

Geospatial Evaluation of Targeted Public Distribution System in India

Submitted in partial fulfilment of the requirements
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By

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Dedication

I declare that this written submission represents my ideas in my own words, and where other's ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any ideas, data, facts, or sources in my submission. I understand that any violation of the above will be the cause of disciplinary action by the institute and evoke penal action from the sources which have thus not been appropriately cited or from whom proper permission has not been taken when needed.

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Dissertation Approval

This is to certify that the M. Tech. Dissertation report titled “**Geospatial Evaluation of Targeted Public Distribution System in India**” by **Vishnu Jayan** (*Error! Reference source not found.*) is approved for the degree of **M. Tech. in Technology and Development**.

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Declaration

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Place:

Abstract

Food security is a major health concern affecting whole nations. Different international agencies like FAO, UN, and World Bank continuously study food security and work towards ensuring food security across the globe. The studies showed that the production of food is enough to feed the entire population, but the actual problem lies in food distribution. Due to the ineffective distribution system, millions of people facing hunger. Different governments started programmes to reduce food insecurity by making proper food distribution channels. India has the most extensive food distribution system in the world. The Public Distribution System evolved through the years and now reached Targeted Public Distribution System (TPDS). However, India faces food-related issues and consecutively ranks low in Global Hunger Index. This research attempt to study food security and TPDS by means of geospatial technologies(GST). The advances in GST can be effectively used to study social science phenomena like food security.

Keywords: Targeted Public Distribution System, Geospatial technology, Evaluation of TPDS,

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Nomenclature

PDS	Public Distribution System
RPDS	Revamped Public Distribution System
TPDS	Targeted Public Distribution System
FAO	Food and Agricultural Organisation
WFP	World Food Programme
GHI	Global Hunger Index
FCI	Food Corporation of India
BPL	Below Poverty Line
APL	Above Poverty Line
FPS	Fair Price Shops
GST	Geo Spatial Technology
MSP	Minimum Support Price
MDG	Millennium Development Goals
SDG	Sustainable Development Goals
IFPRI	International Food Policy Research Institute

Chapter 1

Introduction

This chapter will briefly discuss the motivation to select the Targeted Public Distribution System for research, the background of the Targeted Public Distribution System in India and the organisation of the chapters in the report.

1.1 Motivation

The Targeted Public Distribution System (TPDS) is the largest government-funded food distribution scheme in the world. The National Food Security Act, 2013 (commonly called the Right to Food Act) is an Act of the Parliament of India that provides subsidised food grains to approximately two-thirds of India's 1.2 billion people through TPDS. In the latest Global Hunger Index (GHI) – a macro-level tool that measures hunger globally and provides ranks to each country published by International Food Policy Research Institute (IFPRI) – India ranked 94th out of 107 countries and scored 27.2, which falls under the category of severe hunger issues.

The goal of TPDS, NFSA, some of the Sustainable Development Goals and the indicators like GHI point towards a concept- Food security. It is vital to learn food security and why all the governments and international agencies give much more importance to food security and its measurements.

It is crucial to identify the issues happening at the ground level to the TPDS and develop a framework for evaluating the TPDS using Geo Spatial Technologies (GST).

1.2 Background

Food security is a buzzword in the development sector. The thought process started in the mid of 1960s and continue the debates on food security. During the initial times, it was

just kind of an essential commodity. However, later United Nations declared food as a fundamental human right in article 25 of the Universal Declaration on Human Rights. International organisations like FAO worked on food security and modified the definition of food security by including different dimensions of food security. As per the studies done by FAO, 805M people still face the issue of hunger, and 769 M people face malnutrition(*Food Security and Why It Matters / Australian International Food Security Centre, n.d.*). The world fights against food insecurity with the help of Millennium Development Goals (MDG) and Sustainable Development Goals (SDG). According to the study report of FAO in 2014, 209 M people escaped from malnutrition, and 63 countries reached the hunger target of MDG. Many countries introduced different systems for fighting to secure food security in their way. High-income countries like the US, Europe came up with food banks and food assistance programs like Supplemental Nutrition Assistant programs(SNAP)(Christina M Pollard, 2019). The Middle East and North African(MENA) countries like Egypt, Kuwait etc., improved food security by reducing poverty with the help of enhancing labour rules and wages(Lofgren & Richards, 2003). India introduced Public Distribution System (PDS) to manage food security.

The Public Distribution System (PDS) was initially introduced in India during the second world war in 1945 to mitigate hunger and control the high market price of food. After independence, the Government of India (GoI) expanded PDS in 1960 by introducing FCI and more Fare Price Stores (FPS). The primary purpose of this scheme was to maintain food security, maintain buffer stock and make available food for all the people at an affordable price. It was considered a universal scheme to distribute food in India. The Ministry of Consumer Affairs, GoI, controls the cost of the food grains. Later, on 1st June, 1997, GoI relaunched the PDS system and focused on poor people and renamed it Targeted Public Distribution System (TPDS). The TPDS more focuses on BPL and distribute food grains at a subsidised price to poor people. The main features of TPDS are Targeting, Dual prices and Central state control.

The total population is divided into Below Poverty Line (BPL) and Above Poverty Line (APL) categories. The expert group of estimation of proportion and number of poor headed by Prof Lakdawala identified the methodology for finding BPL and APL based on the Planning Commission report for 1993-94. Later the conditions were modified in 2000 and increased the allocation of food grains per person.

The TPDS helped introduce a dual price system where the food grains were available at a lower price than the open market. The scheme became successful because of the price difference in the open market and TPDS, so that poor people depend entirely on the scheme. Year after year, the gap between the open market and TPDS is increasing with inflation.

The operation of TPDS is controlling by both state and central governments. The central Government does all the procurement of grains from the farmers, allocates food grains to a different state and UT based on the annual offtake of food grain for the last ten years, and transport across the country with the help of the Food Corporation of India (FCI). The state government identify the poor and classify BPL and APL- and allocate the grains to different categories. The state government is also responsible for issuing ration cards to households and distributing food grains to FPS. Sometimes the central assigns more food grains to state and state distributes to APL households.

The major miles stone had happened in 2001 when the central allowed flexibility to the states/UT to maintain the price of food grains through FPS. In 2013, GoI passed the National Food Security Act (NFSA), which changed the approach of TPDS from a welfare programme to a right based scheme.

1.3 Structure of Report

Chapter 1 Introduction – contains motivation, background, and Structure of Report.

Chapter 2 Literature review contains the literature review, including background, basic info about food security, dimensions of food security, evaluation of food security, food security in around the world and food security in India.

Chapter 3 – Research Methodology – contains a short note on the methodology of the research. Followed by research questions, objectives, sub research questions, tasks, subtasks, methods for each SRQ

Chapter 4 – Public Distribution System – contains the evolution of PDS, working of PDS, Targeted Public distribution system, issues related to the TPDS and how it helps in food security.

Chapter 5 –Geospatial techniques to Study TPDS– contains different parameters used for studying food security and TPDS with the help of GST.

Chapter 6 – Conclusions – includes a summary, answers to the research questions, the contribution of the current study, limitations of the current study, has a section on future work.

Chapter 2

Review of Literature

This chapter collects the points related to the study done by researchers on the topic of food security and related areas like dimensions of food security, evaluation of food security, food security and India and briefly explain the programmes developed by the Government of India to ensure food security across the country, within all group of population.

2.1 Food Security

The term food security is generally used in publications, policies, and media. The term is sometimes used to represent hunger, famine (Simon, 2012). Food security is a fundamental concept for nutritional availability and poor physical, mental health. Food security is directly affecting 795 Million people globally, and hence it is considered a significant public concern (Shaw & Clay, 1998). Food security use interchangeably with food safety - a term that included producing, handling, preparation and storage of food items, while food security included both food safety and healthy nutrition(Walls et al., 2019)

The concept of food security was raised during the 1970s in the discussion of global food problems at the time of food crisis across the globe (Clay, 2002). The concept of food security is flexible so that many are trying to define food security in research and policies. Decades ago, more than 200 definitions were available in scholarly articles and publications (Clay, 2002).

During the initial decades, the researchers gave more importance to food supply related issues- availability of food items and stability of the prices of foodstuffs. They did not concern about related issues or dimensions of food security. The access at the national and international level forced the global food economics to change and incorporate other dimensions of food also (Clay, 2002).

In 1974, a world food conference conducted due to the pressure of changing food economics and put forward a new definition for food security as follows “availability at all

times f adequate world food supplies of basic foodstuffs to sustain a steady expansion of food consumption and to offset the fluctuations in production and prices”. The new definition made a major setback in food security research (Clay, 2002).

In 1996, FAO addressed food security at the World Food Summit(WFS) in Rom on November 13-17 with participants from 190 countries (Shaw & Clay, 1998). They came up with a definition widely accepted by researchers and policymakers. It stated that food security exists when all people at all times have physical and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy (Clay, 2002).

In 2002, FAO added the term social to the existing definition and made it a complete definition that ensures all the dimensions of food security (Simon, 2012).

Often, this complex definition was simplified and used by WFP for their official purposes as follows. “Food security is a condition that exists when all people, at all times, are free from hunger (WFP, 2009). Moreover, many policymakers also used a simplified version of the definition as food security exist when people do not have adequate physical, social, or economic access to food as defined (Clay, 2002).

National level, the policymakers defined food security in terms of availability. “Food security exists when the availability of food that meets the demand of the people, either by domestic production or import from other countries (Mahendra Dev & Sharma, 2010).

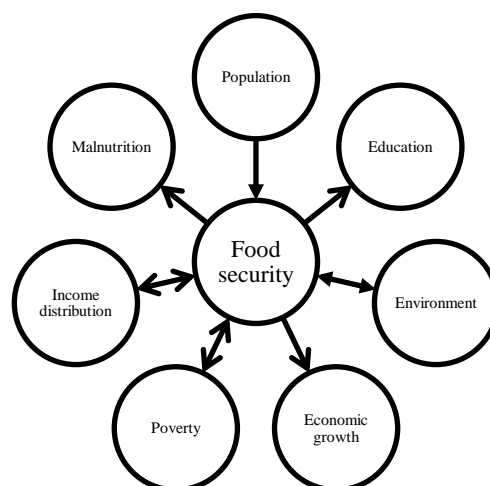


Figure 2.1 Interconnection of food security with other indicators of quality of life.

Source: Created by author

While the broader definition of food security includes all the indicators of quality of life, it provides access to a balanced diet, drinking water, basic sanitation, primary education and health care (George, 1999).

