SPATIAL MAPPING OF FOOD AND NUTRITION SECURITY AND ASSOCIATED NUTRITION INDICATORS USING SECONDARY DATA SOURCE

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SPATIAL MAPPING OF FOOD AND NUTRITION SECURITY AND ASSOCIATED NUTRITION INDICATORS USING SECONDARY DATA SOURCE

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CERTIFICATE

This is to certify that the research work presented in this thesis has been carried out independently by Ms. Payal Meghani under the guidance of Dr. Suneeta Chandorkar in pursuit of Degree of Master of Science (Family and Community Science) with major in Foods and Nutrition (Public Health Nutrition) and this is her original work.

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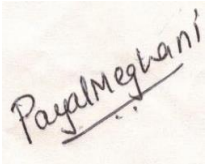

Payal Meghani

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ABSTRACT

ABSTRACT

India has positively progressed on several health outcomes, but the state of food and nutrition security demands more work in the country The Sustainable Development Goal SDG 2 aims to 'End hunger, achieve food security and improved nutrition and promote sustainable agriculture.' by 2030. Food and nutrition security can be achieved by increasing the ability of individuals to access good quality and nutritious foods which are affordable and available at all times. Spatial analysis using GIS technique provides better understanding of changing relationships between food security, effects of climate change, health and nutrition outcomes. This study performs spatial mapping of food and nutrition security to determine its association with agriculture, health and nutrition. Food safety net programs are a basis to improve food and nutrition security status among population. This study also reviews their utilization across India through geospatial analysis.

The data was drawn from all accessible secondary data sources such as national health surveys (NFHS), household consumption survey (NSSO) and agricultural statistics from Ministry of Statistics and Programme Implementation.

The spatial analysis of agroclimatic zones of India and Gujarat identified different cropping systems in each zone and supports the evidence that agroclimatic regional planning can play a major role in improving food and nutrition security. The per capita availability of food grains and pulses showed a decline in the year 2019. However, the estimated per capita availability for 2020 has showed an upward trend.

Spatial variations in utilization of health and nutrition services provided by ICDS across various districts of Gujarat were observed in 2019-20. The weighted sum spatial analysis reveals high prevalence of child undernutrition (stunting, wasting & underweight) in Tapi, Panch Mahals, Dangs, Aravalli, Mahisagar, Chota Udepur, Narmada and Dahod districts whereas lowest in Porbandar and Junagadh. Pearson's correlation between undernutrition in under five children and its co-variates indicates maternal education, maternal nutritional status and improved drinking water & sanitation to be significantly associated with prevalence of undernutrition. Geographically Weighted Regression (GWR) model showed

regional disparities in association between maternal, child care, socio-economic indicators and prevalence of underweight and anemia in under-five children (6-59 months) in Gujarat.

Spatial analysis through Inverse Distance Weighted (IDW) interpolation method for number of meals served in schools reported higher number of meals served in Vadodara, Savli, Padra and Karjan blocks of Vadodara district in the year 2018.

The spatial mapping of utilization of PDS across various states of India reported the share of PDS in consumption of rice, wheat and sugar to be higher for rural sectors as compared to urban sector in 2011-12.

The minimum dietary diversity for women (MDDW) reported lowest score of two and one in rural and urban India respectively. Only six to seven states were able to achieve minimum score of five food groups in rural & urban India in 2011-12.

The future strategies should be spatially targeted with focus on improved agricultural planning, better health and nutrition services provided by food safety net programs and dietary diversity to combat the situation of food and nutrition security in India and achieve the target of SDG-2 by 2030.

INTRODUCTION

1. INTRODUCTION

Food insecurity (that measures hunger) showed an upward trend during 2019 and an estimated 2 billion people in the world did not have regular access to safe, nutritious and sufficient food and 750 million or one in ten people were exposed to severe levels of food insecurity. The COVID-19 pandemic may add an additional 83 to 132 million people to the ranks of the undernourished in 2020. Beyond hunger, a growing number of people have had to reduce the quantity and quality of the food they consume. These trends in food insecurity are likely to affect diet quality of the vulnerable groups and people's health in different ways. **(FAO, IFAD, UNICEF, WFP and WHO. 2020. The State of Food Security and Nutrition in the World 2020).**

The Global Hunger Index (GHI) measures and tracks hunger based on four indicators- undernourishment, child wasting, child stunting and child mortality at global, regional and national level. India has 189.2 million undernourished people and ranks 94 out of 107 countries on the Global Hunger Index which comes under the serious hunger category with a score of 27.2. (*About: The Concept of the Global Hunger Index - Global Hunger Index (GHI) - Peer-Reviewed Annual Publication Designed to Comprehensively Measure and Track Hunger at the Global, Regional, and Country Levels*, n.d.)

In India, the prevalence of under-five stunting and wasting remains high at 37.9% and 20.85% respectively as of 2015. (India Country Profile, GNR,2020). Progress is being made on decreasing child stunting and low birthweight and on increasing exclusive breastfeeding for the first six months of life. However, the prevalence of wasting is notably above the targets and the prevalence of both child overweight and adult obesity is increasing in almost all regions. COVID-19 is expected to exacerbate these trends, rendering vulnerable people even more vulnerable. (FAO, IFAD, UNICEF, WFP and WHO. 2020. The State of Food Security and Nutrition in the World 2020). Sustainable Development Goal (SDG 2) seeks sustainable solutions to end hunger in all its forms by 2030 and to achieve food security. The aim is to ensure that everyone everywhere has enough good-quality food to lead a healthy life. However, current estimates indicate nearly 690 million people are hungry and close to 750 million people in the world are exposed to severe levels of food insecurity. More than one-fifth people in Asia are food insecure and

if the recent trends are not reversed, the SDG 2.1 Zero Hunger target cannot be met by 2030. Achieving this Goal will require better access to food and the widespread promotion of sustainable agriculture. **(FAO,2020).**

