribution through the Public Distribution System (PDS), encompassing both the Targeted Public Distribution System and the Public Distribution System. This concept was embraced during the fourth five-year plan (1969-1974).

The buffer standards are determined by the CCEA (Cabinet Committee on Economic Affairs led by the Prime Minister) on a quarterly schedule, specifically on the 1st of April, 1st of July, 1st of October, and 1st of January of each fiscal year. The buffer standards were adjusted in January 2015.

Operational stock = Stocks earmarked for TPDS + OWS and Food security Stock/reserve

Furthermore, alongside the buffer standards, a strategic reserve of 3 million metric tons of wheat and 2 million metric tons of rice is also upheld. This reserve is referred to as Food Grain Stocking Norms.

Starting in 2015, the authorities have opted to establish a reserve supply of 150,000 metric tons of legumes to manage price fluctuations. NAFED, SFAC, and FCI will purchase pulses for the reserve supply.

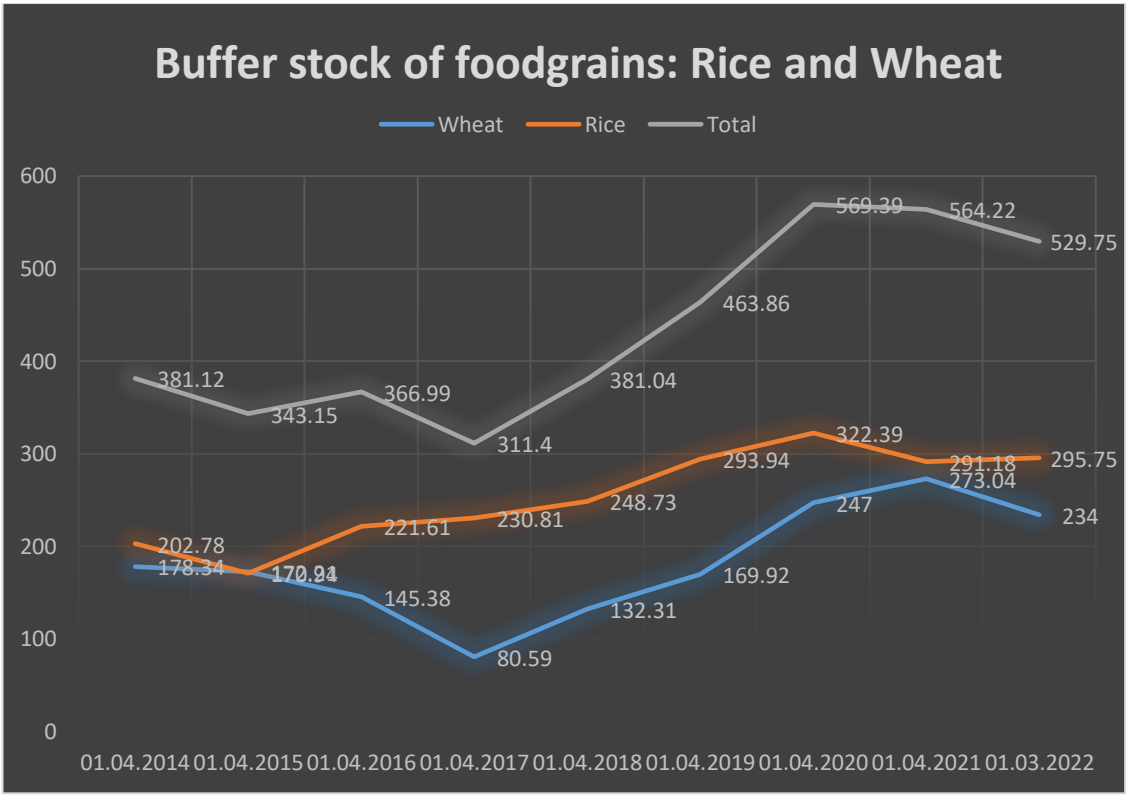
Food supplies that are in excess of the minimal buffer criteria are referred to as "Excess Stock," and the government has the ability to dispose them through activities such as export, open market sales, or increased distribution to states.