By summing up the points from various researchers, food security is a situation where the country's whole population, regardless of their economic status, location, age, and gender, gets enough food to satisfy their nutrition requirement for the entire lifespan.

2.1.1 Dimensions of Food Security

As per the definition of food security by FAO in 1996 and 2002, four significant dimensions or pillars were identified for food security, namely Availability, Access, Utilisation and Stability. Availability is described by the part “sufficient food is available in the definition”. “Social and economic access to food” pointed towards the second dimension of food security- Access. Stability is described by “All people at all times”, and “Safe and nutritious food can be utilised” gave an idea in the direction of utilisation. And these dimensions are helpful for analysing food security (Simon, 2012). Researchers demanded to add sustainability as a fifth pillar to food security for considering the environmental impact of agriculture and resource depletion (Bhimsha Jane & Bheemmappa Astige, 2013).

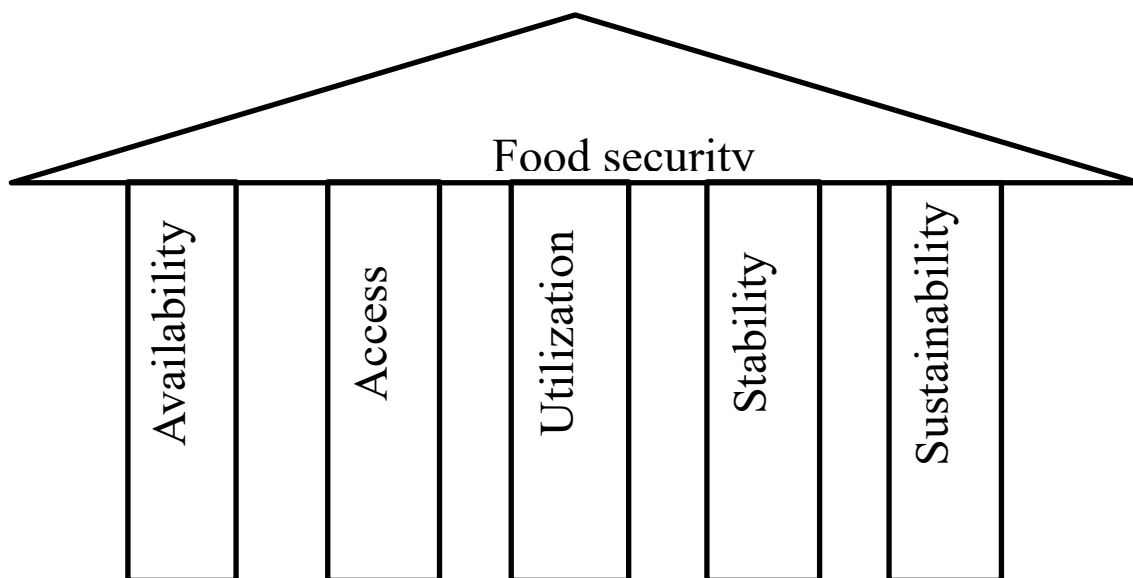


Figure 2.2 Dimensions of Food security

Source: Created by author

Availability

The availability of food is defined as the total amount of food present in the country or area through all forms of domestic production, imports, stocks, and food aid (Simon, 2011). This definition covers not only the countries but also the villages and households. The deficiency in the availability of food leads to malnutrition and hunger. In early times, lack of food availability was considered food insecurity.

The invention of new technologies, including fertilisers, high productive seeds, new irrigation methods, new agricultural practices etc., helped to achieve enough food to feed the entire world population. Still, many people are suffering to get enough food. Climate changes, wastage of food grains due to improper handling along the supply chain, reducing agriculture etc., make challenges to the availability of food grains.

Access

Access is considered one of the significant dimensions of food security. It is defined as the ability of a household to acquire an adequate amount of food (FAO, 2011). The usual methods to collect food included the purchase of food grains from the market, barter system, borrowing, and assistance or gift from the Government or any other third party. Amartya Sen put forward this point in the 1980s through his concept called entitlement. Food-related issues in different countries, for example, the problems that happened in Niger, 2005, gave researchers and policymakers to think and act on this dimension.

The access to food grain is further divided into three subcategories: physical access, economic access, and socio-cultural access. The physical key is concerned with the logistical part of the food distribution. It considered production of the food grains, transportation and storage, road connectivity, rail connectivity and lack of infrastructure to distribute the food. Thus, people cannot reach where the food is available. Economic access is about the financial ability to purchase enough food for satisfying basic needs. Socio-cultural access describes the cultural and social denial of accessing food for a particular type of people, for example, HIV/AIDS patients, gender and caste system etc. As per the recent report of OXFAM, 2017, access to food is still challenging in many parts of the globe.

Utilisation

The term utilisation is related to clean water, proper sanitation, and health care. In other words, utilisation is related to all elements that help select nutritious food items, conservation of them, and preparation and consumption of nutrients (Simon, 2011). This dimension shows how nutrition and health care are interconnected with food security. The insufficient amount of nutrition leads to stunting and wasting in children and various health issues for adults. Excess fat, sugar, and less fibre in food lead to obesity, diabetics, and heart diseases. The improper handling of this dimension leads to malnutrition issues, and many governments do not focus on this dimension.

Stability

Stability refers to the access of food to all people at all time. This dimension ensures the above three dimensions for a long time (Simon, 2011). Food security is a situation that does not happen in a moment; it takes more time to come to an existing. Researchers classified food insecurity into two, chronic and transitory food insecurity, based on the stability dimension. Chronic is a long term or permanent inability to access the required food. At the same time, transitory food insecurity is short term or temporary food insecurity. It may happen seasonally and hence sometimes referred to as cyclical food insecurity (Simon, 2011).

Sustainability

This dimension is not included in the initial Rom declaration of food security. It was introduced in 2009. Climate change affects all other dimensions of food security. Climate change reduced the production of food grains which leads to issues in access to food grains. It also causes to increase in the price of food grains and affect availability. Due to climate change, the food is contaminated quickly and reduced quality, affecting nutrition intake (Berry et al., 2015).

Sustainable management and required to eliminate all unsustainable practices from the patterns of food production to the consumption of foods. Farmers adopted sustainable farming practices, and the consumers requested to adopt more sustainable diets, which play a vital role in food safety and nutrition. Overall, sustainability adds to the long existence of food security by considering the environment, economy, and society (Berry et al., 2015).

2.1.2 Evaluation of Food security

Evaluation of food security is an important task to know about the food security status of a particular household, place, country, and world. The other main uses of measuring food security include monitoring and designing an early warning system of the food crisis, assessing household food access and acquisition, and measuring food consumption and utilisation (Jones et al., 2013).

Measuring food security gives an idea about the reasons behind the food insecurity, type of people and their characteristics like households, villages, towns, provinces, villages, castes, their neighborhood etc., the period of food insecurity and whether it is seasonal or not, actual and potential impact of the situation. It provides an analysis of the qualitative and quantitative sides of the problem (FAO, 2011).

Food security cannot be measured using a single indicator to cover all the dimensions mentioned by FAO. There are many indicators or combinations of indicators used to measure the complex scenarios of food security (Hoddinott, 1999). There is no best combination of indicators that is suitable for all the locations. Each indicator depends on each situation, environment, and nature of the people, law, policies, infrastructure and economy of the country, etc.

Food security can be measured at different levels—micro-level and Macro level (Hoddinott, 1999). The macro-level contains the study at a regional, national and or global level. Micro-level measuring takes place at the household level. Micro-level measuring consists of the following methods.

Micro-level indicators

The micro-level indicators are used to evaluate food security at the individual and household levels. Apart from the food consumption indicators, demographic, income and livelihood, assets, access to drinking water sources, availability of sanitation facilities and healthcare are also considered to study all the dimensions of food security (FAO, 2011).

Individual intake: In this method, researchers measure the total amount of calories/nutrients consumed by an individual in each period. It provides information regarding the food required and food intake disparity inside the household. This is the most accurate

method to measure food security at the household level (Hoddinott, 1999). FAO calculating Food Consumption Score out of it and used for WFP(FAO, 2011).

Household caloric consumption: This method measures the total amount of calories/nutrients available for consumption by the household over a while. This provides the consumption pattern of the family (Hoddinott, 1999).

Dietary diversity: This method is used to identify the nutrition intake of the household. It is calculated by adding the nutrition values from each food item consumed by the household over a period (Hoddinott, 1999). FAO and US Agency use the same parameter for International Development (USAID), called as Household Dietary Diversity Scale (HDDS). They targeted individuals (IDDS) and women (WDDS) for more studies (FAO, 2011).

Household coping strategies: This is a qualitative analysis method to identify the adaptations and cop up approach when there is a presence of food shortage (Hoddinott, 1999). FAO named it as Coping Strategy Index (CSI).

Macro-level Indicators

Macro-level indicators are used to evaluate food security at the country level or a regional level or the status of the entire world. The indicators developed at the macro level are used to compare the countries, to make standards among different countries, identifying challenges at the national level and for setting international goals like MDG and SDG. Data related to underweight, wasting, stunting, availability of macronutrients etc. used to construct different macro-level indicators of food security.

FAO Indicator of Under Nourishment (FAOIU): It is one of the indicators used to measure the insufficient intake of calories in the population. Most of the countries took this parameter for considering food security and nourishment. Quality and quantity of calories available for consumption, inequality of access to food among the population, and mean minimum amount of calories required by the population are used to find the FAOIU (Hanie Pangaribowo Nicolas Gerber Maximo Torero et al., 2013).

Global Hunger Index (GHI): GHI is calculated annually by International Food Policy Research Institute (IFPRI). This gives a clear picture of the success and failure of the food security programs of each country and clearly pointed out the causes of the food crisis.

They considered three parameters, including share of the population with insufficient caloric intake, child underweight under the age 5, and child mortality which provide the information about the unhealthy environment, a major factor of utilisation dimension of food security (Hanie Pangaribowo Nicolas Gerber Maximo Torero et al., 2013). Based on the GHI values, there is five classifications of counties based on the points as low(<10), moderate(10-19.9), serious(20-34.9), alarming(35-49.9) and extremely alarming (>50) (*Global Hunger Index Scores by 2020 GHI Rank - Global Hunger Index (GHI) - Peer-Reviewed Annual Publication Designed to Comprehensively Measure and Track Hunger at the Global, Regional, and Country Levels*, n.d.).

Global Food Security Index (GFSI): This indicator is developed by the Economist Intelligent group and is applied to more than 100 countries. This indicator measures the three major dimensions of food security – accessibility, availability and utilisation. The data are collected from annual reports of Governments on food security, WHO, FAO, and GHI. It considers food consumption, diet diversification, GDP per capita, food safety program, agriculture import tariff, average food supply to the population, infrastructure of the country, etc. (Hanie Pangaribowo Nicolas Gerber Maximo Torero et al., 2013).

Poverty and Hunger Index (PHI): This indicator was developed to monitor the MDG 1 - eradicate extreme poverty and hunger - and focused on the food availability and access of the food other than the economic status of the people. The proportion of people living on less than \$1 per day per person, poverty gap, the share of poorest people in national income, children's underweight and undernourished populations are the variables considered to calculate Poverty Hunger Index (Hanie Pangaribowo Nicolas Gerber Maximo Torero et al., 2013).

Hunger and Nutrition Commitment Index (HaNCI): It evaluates and ranks countries based on the governance and the political commitments to reduce food insecurity, introduced by the Institute of Development Studies. It takes care of all the dimensions of food security and helps to reshape the policies to make them more effective. This framework analyses policy and programs, legal frameworks, public expenditure on both agriculture and nutrition (*About HANCI / Hunger and Nutrition Commitment Index*, n.d.).

Indicators based on dimensions of food security

Apart from these methods and indicators, some other indicators are available to measure each dimension of food security as mentioned earlier under 2.1.1 given in Table 2.1: List of indicators.

Table 2.1: List of indicators

Source: Based on the UNCTAD report, 2012.

Dimension	Parameters used to measure
Availability	Average Dietary Energy Supply
	Average Value of Food Production
	Share of dietary energy supply derived from cereals, roots & tubers
	The average supply of protein of animal origin
	Average protein supply
Access - Physical	Per cent of paved roads over total roads
	Road density
	Rail line density
Access - Economical	Domestic Food Price Level Index
Utilisation	Access to improved water sources
	Access to improved sanitation facilities
	Percentage of children under 5 years of age affected by wasting
	Percentage of children under 5 years of age who are stunted
	Per cent of adults who are underweight incidence
	Prevalence of anemia among pregnant women (%) and children below 5
	Prevalence of Vitamin A deficiency
Stability	Cereal import dependency ratio
	Per cent of arable land equipped for irrigation
	Value of food imports over total merchandise exports
	Political stability and absence of violence/terrorism
	Domestic food price level index volatility
	Per Capita food production variability

Sustainability	The ratio water footprint of food production
	The ecological footprint of food
	The ratio water footprint of food production
	Stability and variability

(x

Measuring food security at micro-level, macro-level and at different dimension levels is a very complex task. No single indicator gives the exact picture of the food security of the location. It required a combination of various indicators mentioned above. Also required to study other related areas like poverty, climate, employment status, law and policies, regional issues, literacy, etc., are some of them. Overall, the measurement of food security gives a clear idea of the economic and societal development of the country or a region.

2.1.3 Food Security Across the World

Food security is one of the significant health challenges in the world. Food security does not include in the problem of accessing food. The impact of food insecurity affects the economy and society of the entire nation.

Due to the importance of food security, world leaders came up together and make new initiatives to fight against food insecurity. In 2000, Millennium Development Goals launched, and it focused on the wellbeing of people in all directions and improving things in 2015. MDG had eight goals and gave first preference to eradicate extreme poverty and hunger by improving agricultural productivity and income to ensure food security, supported by FAO for new farming practices, supported livestock and fisheries. The aim of MDG 1 included reducing poverty, improving employment and food security (*MDG 1: Eradicate Extreme Poverty and Hunger / Sustainable Development Goals / Food and Agriculture Organization of the United Nations*, n.d.).

The MDG brought a considerable reduction in poverty, and the number of the undernourished population dropped 50% from 1990 due to the implementation of MDG.

After the MDG, the UN introduced a new set of goals named Sustainable Development Goals (SDG) and aimed to achieve complete food security across the globe by 2030. There are 17 SDGs available, and SDG 2 is related to food security and is titled Zero

hunger. The principal objective is to end hunger, achieve food security and improved nutrition and promote sustainable agriculture. The goal will be achieved through five targets: accessibility of food to all, end malnutrition, double the agriculture productivity, sustainable agriculture and genetic diversity of nature (*Goal 2 / Department of Economic and Social Affairs*, n.d.).

The review report by the FAO in 2020 revealed that SDG 2 started shifting their focus from food production to the entire food production system; meanwhile, some fragmentation occurred and working to improve the goals.

Almost all the countries in the world are trying to ensure food security for their people. In rich countries like Australia, Canada, New Zealand and the UK, household-level food security is considered a major public health concern. The studies show that 8-12% of rich countries' populations suffer from poor diets related problems (Christina M Pollard, 2019). 7.2% of the population use food banks. Most of these countries follow voluntary food assistance to hungry people with minimal government support (Christina M Pollard, 2019).

In Norway, the Government provides support in agriculture, imposes regulations on food prices, and ensures universal social security to get rid of food insecurity (Christina M Pollard, 2019). In the USA, government funds for food assistant programs named Supplemental Nutrition Assistant Program (SNAP), commonly known as Food Stamp Program to support low-income individuals, children, old age people and families to ensure nutrition availability and food security (*USDA Food and Nutrition Service / USDA-FNS*, n.d.). Europe has low-cost food banks available to low-income individuals.

The Middle East and North African (MENA) countries tried to ensure food security by improving wages and labour. The increasing production of food grains is challenging due to their geographical condition and low rainfall. Hence, they imported food from other countries. Egypt provided food grants for vulnerable families, and Libya promoted household level agriculture of fruits and vegetables to handle food insecurity (Lofgren & Richards, 2003).

China faces many issues in food security even they are one of the top producers in the world. The high population growth, the demand for food for animal feeding and biofuels, degradation of the agricultural area because of the increased usage of fertilisers, urbanisation, and low yield crops etc., are the major challenges for food security in China (Mukhopadhyay et al., 2018). The Government ensures food security by importing food items like rice, milk,

soybean etc., from other countries to meet the population's demand and provide subsidies to agriculture to produce more foods in the country to obtain food security (Cui & Shoemaker, 2018).

Brazil has initiated food security policies in Latin America with well-structured laws, infrastructure and public awareness programs to cover food security at different levels. The Government started the Zero hunger program in 2003 and Bolsa Familia is one of the successful programs. Bolsa Familia is a kind of family grant program. Income transfer, Social income and food security are the three central pillars of the Bolsa Familia program. Furthermore, the Government improved the salaries and employment rate to reduce poverty and thus improve food security. It is one of the successful projects and reduced the poor population from 57 M to 30.9M within the first ten years (Souza et al., 2015).

While considering the programs of different countries to eradicate food insecurity, there exists a familiar pattern. Most of the nations, irrespective of the GDP, provide subsidised food to poor people and meanwhile trying to improve food availability by either increasing the production of food grains or importing from other countries and making regulations for food items in the market. Middle- and Lower-Income Countries (MLIC) trying to reduce the poverty level by giving income transfer programs, improving employment and salaries, which will lead to food security and better prosperity in the life of the people.

Meanwhile, the governments of different countries and international organisations work towards food security; several challenges need to be overcome. According to World Economic Forum, the significant challenges would be population growth, climate change and water scarcity, changing the food pattern, farmers' crisis and changing food price (*Food Security and Why It Matters / World Economic Forum*, n.d.). By 2050, the population will be increased to 9 billion, so that the demand for food also increases accordingly. Due to climate change, the temperature will rise, and which will cause more deserts and arid regions. 28% of the total agriculture depends on rainwater. Climate change and water scarcity affect food production badly (*Food Security and Why It Matters / World Economic Forum*, n.d.). Dietary patterns change, and people eat more milk and meat, ultimately demanding more food to feed animals. The number of people who choose farming is reduced due to less income and high risk.

To ensure food security, the governments and international agencies need to solve or mitigate these challenges. Sustainable farming methodologies, climate mitigation programs,

subsidies and supports for farmers, alternative diets etc., need to come under food security-related policies.

2.1.4 Food security in India

After the two decades of independence, India became self-sufficient in food grain production from a food deficit country at the macro level with the help of the green revolution (Mahendran, 2010). The food production was increased from 50MT to 223.9 MT in the 2000s, and the growth rate was 2.5%. Along with the food grains, other industrial crops like oilseeds, sugarcane, cotton also increased during the period. The Government of India used to give much support for farmers from fifth to nine five-year plans.

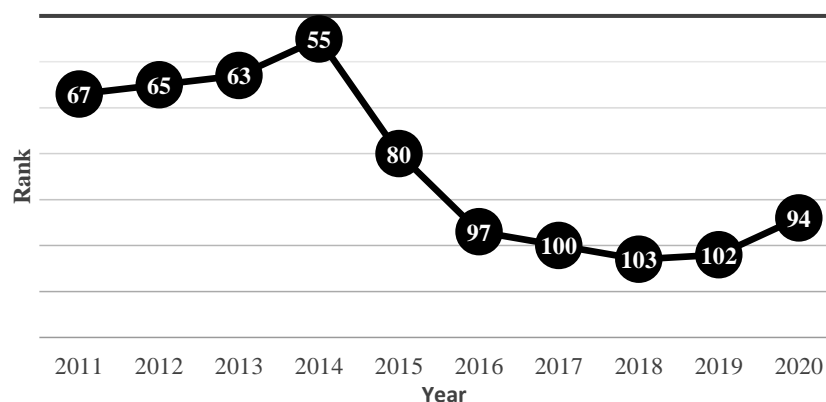


Figure 2.3 GHI ranking of India for last ten years

Source: <https://globalhungerindex.org>

Currently, India needs to improve in food security. India ranks 94th in global hunger ranking out of 107 countries prepared by IFPR (<https://globalhungerindex.org/india>). IFPR classified the status of hunger into five categories - low, moderate, serious, alarming, and extremely alarming. India falls under the alarming category. The growing GDP of the country has little impact on the food security and nutrition level of the population. Still, the bottom half of the population suffering the issue of food security and malnutrition (3-4). Figure 2.3 shows the GHI.