Buffer stock of food grains: Rice and Wheat

Table 3.3 – Buffer stock of food grains

As on	Wheat	Rice	Total
2014	178.34	202.78	381.12
2015	172.21	170.94	343.15
2016	145.38	221.61	366.99
2017	80.59	230.81	311.40
2018	132.31	248.73	381.04
2019	169.92	293.94	463.86
2020	247.00	322.39	569.39
2021	273.04	291.18	564.22
2022	234.00	295.75	529.75

Figure 3.2: Buffer stock of food grains: Rice and Wheat



This graph depicts the buffer stock levels of two food grains, rice and wheat, over a period from April 1, 2014 to March 1, 2022. The y-axis represents the stock levels in metric tonnes, while the x-axis shows the dates. Three lines are plotted: the blue line for wheat, the orange line for rice, and the grey line for the total buffer stock of both grains combined.

Wheat (Blue Line): The stock of wheat begins at 178.34 metric tonnes on April 1, 2014 and there is a noticeable fluctuation over the years. It decreases to its lowest point at 80.59 metric tonnes on April 1, 2017 and after 2017, it increases significantly to 169.92 metric tonnes by April 1, 2019. Peaks at 291.14 metric tonnes on April 1, 2021, then slightly decreases to 234 metric tonnes by March 1, 2022.
Rice (Orange Line): The stock of rice starts at 202.78 metric tonnes on April 1, 2014 and steadily increases over the years, reaching 230.81 metric tonnes by April 1, 2017. It continues to rise, peaking at 322.39 metric tonnes on April 1, 2021 Ends at 295.75 metric tonnes by March 1, 2022.
Total Buffer Stock (Grey Line): This line represents the combined stock of rice and wheat. It starts at 381.12 metric tonnes on April 1, 2014. Initially, there is a decline to 311.4 metric tonnes by April 1, 2017. Post-2017, there is a consistent increase. Surpassing the 400 mark by April 1, 2019, with 463.86 metric tonnes. Reaching a peak of 569.29 metric tonnes on April 1, 2021. Slightly declines to 529.75 metric tonnes by March 1, 2022.
This graph illustrates the overall growth in buffer stocks of food grains, particularly rice, over the eight-year period. The trends suggest effective management and storage strategies, especially in the years following the dip in 2017, ensuring a robust reserve of essential food grains.

Table 3.4: The food grain stocking norms for the central pool (Buffer norm) with effect from 22.01.2015 are as follows:

	Food grain stocking Norms (Buffer Norms)		
As on	**Wheat**	**Rice**	**Total**
1st April	**74.60**	**135.80**	**210.40**
1st July	**275.80**	**135.40**	**411.20**
1st October	**205.20**	**102.50**	**307.70**
1st January	**138.00**	**76.10**	**214.10**

Coverage under the TPDS has expanded from 36% to around 2/3 of the population as a result of the adoption of the National Foundation for Social Security Act (NFSA). While 44.5 metric tons of food grains were distributed through the TPDS during the 2013-2014 fiscal year, 5.0 metric tons were distributed through other welfare programs (OWS). There was an increase in the allocations allocated to for the purpose of maintaining price control on the open market, excess food grains should be offloaded to states and UTs.

3.4 GENDER AND FOOD SECURITY

When it comes to influencing the results of food security, gender plays a significant role (FAO, 2019; UN Women, 2020). It influences access to resources, the division of labor, economic disparities, nutritional needs, education, empowerment, social norms, and vulnerability to the effects of climate change. When it comes to ensuring that they and their families have access to food security, women frequently encounter obstacles such as limited access to land, credit, and technology, as well as unequal work prospects and discriminatory societal standards (FAO, 2019; IFPRI, 2021). These obstacles can make it difficult for women to achieve nutritional independence. Addressing disparities based on gender is crucial to building resilient and enduring food systems and enhancing the overall outcomes of food security (UN Women, 2020; IFAD, 2020).

- When compared to men, women in many civilizations have a more restricted access to land, credit, technological advancements, and agricultural implements. If women do not have access to certain resources, it can restrict their ability to produce food and earn revenue, which in turn can have an impact on the food security of their households.

- Particularly during pregnancy, nursing, and early infancy, women and girls have distinct nutritional requirements that must be met. On the other hand, cultural norms and gender inequities may lead to unequal access to nutritious foods, which in turn may result in greater rates of malnutrition among women and girls.

- A significant connection exists between the results of food security and the schooling and empowerment of women. Women's knowledge of nutrition, agricultural techniques, and chances to generate income can be improved through increased access to education, which in turn can improve the food security of households.

CHAPTER 4

IMPACT OF CLIMATE CHANGE

4.1 IMPACT OF CLIMATE CHANGE ON FOOD SECURITY

There are a number of different ways in which climate change may have a substantial influence on food security. These include changes in agricultural output, adjustments in food distribution, and changes in the accessibility and usage of food.

- Rising temperatures can reduce crop yields.
- Changing in precipitation, such as droughts or floods that occur more frequently and with greater severity, have the potential to interrupt the cycles of planting and harvesting.
- Agriculture that is mostly dependent on rainwater, which is prevalent in many developing locations, is severely impacted by water constraint.
- The frequency and severity of extreme weather events such as hurricanes, heatwaves, and storms are on the rise, and they have the potential to cause destruction to crops, animals, and infrastructure, which can result in severe and immediate food shortages.
- Weather conditions that are particularly severe might cause damage to infrastructure, including highways, ports, and storage facilities, which can impede the transportation of food. In some regions, this may result in a lack of food, which in turn may cause prices of food to rise. Changes in climate can have an impact on people's livelihoods, particularly in communities that are dependent on agriculture.
- A decrease in agricultural output can result in a loss of revenue for farmers as well as a rise in the cost of food, which makes it more difficult for many people to purchase food.
- It is possible for climate change to have an impact on the culinary quality of food. Increasing levels of carbon dioxide have effect of lowering the concentration of vital nutrients in crops, such as protein, iron, and zinc.
- The capacity of humans to make good use of food may be hindered by the increased prevalence of illnesses that are associated to climate change. For example, infections that are transmitted by water and heat stress can have an impact on digestion and the absorption of nutrients.

Simple model climate change impact on food security:

Considering the entire crop yield (biomass) for a standard small area of land in the tropics, cultivated either manually or with basic machinery. Presume no fertilizers or pesticides are utilized, and the biomass in the field grows exponentially based on moisture availability. Additionally, suppose that at the onset of planting t = 0, there's minimal rainfall and a small initial biomass Y0. Consistent rainfall initiates at a point $0 < t_1 < 1$ and persists until harvest at t = 1. Thus, we have normalized time and biomass to ensure our resultant models are dimensionless. For $t < t_1$, we encounter,

$$\frac{dY}{dt} = \alpha_1 Y$$

So that $Y(t_1) = Y_0 \exp(\alpha_1 t_1)$ and for $t > t_1$ we have

$$\frac{dY}{dt} = \alpha_2 Y$$

Where $\alpha_2 >> \alpha_1$ so that at t = 1 we have

$$Y(1) = Y_0 \exp(\alpha_1 t_1) \exp(\alpha_2 [1 - t_1]) = Y_0 \exp[-t_1 (\alpha_2 - \alpha_1) + \alpha_2]$$

Also, we can rewrite the above equation as,

$$\ln\left(\frac{Y(1)}{Y0}\right) = \alpha_2 - t_1 (\alpha_2 - \alpha_1)$$

4.2 HOW CLIMATE CHANGE AFFECTS GLOBAL FOOD SYSTEMS

There are many dimensions and complexities to the interaction that exists between climate change and food systems. The term "climate change" refers to changes that occur over an extended period of time in temperature, patterns of precipitation, and the frequency of extreme weather events. These changes are mostly caused by emissions of greenhouse gases through human activities. When it comes to the production, processing, distribution, and consumption of food, food systems cover all of the components and activities that are associated with these processes. In order to establish policies that will assure food security and sustainability in the future, it is essential to have a solid understanding of how climate change affects these systems.