Based on the NFHS survey, India is facing three major issues of malnutrition. Inadequate calorie intake, undernutrition among a large section of the population, and excess intake of dietary energy leading to obesity and related diseases in other portions of the

population. In a country like India, food security is a crucial societal issue. 1/3 of the total population is in the absolute poor category, and 1/2 children are facing malnutrition in one or another way (Upadhyaya, 2018).

In the country, enough food is produced. Production of food grains, cereals and pulses, dairy, fruits, and vegetables etc., improved, which is enough to fill the requirements of the country. The trends in food pattern diversification also improved in India. At the same time, the food distribution system facing a lot of issues. High inflation rates on food items in recent years increased and made the gap between economic growth and the ability of the people to buy the food items from their earnings. (03-03)

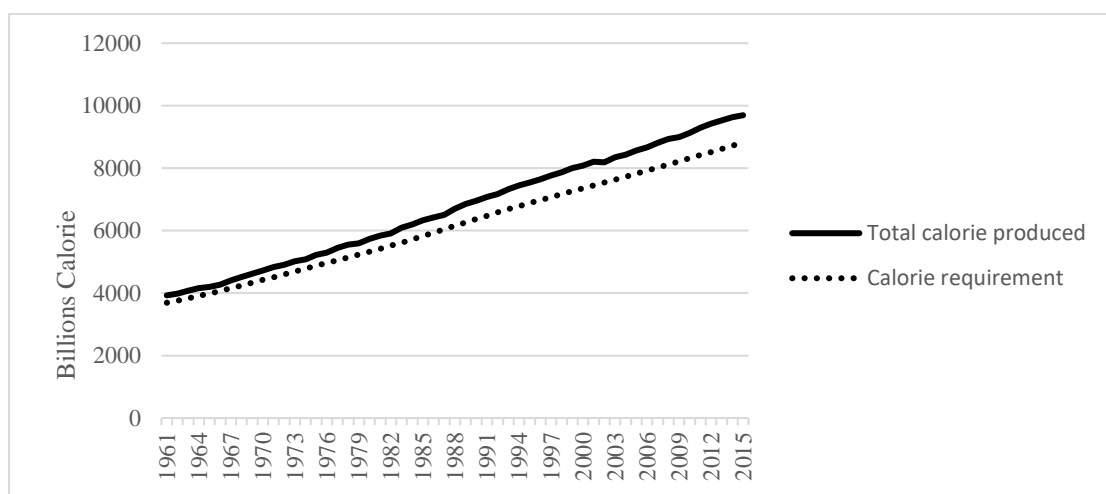


Figure 2.4 Total calorie produced and total calorie requirement for India

Source: FAOSTAT, 2021

Figure 2.4 clearly shows the difference in calorie production and demand of the calorie. For calculating the calorie required, 1200 calories per person per day is used. And the caloric value of rice, wheat and pulses is used to calculate the total calorie produced by India.

There are many issues for food insecurity in India. But the major issues are as follows by Upadhyaya, 2018

Malfunctioning of the food distribution system: Public Distribution System failed to effectively give the food grains to the households. It ensures the access of the food nearby the household but does not ensure all the aspects of food security.

Poverty: It limits the amount of food available to the children. The economic growth of the country not reaching to a particular section of the population. It will reduce the purchasing power of the people.

Unmonitored nutrition programs: There are many programs are designed and implemented by state and central government. But the implementation was not suitable. For example, Bihar Orissa does not implement the Mid-Day Meal program yet.

Lack of intra sectoral management: The failure of coordination between different ministries and departments makes trouble in various levels of food security in India.

The demand for food: The population of India increasing, and hence the demand for food is also growing. There is a gradual decrease in food grain production due to various reasons from the last few years.

2.1.5 Ensuring food security in India

India came up with many programs to ensure food security in the whole country, to everyone. The initial step was increasing food production by introducing the green revolution in the 1960s. It increased the food grain production on a large scale by providing improved technology and services to the farmers, which include high yield seed varieties, modern farm machinery, the introduction of new irrigation methods, credit and subsidies and MSP.

It improved the macro-level food security of the country, but malnutrition and hunger continue in deficit areas. Environmental degradation was another side effect of the green revolution, and many discussions going on the topic.

After Amartya Sen's theory of entitlement, the Government gave more importance to the access direction. The paradigm changed from a charity to right based approach with the introduction of public distribution System and later right to information.

Green revolution and PDS helped to achieve the availability and access dimensions of food security. GoI introduced different programs to ensure the other dimensions of food security. Integrated Child Development Scheme (ICDS), MGNREGS, Antyodaya Anna Yojana(AAY), and Mid-Day Meal program are some of the examples of such programs.

Many researchers claim that Minimum Support Price (MSP), Buffer stock and PDS are the major instruments of food security in the country (Mahendra, 2010). Farmers required remunerative prices for their products according to their investments, and consumers required the food grains at a reasonable price. MSP helps to balance these two requirements. MSP is

available to 24 major crops, and it will be fixed by the recommendation of the Commission for Agricultural Cost and Prices (CACP).

In order to ensure food security in the country during any natural/artificial conditions, the Government stores food grains- mainly wheat and rice- from surplus food production. If the production is not as per the requirement by different norms, food grains will import to keep the buffer stock.

2.2 Geospatial Technologies

Geospatial technologies are modern tools used for geographic mapping and analysis of spatial data with the help of computers. The Geo Spatial Technologies(GST) started with the creation of the first map in the 19th century (*What Are Geospatial Technologies? | American Association for the Advancement of Science*, n.d.). The technology expanded during World War II and cold war time with the help of satellites and computers.

2.2.1 Geo-Spatial Technologies (GST)

During the last few decades, geospatial data, geospatial tools and geospatial services expanded and are readily available to study and monitoring natural and social behaviours (van Manen et al., 2009). Different agencies such as governments, non-government organisations, armies, research organisations are developing new methodologies to capture and analysis of geospatial data. Individuals also get the opportunity to play around the geospatial information because of the internet and computer technology advancement. Commonly used geospatial technologies for analysing both natural and social sciences phenomena are listed.

Geographic Information System: It is a technology that collects, store and analyse geographic data by creating a digital map. Many GIS software available, which can be used to create maps with different layers of data and visualise the result in a helpful manner. This technology is beneficial in scientific analysis, resource management, environmental impact study etc., (*What Is GIS? | Geographic Information System Mapping Technology*, n.d.).

Location-Based Services (LBS): LBS became popular in modern Information Communication Technology (ICT). The LBS collecting and analysing the spatial information

of the people at a different locations. The primary example of LBS is finding nearest restaurants, traffic information, tracking of parcel service etc. Ordinary people widely use this technology for various purposes (van Manen et al., 2009).

Global Positioning System (GPS): GPS is a satellite-based navigation system developed by the US government for military purposes and opened to the public. GPS can be used to monitor vehicles, provide accurate timing across the globe, and use travel survey data collection to get more precise location information (Wolf et al., 2001).

Remote Sensing (RS): Remote Sensing is a geospatial technology takes areal photographs of the study region using satellites, airborne camera and other similar equipment and analyse the information. With the advanced development of sensor technology, the RS system can capture energy emitted and reflected and analyse those data using a computer to get a better understanding. The RS is used to study archaeological sites, urban planning, rural development, environmental monitoring, Land Use Land Cover(LULC), agricultural production estimation and weather forecasting (Anyamba et al., 2015).

2.2.2 Previous attempts to study Food security using GST

All these technologies can together use to monitor the social phenomenon with the least cost-efficiently. Many organisations and scientists studied food security using GST. Some of them are listed below.

- FAO developed a Global Information and Early Warning System (GIEWS) on food and agriculture by utilising geospatial data including rainfall data, Normalized Difference Vegetation Index (NDVI), and LULC (*FAO, GIEWS, Earth Observation, METOP, NDVI, ASIS, VHI, VCI, ECWMF, Agricultural Stress Index, NDVI Anomaly, Vegetation Condition Index, Vegetation Health Index, Estimated Precipitation, Precipitation AnomalyMap*, n.d.).
- Andrew Tomita and his team found out the food insecurity clusters in South Africa using geospatial technology (Tomita et al., 2020).
- Food status and food nutrition security of Koch Bihar, West Bengal, India, was studied by remote sensing and GIS techniques by Alam et al. (Alam et al., 2021).

- US Department of Agriculture (USDA) also attempted to study food security based on GST (*Geospatial Applications in Agriculture and Global Food Security: An NGA and USDA Project Success - Earthzine*, n.d.).
- Bhakhtiar and his team assessed food security based on GIS and RS data analysis for rural areas of Eastern Iran (Feizizadeh et al., 2015).

2.2.3 Advantages of GST

Geospatial technology can be used to study a large range of development issues, including food security, availability of drinking water, economic development, accessibility to the developments in infrastructure, and natural risks (UNCTAD, 2012).

The GST can be used to study spatial changes at different levels such as village level, provincial level and national level. It helps to find out the patches and clusters of issues. Many researchers are trying to implement GST on governance and disaster risk management. The following Table 2.2 briefly gives an idea about the advantages of GST in different development challenges.

Table 2.2 Advantages of GST
Based on the UNCTAD report, 2012.

Area	How GST can be utilised
Health	Monitoring epidemic spread, the relation between geological properties and diseases, accessibility to the hospitals
Disaster	Risk assessment, forecasting of disasters, damage assessments and planning
Energy	Find out optimum locations for renewable energy plants.
Climate	Monitoring and forecasting, climate change monitoring and mitigation projects.
Agriculture	Precision agriculture, monitoring crop conditions
Ecosystem	Monitoring different ecosystems at different places like marine, deep forest

	etc.
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2.2.4 Limitation of GST

There is some limitation to GST, which resist the growth of GST and their application in different development and policy-related areas. The geospatial analysis required a large quantity of continuous spatial data. To store and process those big data, more extensive computer and storage facilities are necessary and which is costly. The price of the software to do such analysis is also very high. The small players and startups can not easily come to this sector (*What Are the Challenges in Implementation of Geospatial Technologies? – Geospatial World*, n.d.).

The learning curve and lack of human resources who are appropriately trained on GST are one of the issues facing nowadays. There is a lack of awareness about GST, and their application is in different areas.

The next reason is related to the geographic error due to the shape of the earth. The error while computation also makes a sizeable false impact on the output (*GIS Technology: Advantages and Disadvantages*, n.d.).

Chapter 3

Research Methodologies

Research must set Research Objectives, research questions, and a suitable methodology to make reliable and unbiased answers to the research questions. This chapter explains the need for the research, research questions, research objectives and methodology, timeline, and methods used for analysis and interpretation of the data.