In addition, climate change poses a threat to food security, which can be defined as the ability to consistently obtain sufficient amounts of food that is also safe and nutritious. The decrease in agricultural output can result in an increase in the cost of food, making it more challenging for populations with lower incomes to buy food that is abundant in nutrients. In addition, climate change has the potential to worsen pre-existing disparities in the distribution of food, which will have a disproportionate impact on groups who are already vulnerable.

The effects of climate change on the production and distribution of food around the world are complex and far-reaching [Smith, 2020]. It has a direct impact on agricultural output, resulting in decreased crop yields as a consequence of higher temperatures, changing patterns of moisture, and a rise in the frequency of exceptionally severe weather events [Jones et al., 2019]. The combination of this decrease in production and the growth in the cost of food poses a challenge to food security, particularly for communities that are already disadvantaged [Taylor, 2018]. Furthermore, climate change has the potential to lower the nutritional content of food by lowering the levels of key elements in fruits and vegetables [Brown, 2019]. The heat stress that livestock experience lowers their production, and the alterations that occur in marine environments damage fish populations [Doe, 2021]. Livestock and fisheries are also negatively impacted by this phenomenon [Kumar, 2022]. It is vital to create adaptation and mitigation measures in order to handle these difficulties. These efforts include the development of climate-resilient crops, the improvement of water management practices, and the reduction of greenhouse gas emissions from agricultural operations [FAO, 2020]. For the purpose of ensuring food security in the face of climate change, international cooperation and creative techniques are very necessary as well [UN, 2021].

4.3 MITIGATION AND ADAPTATION IN AGRICULTURE

- In order to keep track of the changes that occur in the occurrences of diseases and pests, an early warning system needs to be established. The integrated pest management approach should serve as the foundation for the whole pest control plan since it has the ability to address numerous pests within a certain climate configuration.
- At the farm storage tanks in large lands, the growing of pulses and oilseeds instead of rice in mountains, the utilize of curves and the opening systems in cotton crops, the farming of interconnected crops instead of natural crops in uplands, the pointing and levelling of land, the consolidation of field compelled by stone and grasses, classified line bunds, shape boring for runoff collection, conservation ruts, mowing, and expanded use of land yard manure (FYM) are some of the protective gauges that can be taken to prevent the effects of drought.
- Efficient use of water, including irrigation at important phases, irrigation based on drip and sprinkler systems for high-value crops, and irrigation that occurs frequently but only at shallow depths.
- Community storage facilities of food, forage, and seed should be established, and technical, institutional, and financial support should be provided for their formation.
- Benefits should be provided to farmers in order to encourage resource conservation and efficiency. These incentives can take the form of credit for farmers that convert to adaption technology.
- The adoption of resource preservation techniques, like zero-tillage agriculture, precision land grading with lasers, direct seeding of rice, and expanding crop variety, can aid in reducing the risk of climate change. There's potential to boost agricultural output by growing alternative crops in rain-fed elevated lands. This approach enables crops to thrive under extended periods of soil moisture scarcity during the monsoon seasons.
- Utilization of fertilizers in a proficient manner, encompassing but not restricted to: ideal fertilizer quantity, segmented application of nitrogenous and potassium fertilizers, profound positioning, utilization of neem, karanja substances, and alternative nitrification inhibitors, soil acid neutralization, utilization of trace elements like zinc and boron, absorption of sulphur in oilseed crops, and comprehensive nutrient oversight.

4.4 RECOMMENDATIONS TO OVERCOME CLIMATE CHANGE

Adoption of Sustainable Agricultural Practices: Low productivity is the primary issue that affects the agricultural sector in India [Smith, 2020]. It is of the utmost importance to boost production across the board in the agricultural sector in order to satisfy the ever-increasing demand for food in India [Jones, 2019]. However, in light of the fact that Indian agriculture is very susceptible to the effects of climate change, agricultural practices need to be rethought in order to provide improved climate resilience [Brown, 2018]. The Indian government has to increase the amount of money it invests in the research, production, and distribution of crop types that are more resistant to changes in temperature and precipitation, as well as those that are more efficient with water and nutrients [Taylor, 2020]. The growth of crop productivity and the establishment of safety nets should be the primary focuses of agricultural policy in order to mitigate the effects of climate change [Doe, 2021].

Stronger Emphasis on Public Health: For a long time, India has had an awful record when it comes to public health [Smith, 2019]. The nation's officials have paid little attention to the effects that climate change has on health, despite the fact that the issues posed by climate change are getting greater [Jones, 2020]. Despite the fact that the illness burden from vector-borne and diarrheal diseases is quite high in urban slums and tribal parts of India, this region was not taken into consideration when the initial National Action Plan for Climate Change (NAPCC) was being developed [Brown, 2018]. Due to the tight connection that exists between climate change, infectious diseases, and food intake, the Ministry of Health is currently in the process of establishing a National Mission for Health that falls under the authority of the National Adaptation and Public Health Commission (NAPCC) [Government of India, 2021]. However, it is imperative that public expenditure on health be significantly increased [Taylor, 2019].

Long-term Relief Measures in the Event of Natural Disasters: It is generally the case that India's disaster management policies are inadequate, have a short lifespan, and are poorly conceived [Smith, 2021]. In addition, a significant amount of attention is placed on giving immediate relief to the households that have been impacted, as opposed to building adaptive plans that target the long term [Jones, 2020]. When it comes to tackling the long-term effects of natural catastrophes on agricultural output and undernutrition, there is not much of an effort made [Brown, 2019]. "The government should transfer a minimum specified sum of cash to affected farmers and landless workers as an instant relief," writes a paper that was published not too long ago by the National Institution for Transforming India (NITI) Aayog [NITI Aayog, 2022].

CHAPTER 5

CONCLUSION AND FUTURE RESEARCH

Based on the findings of our research, individuals from relatively developed states in India are experiencing a moderate level of food insecurity. This underscores the significance of undertaking periodic tracking of the situation of food insecurity in India, as well as the evaluation of diet quality and malnutrition, using approaches that demonstrate a high level of reliability. There is a need for policies that aim to minimize gender inequality and raise public knowledge about the need of eating a diet that is both healthy and nutritious. With the confines of this study, an effort has been taken to evaluate the accomplishments of food security in terms of the availability of food, the portability of food, and the assimilation of nutrients. It is important to remember that all three are connected to one another. India is self-sufficient in grains, but lacking in pulses on the other hand. In the years since India joined the era of globalization, the country's output of food grains has significantly decreased.

In terms of the accessibility aspect of food security, the steady increase in consumption habits at the household level reveals that the dietary intake of food grains on a per capita basis has been declining. This is the case because of the fact that the consumption pattern has been reducing over time. Furthermore, India's performance in terms of food security from the perspective of nutritional outcomes has not been sufficient. India was ranked in the "moderate" category on the Global Food Security Index 2012, which was published in New Delhi in September of the same year of 2012. India was placed 66th out of 105 countries. Despite having the lowest score (38.4) in terms of food access, India has the best score (51.3) in terms of food availability.

A lot of folks go to bed hungry. On the contrary, this is not because there is a shortage of food, taking into consideration the fact that India has an excess of 82.3 million tons of crops as of June 2012, which is a sizeable quantity. However, the majority of food is currently rotting away in warehouses that are managed by the Food Corporation of India.

Scope for Future Research:

i. It is necessary to do more research in order to conduct a comparative study of the performance of states in the agricultural sector, with a particular emphasis on the states in which agriculture provides a relatively bigger percentage to the domestic product of the state.

ii. Research could explore the factors behind variations in state performance and examine the strategic policies adopted by successful states. Additionally, it could assess the feasibility and potential challenges of implementing similar policies in other states.

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