The Research Objectives are,

1. To review the role of TPDS in India's food security.
2. To review the various geospatial techniques to evaluate food security.

From the Research Objectives, 2 Research Questions are formulated.

1. What is the role of TPDS in India's food security?
2. What are the Geo-Spatial Techniques to review food security?

3.1 Research Design

This section provides information about the division of research questions into sub research questions and tasks associated with each SRS. The research design is shown in Table 3.1 Research design. It contains two research objectives and two research questions derived from the objectives. Each research question is divided into sub research questions. Each sub-questions is further divided into different tasks for easy execution of the research.

The research timeline is also provided in Table 3.2 Timeline, which provides the information about the sub-questions and the time taken for covering the sub-tasks.

Table 3.1 Research design

Objectives	Research Questions	Sub Questions	Tasks
To review the role of TPDS in India's food security	What is the role of TPDS in India's food security?	1. What is food security? 2. How did the TPDS evolve through the years 3. What are the logistical activities behind the TPDS 4. How does TPDS help to achieve the food security	1. Quality literature review to understand <ol style="list-style-type: none"> Food security History of TPDS Working of TPDS Stakeholders of TPDS Challenges by TPDS Initiatives to overcome the challenges 2. Collect the secondary data from websites and portals to verify the findings from the literature review.
To review the various geospatial techniques to evaluate the food security	What are the geospatial techniques to review food security?	1. What are the specific technologies can use to analyse food security? 2. What are the key parameters and data to consider for analyse TPDS?	1. Quality literature review to understand different geospatial techniques used related to food security 2. Analyse the different geospatial layers(variables) required to analyse the TPDS in India from literature.

Table 3.2 Timeline

Date	Work To be Done	Source/Method
1st June- 20th June	Food security and its dimensions	Literature review
21 st June–12th July	TPDS, working of TPDS and food security	Literature Review
15 th July- 18th July	Challenges of TPDS and data collection	Literature Review and Secondary data collection from government websites
19 th July–15th August	Geospatial Techniques for analysing food security and TPDS	Literature Review

3.2 Study Area

In this study, the researcher is trying to understand the food security, the working of TPDS and suitable Geospatial Techniques to evaluate the food security and TPDS in the Indian context. Due to the pandemic condition, the researcher avoids field visits and completed the research using the literature review.

3.3 Data Collection

Secondary data is collected from the annual reports and websites of different Government, international organisations and programs, Information management systems (IMS) of respective programs and scholarly articles to analyse food security and working of TPDS.

Chapter 4

Public Distribution System

Public Distribution System (PDS) is developed in India to address food security issues across the country. PDS was evolved through the long process of 25 years, and it began before the independence of the country. The discussion on PDS started in 1939 and extended up to 1965, and implemented several methods to decrease the food insecurity in the country to the creation of Food Cooperation of India (FCI) to purchase, store and distribute the food grains (Mooij, 2008). In other words, PDS is a food rationing and distribution system to ensure food security at the national and household level (Mooij, 2008). More than 2.5 Crore household depends upon the PDS as per the PDS Portal of GOI. Thus it became one of the most extensive food distribution programs in the world funded by any Government.

4.1 Evolution of PDS

Since 1861, India was adopted a Laissez-faire System in food prices where there was no control over the price of food grains. The food price was determined by the supply and demand of the food grains (Mooij, 2008). The production of food grains in India was gradually declining from 1914 to 1942. In 1914 the rice production in India was 254kg per capita and was reduced to 181 kg per capita in 1942. The reduction of food grains was not a big issue since the rice demanded and produced was maintained by the imports from the neighbouring country, Burma.

During Second World War, the scarcity of food increased. The food demands for food grains by the armed forces increased, the imports from Burma stopped after the failure of Burma in 1942, and thus food prices increased. The first form of PDS started in Mumbai, 1939, to deliver the food grains to the urban population to mitigate the price hike of food grains. The price hike was worst affected in Bengal, where the famine killed 1.5 to 3 million people in 1943. It expanded to other places like Mumbai, Cochin and Travancore, but the intensity was not high as Bengal (Mooij, 2008).

After these events, India started controlling the food prices by implementing new food policies and formulating efficient food price control policies and avoiding famine. Food insecurity and GoI India started to conduct food price control conferences.

In 1942 September, the early stage of PDS started. India started a centralised mechanism for purchasing foods from surplus provinces and distributed them to deficit provinces. The decision was made at the 6th food price control conference (Mooij, 2008). In December, GoI developed a new food department to coordinate all the activities regarding food collection, distribution and started working on food policy development.

The food department formulated an All-India Basic Plan for food policy. The plan addressed the issues during procurement of food grains, contracts for purchasing agents and farmers, distribution of food grains, supplies, inspection, storage, finance, etc. (Mooij, 2008). The initial aim was to protect the people from the high food price. The food distribution was primarily focused on urban areas and rationed one pound of food grains per capita per day (1600KCAL/day/capita).

The second food gain policy committee formulated in 1947 recommended producing more food grain domestically to ensure food security in India (Mooij, 2008). In 1948, GoI introduced a food policy. While during the initial time, the production of food grains reduced because of the extreme weather conditions and hence food prices increased further.

In 1957, more socialisation of rationing system proposed along with Fair Price Shops (FPS) in no profit no loss model. FPS played a crucial role in delivering food grains to different regions across the country. It included both urban and rural areas of the country and covered all the types of people. From the following year onwards, the expansion of food distribution system started expanding. Foodgrains were required to distribute imported from the USA. During the time, 14% of total food distributed in India was contributed by the USA either as a gift or paid under the US Public policy law 480 (Mooij, 2008).

In 1965, the Food Corporation of India (FCI) was established based on the Food Corporation's Act 1964 as a nodal agency for food grain procurement, storage, and distribution from surplus to deficit regions. It would take trading and distribution operations from Government and act as a critical player for the price stability of food grains in India. Started a minimum guarantee to the farmers for procuring and decided basic amount called Minimum Support Price (MSP). Later, the supply of food grains changed to domestic

production from imports. India became self-sufficient in food production due to the green revolution.

During the 1970s, the PDS system evolved as a universal system to alleviate poverty (Souza et al., 2015) (Parwez, 2014) from mere food distribution and price stabilisation mechanisms. It involved the whole population and covered the entire span of the country. PDS became a vital tool to improve the food security of India.

In 1992, GoI sharpened PDS and renamed as Revamped PDS (RPDS) and covered rural populations of 1700 blocks which include desert areas, drought-prone areas, tribal areas, and hilly regions (*Rural Marketing - Sawalia Bihari Verma, M. Narayan, P. Thryambakam - Google Books*, n.d.). All families of these areas were provided with a ration card built infrastructure like FPS and storage facilities for food grains.

Last three decades, PDS witnessed sharp changes in their beneficiary structure and paradigm. In 1997, PDS was renamed as Targeted PDS, and focused more on poor people, gave more subsidised food grains to 6 crore families and included state government in PDS. TPDS intended to reduce the leakage and diversion of food. Antyodaya Anna Yojana (AAY) was introduced to feed the poorest of the poor population in 2002 and ensured 35Kg of food grains(wheat/rice) at a subsidised price rate. In 2013, the parliament of India approved the National Food Security Act (NFSA), which improved the PDS beneficiaries to 2/3 of the total population and shifted the PDS paradigm towards the right based approach.

In recent years, GoI started modernising PDS with the help of Information Communication Technology (ITC) to make it more accountable and reduce the leakages in PDS. Digitisation of Ration cards, Aadhaar seeding, Electronic Point of Scale (EPoS), Integrated management of PDS, etc., are some examples of modernisation of PDS.

PDS evolved through the years, and still, it is undergoing evolutionary changes to ensure the access, availability and stability dimensions of food security in India.

4.2 Working of PDS

The public Distribution System of India is one of the most prominent and complicated food distribution mechanisms in the world. The working of the Public Distribution System

includes different activities, including procurement of food grains, storage, transportation and distribution. Each activity is performed by well-defined organisations and having a good infrastructure and policy backbone.

4.2.1 Governance

The PDS is controlled by the Ministry of consumer affairs, food and public distribution in India. The Ministry has individual departments for food and public distribution and consumer affairs. The department of food and public distribution further divided for purchase food grains and storage of food grains (Pal, 2011). FCI also comes under the same Ministry, which handles the procurement of food grains from farmers or Mandis and storage of food grains at different places of the country.

The state government also has responsibility for the implementation and smooth working of PDS. Each state has a department of civil supplies managed by a director of civil supplies. The director helps the Government in day to day activities related to PDS by examine various reports and implement various policies related to food security. Under the director, an office of the commissioner of supplies established the sound functioning of PDS. Apart from that, each district has District offices handling Taluk supply offices and godowns. Taluk supply offices calculate the demand for food grains for each FPS under the jurisdiction of the Taluk and inform the district office and distribute food grains to FPS. FPS s are the endpoints where the consumers get their benefits (*Public Distribution System*, n.d.).

4.2.2 Procurement

The purchase of food grains performed by FCI was established in 1965 and significant duties assigned are purchase food grains from farmers at an efficient price which save the interest of farmers, distribute the food collected throughout the country and maintain a decent buffer stock of food to ensure food safety (Pal, 2011). FCI spans across the country with five zonal offices and 26 regional offices. Approximately 15-20% of the wheat produced by India and 10-15% rice out of India purchased by FCI (Pal, 2011). There is no upper limit for the purchase in terms of quantity and maintain the stock recommended by the Fair Average Quality (FAQ) recommendation. FCI purchase rice and wheat from farmers at a rate named

Minimum Support Price (MSP). Sometimes the grains are collected by the state government agencies and added to the central pool maintained by FCI.

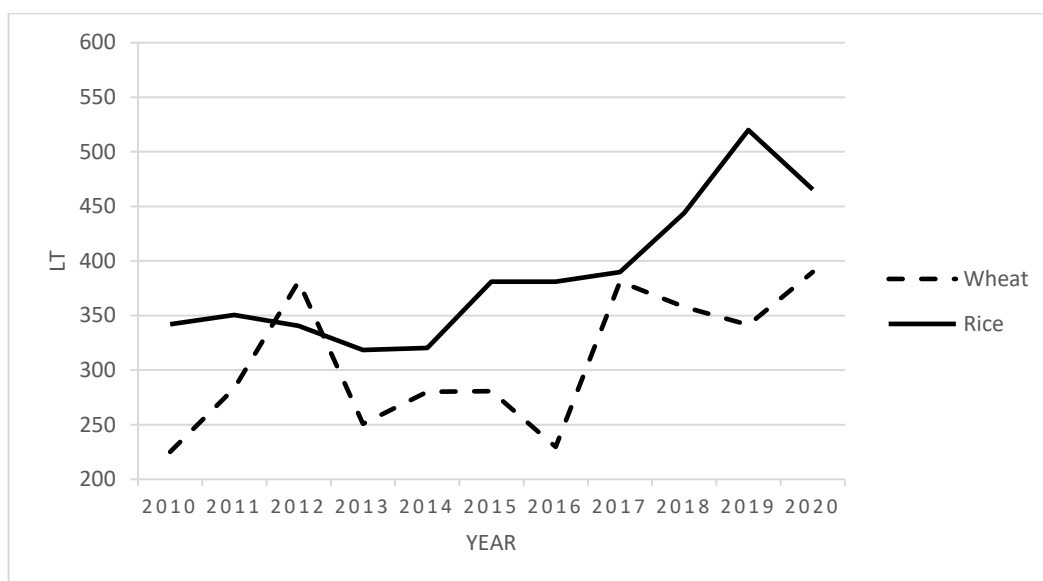


Figure 4.1 Procurement of rice and wheat

Source: Department of food and distribution, GoI

From Figure 4.1, it is clear that the proportion of rice and wheat storage and also provides information about the country's consumption pattern. More populations use rice for their staple food as compared to wheat. From 2010 to 2012, wheat production went high because of increasing cultivation and favourable conditions (Mustard & Singh, 2012). The drought condition in 2013 affected wheat production and badly, which caused a reduction in the procurement of wheat.

4.2.3 Storage

Storage of a large quantity of food grains needs to store across the country is one of the most challenging parts of PDS. The food grains for distribution and buffer stock of PDS need to store. FCI is also handling the storage of food grains as per the requirement of PDS. Apart from FCI, Central Warehousing Corporation (CWC) and 17 State Warehousing Corporations (SWCs) helps store the food grains.

Based on the press release by the Ministry of Consumer Affairs, Food and Public distribution dated 16th July 2019 claimed that a total of 862.45 LMT storage capacity was available, and 85% of the total storage capacity was utilised for storing rice, wheat and pulses

(*Storage of Foodgrains*, 2019). There are mainly three types of storage facilities used to store food grains. They are Large godowns, special type constructions named silo and cover and plinth storage as shown in Figure 4.2.



A view of Cement Silo



Figure 4.2 Silo and Godown

Source: Annual report, GoI

4.2.4 Buffer stock

India can produce more agricultural output than the population's requirement using new technologies, high yielding seed varieties and new irrigation methods. Still, our agriculture faces many risks and which reduce food production rapidly. Buffer stock is a strategy of physical stocking of food grains to use in emergency situations to ensure food security to the people (Kozicka & Saini, 2014).

In India, rice and wheat are the two major crops stored as buffer stock and associated with FCI and CWC and regulated by National Policy On Bulk Handling Storage & Transportation Of Foodgrains (Kozicka & Saini, 2014). GoI controlled the food stock and reframed the policies and regulations related to the stored food grains. The circular by the Ministry of Consumer Affairs Food and Public Distribution in 2015 released one circular related to excess food grains to sell in the domestic or international market is an example. Table 2.1. denote the buffer stock performance of the country for the last decade. According to the annual report of GoI, stock grains in 2021 was 532.79 LMT, where the total amount of wheat was 342.9 LMT, and the amount of rice was 186.69, and the amount of Nutri cereals was 3.2 LMT.

The buffer stock is released to distribute through the domestic market with subsidies with the help of PDS and distributes without subsidies through the open market. A good amount of food grains is exported at an export price.

Table 4.1 Buffer stock: Wheat and Rice Last decade

Source: Directorate of Economics & Statistics, Department of Agriculture & Cooperation

Year	Rice(LMT)	Wheat(LMT)
2000	14.18	17.17
2001	20.70	25.04
2002	25.62	32.41
2003	19.37	28.83
2004	11.73	12.69
2005	12.76	8.93
2006	12.64	6.19
2007	11.98	5.43
2008	11.47	7.71
2009	17.58	18.21
2010	24.35	23.09
2011	25.58	21.54

4.2.5 Fair Price Shops

PDS is working through an extensive Fair Price Shops(FPS) network, functioning in urban and rural regions. As per the national food security portal

(<https://nfsa.gov.in/public/nfsadashboard/PublicFPSDashboard.aspx>), currently, there are 5,45,002 FPS available across 721 districts. FPSs are more utilised by the people than the open market (Ghumaan & Kumar, 2016).

Each FPS is associated with a distributor distributing food grains and maintaining the supply of each FPS. The FPS has a set of beneficiaries, so the demand of each FPS is constant. The total supply by the distributor is equal to the demand of FPSs under him (Chakraborty & Sarmah, 2020). Figure 4.3 Working of FPS showing the schematic diagram of working of FPS.

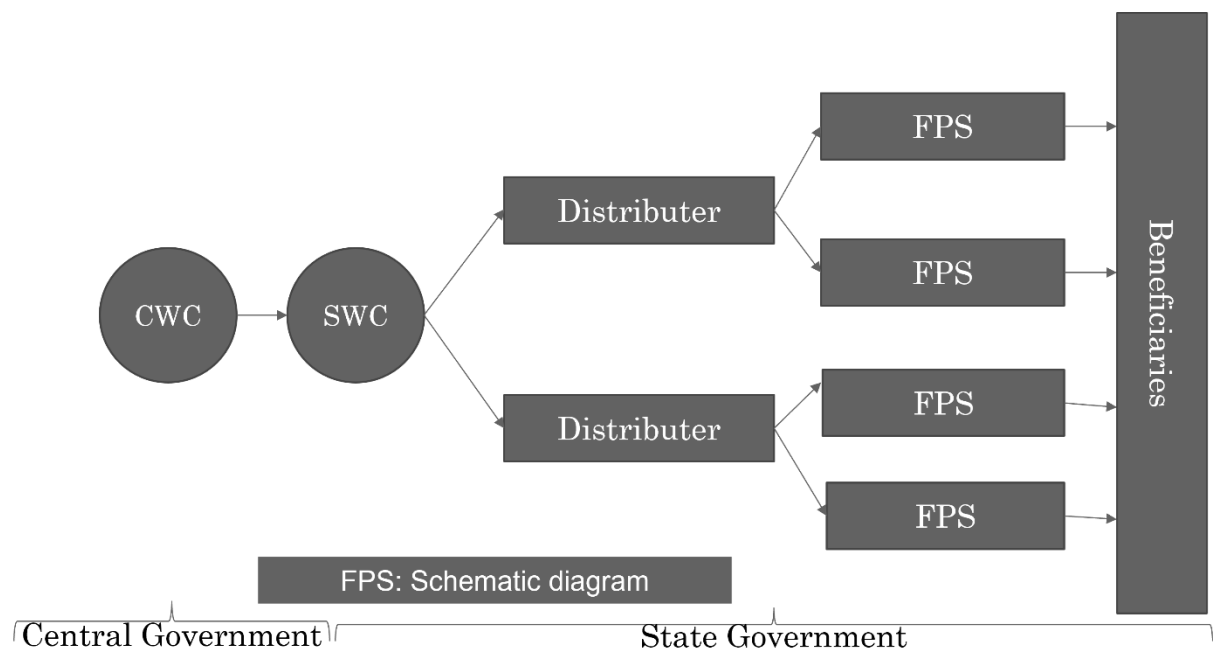


Figure 4.3 Working of FPS

Source: Created by author

4.2.6 Ration Cards

A ration card is a document that contains a unique code and information related to all family members. A ration card is associated with an FPS near the house of each beneficiary. Most states implemented multiple colour ration card systems to distinguish different types of beneficiaries like APL, BPL, and AYY. Table 4.2 explains the colour code system and its benefits as per the state, Maharashtra.

Table 4.2 Ration cards colouring system of Maharashtra

Source: Based on <http://www.mahafood.gov.in>

Type	Colour of cards	Criteria	Benefits	Price rate
AYY	Yellow Ration cards	Annual income up to Rs. 15,000/-	35 Kg/card/month	2 Rs for Wheat, 3 Rs for rice
BPL	Saffron Ration Cards	Annual income above Rs.15,000 and below Rs.1 lakh	5 Kg/Person	2 Rs for Wheat, 3 Rs for rice
PHH	Public House Hold Stamp over saffron	Annual income <Rs.59,000/- (<44,000)	5 Kg/Person	2 Rs for Wheat, 3 Rs for rice
APL	White ration cards	Annual income more than 1L	15 Kg	

The working of PDS includes all the organisations mentioned above. The significant parts of PDS are procurement of food grains from farmers with MSP, storage of food grains at godowns, and distribution of food grains through FPS to the beneficiaries with a subsidised amount. FCI, CWC, state government, distributors, and many others are actively participating in the distribution of food grains from farmers to ensure the country's food security.

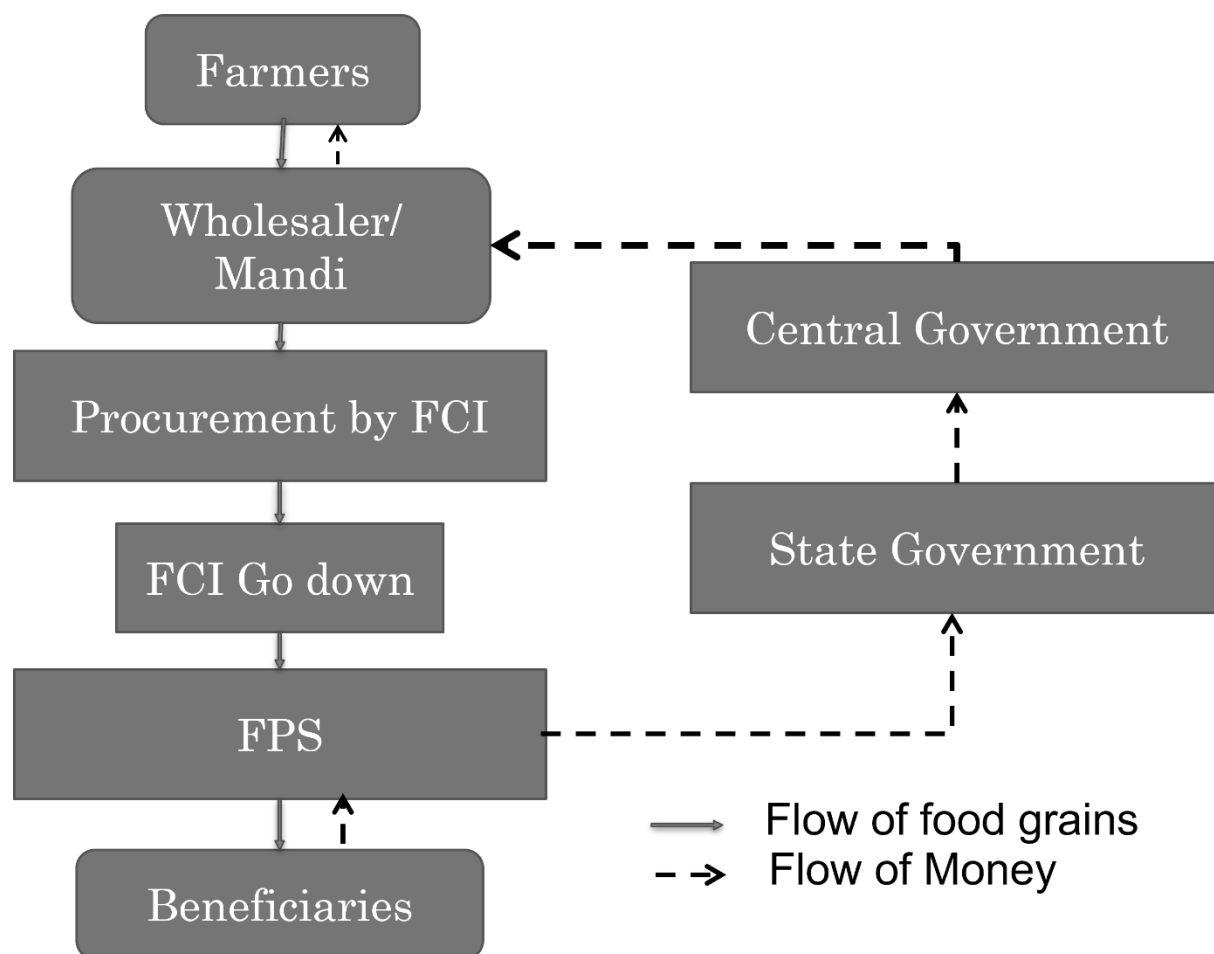


Figure 4.4 Working of PDS

Source: Created by author

4.3 Targeted Public Distribution System (TPDS)

PDS was started by GoI to ensure food security at the household level. The mismanagement, misuse of resources, corruption and inability of the system are the major problems faced by the PDS all over India. The Government relaunched the PDS system as TPDS in June 1997, started operated under central state control (Kattumuri, 2011) and coordinated by the Ministry of consumer affairs and food and Public distribution.

TPDS classified the entire population as Above Poverty Line(APL) and Below Poverty Line(BPL) based on the poverty estimation methodology of the planning commission proposed in 1993-94. TPDS focuses on the poor people of the country. An estimated 6.5 cror

families that come under the BPL category get benefited, and 103 LT food grain earmarked annually.

4.3.1 Properties of TPDS

Targeting: Targeting is the most distinctive feature of the TPDS. TPDS divided the population into APL and BPL, and more focused on BPL and increased their benefits. If the household's annual income falls under Rs 15,000, then the family is considered as BPL.

Dual Prices: This is an important feature of TPDS. TPDS implemented two different issuing prices for food grains. One for BPL household and another for APL household. It provides wheat at 3 Rs/Kg, rice at 2 Rs/Kg and other millets at 1 Rp/Kg. And higher price or open market price for APL households. Another category was introduced and named AAY in 2001.

Central state control: The responsibility of TPDS is divided and provided over Central and State governments. Procurement of food grains, allocation of food grains to states based on the demand and previous usage of each state and transportation of food grains from one state to another state - interstate- are the responsibility of the Central Government. At the same time, identification of APL and BPL, allocation of food grains to each FPS, distribution of food grains to FPS and issuing Ration Cards are the significant duties of state governments.

4.3.2 Significant issues related to TPDS

Conceptual issues: Defining the poor population was one of the conceptual issues faced across the country. Since the state governments classify APL and BPL, different governments use different methodologies to classify the population, making it non-uniformity across the country. This issue leads to inclusion error and exclusion error in the whole system. Some below poverty families are not included in the BPL list (exclusion error), and some APL families are included in the BPL category named inclusion errors. Corruption in the system also helped to raise the number of inclusion and exclusion errors.

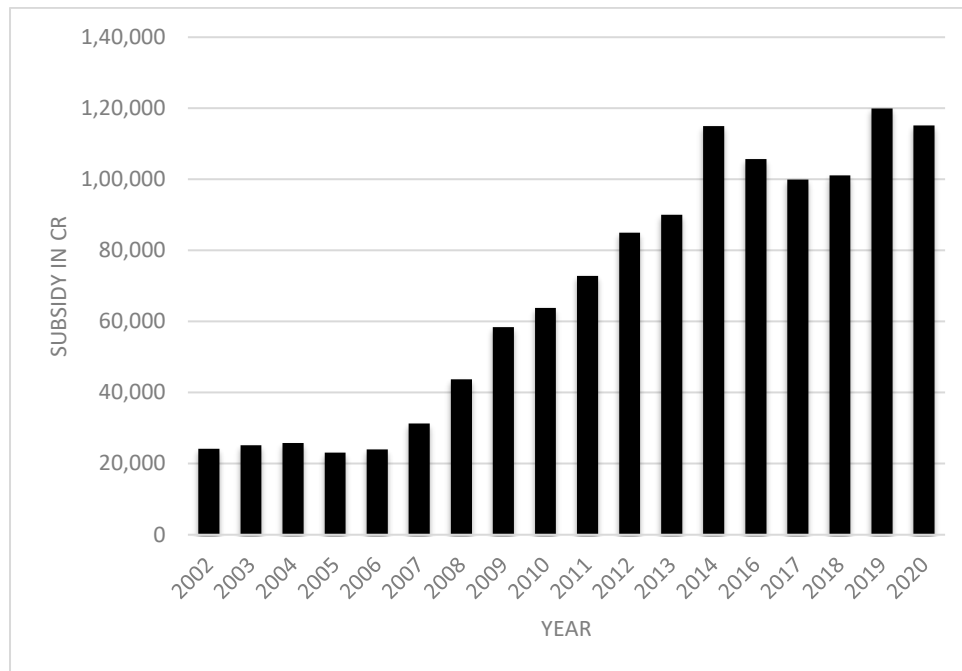


Figure 4.5 Food subsidies

Source: Annual report, Dept. Food and Public Distribution, GoI

Operational issues: These errors happening due to the wrong implementation and practice of the TPDS. Ghost ration cards, leakage and diversion of food grain to open market, late and irregular arrival of food grains at FPS, the enormous burden on subsidy, the viability of FPS etc., are some of the significant issues related to the operation. Figure 4.5 Food subsidiesFigure 4.5 shows the increasing food subsidy by the Government of India. Other major issues are listed below.

- Excess allotment of food grains to FPS, which will either reach the black market or go useless.
- Not considering the previous stock available at FPS, which again leads to wastage of food grains or divert to open market.
- Lack of proper monitoring of rationing system. The Government has no idea about whether the food grain reached the beneficiaries or not.
- Diversion from the godown to the black market. The distributor doing malpractice, and the food grains not reaching FPS in proper quantity and quality.
- Duplicate ration cards and ghost ration cards, which also make the diversion of food grains.

- Lack of proper complaint system to inform about the service or the quality of the food grains.
- Lack of transparency increases corruption at different levels.

4.3.3 Measures took by GoI to improve the TPDS

GoI implemented different modernisation programs on TPDS to eliminate operational issues such as leakage and diversion, inclusion and exclusion error, fake ration cards and lack of transparency. The Government started implementing end to end computerisation with the help of all states and XII five year plan(2012-17). The scheme introduced the following things:

- Digitisation of Ration cards and beneficiaries data: All states started to provide digital ration cards to the people. Completed all states and produced 23.5 Cr ration cards.
- Aadhar Seeding: Connecting beneficiaries Aadhar cards with the ration card to eliminate diversion and fake ration cards. Completed 80% overall, and 91% of new ration cards were connected with Aadhar cards(GoI, 2020).
- Online allocation of food grains to FPS: To avoid overstocking and diversion, all state governments except 2 UT implemented the online allocation of food grains to FPS.
- Computerisation of supply chain: To avoid diversion and leakage, computerisation of the supply chain is implemented in all states.
- Grievance redressal facilities and transparency portals: Every state implemented a toll-free number to address the issues related to TPDS and started web portals to show the current quantities of food grains to increase the transparency of the system.
- Automation of FPS: 92% of the total FPS has electronic Point of Scale (ePoS) facilities for transparent and accurate distribution of food grains to the beneficiaries.

Apart from that Government started implementing new policies and schemes to increase the accessibility of foods to all beneficiaries. National Portability of Ration Cards under Integrated Management Public Distribution System (IM PDS) implemented with a

motive – one nation, one ration card – through which the people empowered to lift their food grains from any FPS as per their choice. As per the annual report of GoI, the scheme will be fully functional in April 2022. The Government started coordinating different departments and ministries such as Railway, Panchayati raj, Ministry of Information and Broadcasting, Prasar Bharati to promote the one nation one ration card programme by creating widespread awareness among the people. Mobile applications have already launched, providing different information related to the scheme.

Evaluation and capacity building initiated by GoI by implementing concurrent evaluation of PDS and NFSA with the help of 12 monitoring institutions (MIs), which conduct evaluation process half-yearly. The training programme started for TPDS functionaries regarding the latest changes in the system. A vigilance committee and social audits were established to reduce the corruption in TPDS along with central portals for showing various information.

To support the viability of dealers, many states increased the dealer's margin from Rs 70 per quintal to Rs 143 per quintal and started allowing the sales of non-PDS items to increase the income of the dealers.

After the implementation of the National Food Security Act (NFSA) in 2013, the role of TPDS became more significant. The act covered 75% of the rural population and 50% of the urban population and was implemented in all the states and UT. In 2020-21, a total of 598.41 LMT food grains were allocated to the people through TPDS, AAY, PHH, MDM and Wheat Based Nutrition Program(WBNP). During the same year, 407.270 LMT food grains were off taken under TPDS(up to December). TPDS expanded and included vulnerable groups like beggars, female domestic workers, sanitation workers etc. Policy changes in TPDS allow the advance lifting for food grains up to 6 months when there would be some financial or environmental issues due to bad weather etc.

Despite all issues, different policy changes, including TPDS, have an important role in securing food security. According to the study by NITI ayog for SDG goal 2, zero hunger clearly indicates that India's performance is improving in terms of coverage of food distribution with the help of TPDS. But, still, India is much behind in many other parameters like the yield of wheat and rice, percentage of children under five who are underweight, percentage of children under five who are under stunted, percentage of people aged 10-19 who are anaemic. Because of these values, India continuously ranked below in the Global

Hunger Index. GHI calculation gives importance to the percentage of children under five who are stunted and wasted.

Chapter 5

Geospatial Technology to Study TPDS

Geospatial technologies have become more advanced and widely used to study social science phenomena nowadays. The availability of social data, free satellite data, the popularity of free and open-source GIS software like QGIS, analysis of complex information within a limited time, preparation of different types of maps etc., are some reasons for selecting GST to study social phenomena. As a part of digitisation, GoI geolocated 40% of its total FPS to analyse TPDS through geospatial technologies. This chapter attempts to introduce different parameters and methodologies for analysing the Targeted Public Distribution System(TPDS) with the help of geospatial technologies.

5.1 Geographic Parameters for studying food security and performance of TPDS

The geographical location of the FPS: The location of the FPS and grocery stores plays a vital role in food security. If the location is near the home and with a walkable distance, then studies show that the people access the shops more frequently and the food security is high(Christina Mary Pollard et al., 2014).

Population density: Population density is critical while considering the success and failure of FPS and TPDS. Studies by Christina and her team showed that the number of grocery stores and food distribution shops should be higher as the population density is higher. A higher number of shops help to make easy access to food items in highly dense regions.

Transportation network: Lack Transportation is an essential infrastructure facility required to ensure food security. The transportation of food grains from the godowns of FCI to FPS required enough transportation facilities. Geodata about the road map and the location of FPS gives a direction toward the connection between food security and transportation network (Christina Mary Pollard et al., 2014).

Climate: Extreme rainfall affects food security in many complex ways. The access and utilisation dimensions of food security are affected by the climate. Rainfall impacts the growth of crops and livestock. It causes social and economic problems that lead to less income and cannot afford to buy food and reach food insecurity. The geospatial data of climate gives an idea about food security and evaluation of the performance of TPDS.

Presence of agricultural land: The studies related to the connection between food security and agriculture land clearly showed that area close to agriculture land has better access and availability of food grains than the places that are away from the agricultural land. The lifting of food grains from FPS needs to study in those regions.

The altitude of the land: The food security at high altitude areas is very challenging. The people at those places consider agriculture as a significant source of food. However, climate change affects agriculture at high altitudes very severely (Merrey et al., 2018). Lack of enough transport facilities to high altitude regions is another burden to any food distribution system. GoI started special programmes for high altitude areas.

Availability of water: Food security is highly dependent upon water security. Water is required in all areas of food security -from the production of food grains to the consumption of food grains. The lack of freshwater required to consume food properly and it affects the utilisation dimension of food security. Lack of water availability also affects health and nutrition in various ways (*Food Security Depends on Water Security – and We Need to Act Now* | IFPRI : International Food Policy Research Institute, n.d.).

Availability of cooking energy: Similar to freshwater, clean cooking energy is required for improving the utilisation of food. World Food Programme implemented sustainable energy to strengthen food cooking methods to reduce hunger and improve food security (*Energy for Food Security* | World Food Programme, n.d.).

Demography: The study by FAO and Asian Development Bank (ADB) found that gender discrimination plays a vital role in food security. The study estimated that 60% of the total under healthy population are women or girls. It required to study how TPDS helped to reduce gender discrimination in food security.

Others: Other parameters like population undernourished, child mortality, children under five who have affected stunting and wasting etc., also need to study with the help of

geospatial technologies to get an idea of spanning of food security and effectiveness of TPDS to ensure food security.

5.2 GST methodologies

There are several methodologies available to analyse the information geospatially with the help of GIS tools. Some of them are,

1. **Overlay analysis:** This is a commonly used technique to analyse different parameters together. The different data map into different layers and combining these layers by adjusting the scales. The technique allows giving different weights to each layer for more accurate layers. The final output is analysed to find particular patterns or areas which satisfy our requirements.

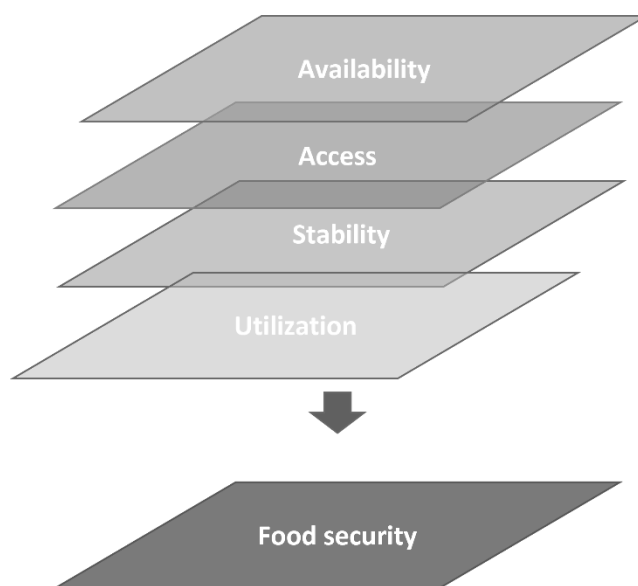


Figure 5.1 Overlay analysis

Source: Created by author.

2. **Routing:** This technique is essential for analysing the supply chain of TPDS, distribution of families around the FPS, etc. It can be used to analyse the optimum location for FPS so that everyone in the area can easily access the FPS with less effort.

3. Satellite images: It is helpful to estimate the elevation of the land, Land Use Land Cover (LULC), population, distribution of families, and availability of transportation facilities etc. The satellite images are freely available from different government portals like Bhuvan.
4. Psycopg: It is a python library used to perform dynamic GIS analysis based on time or location. This is also used to make interactive maps which can be convey more messages.

Chapter 6

Conclusion

The research objectives are to review the role of TPDS in India's food security and to review the various geospatial technologies to evaluate food security and TPDS. The literature review has been done related to the History of India's Public Distribution System from various scholarly articles, websites of governments, non-government organisations. Compared to other nations, India took nearly 25 years to design and implement a food distribution system nationwide, which has many loopholes through which leakage and diversion of food happened. The GoI started the modernisation of PDS through Information Communication Technology (ICT) to reduce leakage and other limitations of PDS across the country.

The PDS of India is one of the largest food distribution systems owned by the Government in the world. Hence, the logistic and implementation activities are much complicated. The significant chunks of logistics handled by FCI were established by GoI in 1965. FCI procure food grains from farmers with MSP- a price mechanism to help farmers to get a reasonable price for their crops. FCI is responsible for the storage of food grains at different parts of the country for present use and for future use called buffer stocks. Distribution of food grain across the states is also done by FCI with the help of Railways or other transportation systems available.

The Targeted Public Distribution came up in 1997 with new ideas such as targeted, dual price and central-state responsibility. TPDS classified the entire population into two categories- Above Poverty Line (APL) households and Below Poverty Line (BPL) households - and focused on the vulnerable group – BPL – by giving more subsidised food grains to them. It created a dual price system - subsidised price for BPL with a rate of Rs 3/Kg for rice, Rs 2/Kg for wheat and Rs 1/Kg for cereals and a regular rate for APL households. The procurement, storage and allocation to the states are done by the Central Government, while the state is responsible for finding the beneficiaries, distribution of food grains to the beneficiaries and establishing FPS. Later in 2013, GoI introduced National Food Security Act (NFSA), which ensure food is a fundamental right. The act changed the paradigm of food

security from No Profit No Loss (NPNL) approach to right based approach. It improved the food security activities and cover 1/3rd of the total population of the country.

Advances in ICT, satellite technology, and areal photography helped improve the GeoSpatial Technology (GST) and digital mapping techniques like GIS, which are now widely used in Social Science. Social science phenomena like poverty, population distribution, food security, economic growth etc., were studied and presented with the help of GST. Many attempts are already made to study food security using GST in different parts of the world by FAO, WFP, and different academic institutions.

Various geospatial technology, including Remote Sensing (RS), Geo Informatic System (GIS), Global Positioning System (GPS), are studied in detail. Found out some key parameters such as population, elevation, climate, transportation facilities etc., from literature to evaluate food security and performance of TPDS. The overlaying, routing, etc, using GIS learned for future works of the research. Table 6.1 gives a brief idea about the research objectives and findings of the research.

Table 6.1 Research objectives and findings

Source: Created by the author

Objectives	Research Questions	Sub Questions	Findings
To review the role of TPDS in India's food security	What is the role of TPDS in India's food security?	1. How did the TPDS evolve through the years	1. Studied the evolution of PDS to TPDS in detail.
		2. What are the logistical activities behind the TPDS	2. Studied different logistic activities like procurement of food grains from farmers, storage and distribution of food grains.
		3. How TPDS help to achieve the food security	3. Studied the impact of Food security.
To review the various geospatial techniques to evaluate the food security	What are the geospatial techniques to review food security?	1. What are the specific technologies that can use to analyse food security?	1. Reviewed literature to understand different geospatial technologies to analyse food security.
		2. What are the key parameters and data to consider for analyse TPDS?	2. List out different key parameters for evaluating the performance of TPDS.

6.1 Contribution and limitation

This research gives an in-depth idea about the food security, public distribution system and its evolution in India and strategies followed by other nations to reduce food insecurity. It introduces the evaluation of food security, different GST methodologies to evaluate food security. This study gives an idea about how GST can be used to evaluate the performance of TPDS.

Due to the COVID 19 Pandemic condition, the field study was not possible to precisely understand the ground reality of food security in India. The available literature is more focused on governance and logistic aspects. Due to the small time frame, the study can not include other scenarios like the effects of COVID 19, frequent extreme weather conditions, political changes in food security.

6.2 Future Work:

Collect all available geospatial information to evaluate food security and the performance of TPDS using GIS techniques. Field visits and semi-structured interviewing with different stakeholders were planned to triangulate the findings from the analysis.

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