Food and nutrition security can be achieved by increasing the ability of individuals to access good quality and nutritious foods which are affordable and available at all times. However, in addition to provision of accessing nutritious food, the food systems have to take account for external conditions such as climate change which moderate the accessibility to nutrition. Climate change is considered as one of the greatest threats for food and nutrition security. The minimum temperature increase has been around 1 degree Celsius in India as suggested by satellite data which may further increase by 2 to 4 degrees Celsius. The availability of food and nutrients is expected to affect by changes in optimal growing conditions for crops and increasing the uncertainty for extreme weather events. The agricultural production is also affected lowering the access to nutrition in already available foods for consumption which also affects the overall health quality of individuals.**(Pingali et al., 2019b).** The climatic classification in terms of agroclimatic and agroecological zones helps in determining the different features of a region and thereby providing an insight to farmers to grow the crops according to the climatic conditions of their region**.(Adnan et al., 2017).** Agrobiodiversity is widely being perceived as a promising strategy to improve dietary quality and diversity. Therefore, it is important to understand the relationship between agrobiodiversity and dietary diversity, as this could help in tackling the complex problem of malnutrition. **(Gitagia et al., 2019)**. India has been divided into 15 agroclimatic zones by the Planning Commission which can be used as a basis to improve the dietary diversity and food security. The application of remote sensing techniques along with geographic information system (GIS) can reduce the amount of field work and provide a considerable contribution such as for mapping of agricultural land and agroecosystem zones**.(Murti, 2018)**

Food security can be analyzed through various approaches and various tools are used to gather data such as household dietary intake surveys, household expenditure surveys, food security measuring scales, etc. Whilst these tools are crucial part of the public health toolbox, the information provided by such tools is not easily interpreted and such data lacks

to reveal the direct correlation between geographic location and health and nutrition security.**(Graham et al., 2011)**. Geographic Information System play an important role in better understanding of food security across the globe. Due to an increased population density across the globe and several agricultural limitations the spread of food deserts is increasing. Food deserts are the impoverished areas with limited access to fresh affordable food. Therefore, for the identification of such food deserts Geographic Information System (GIS) can help in examining the spatial links along with the threats to food security sources in a given environment. For example, spatial analysis of food availability for a given area can help to develop strategic plans for the future by shedding light upon the food deserts. **(GIS for Food Security | GeoMarvel, n.d.)**.For identification of such hotspots of food and nutrition insecurity, utilization and coverage of food safety net programs in India is to be known.

Food assistance at various stages of life is provided through ICDS, MDMS, and PDS with a life-cycle approach to food security. India has enacted the following food-based safety nets to improve food and nutrition security

1. Integrated Child Development Scheme (ICDS),1975
2. Mid-Day Meal Programme (MDM),1995
3. National Food Security Act (NFSA) 2013.

The Integrated Child Development Scheme (ICDS) launched in 1975 by the Government of India is one of the world's largest flagship programmes. The programme aims to improve early childhood care, nutrition and development at village and AWC (Anganwadi Center) level. The program delivers a range of services broadly classified as pre-school and non-formal education, supplementary nutrition, immunization, health and nutrition education, health checkups and other referral services for pregnant women, breastfeeding mothers and children up to six years. However, in India every second child (0-59 months) suffers from some kind of malnutrition (stunting, wasting and underweight) according to National Family Health Survey (NFHS) 2015-16. ICDS program has an instrumental role in addressing the high burden of maternal and child undernutrition. There has been a greater emphasis on improving inter-departmental coordination and programmatic performance

since the launch of POSHAN (Prime Minister's Overarching Scheme for Holistic Nourishment) Abhiyan to reduce the rises in child undernutrition. Some concerns still exist about ICDS such as lack of infrastructure, issues regarding unskilled and underpaid staff and political will for implementation varying its performance by states. The key for better performance of the programme is a holistic understanding of utilization patterns of all services provided across urban and rural settings and solutions to challenges of socioeconomic and geographic inequalities in accessing the services under this umbrella scheme. **(Rajpal et al., 2020a**) **(Pingali et al., 2019a)**

The Mid-Day Meal (MDM) Programme, one of largest school feeding programme aimed at improving enrolment and retention rates at school as well as improving nutritional intake of children. Under this programme, hot cooked mid-day meal containing minimum 450 kilocalories and 12 grams of protein per day for primary students and 700 kilocalories and 20 grams of protein for upper primary (6-8) students for minimum of 200 days per year. The programme successfully managed to increase school enrolment rates, but the impact on child nutrition has been a topic of concern as supplementation of food and low-quality food. The school meals have low nutrient intake in comparison to daily requirements for macro and micronutrients. Also, issues like inadequate infrastructure at schools, lack of trained and sufficient staff, inadequate accountability mechanisms and improved nutrient composition need immediate attention to make Mid-Day Meal programme more effective. **(Pingali et al., 2019a)(Anitha et al., 2019)**

NFSA, with the aim to provide food and nutritional security by ensuring access to adequate quantity of quality food at affordable prices to people was passed in 2013 in the Indian Parliament. It further aims expansion of the coverage of PDS to about 75% rural and 50% urban population by providing monthly entitlements including 5 kg of grains per person at highly subsidized rate of Rs. 3/2/1 per kg for rice/wheat/coarse grains. The poorest household identified continues to receive 35 kg food grains per month. The Fair Price Shops (FPS) as the outlets ensure the huge procurement of food grains by government. However, inefficiencies like corruption and leakages were rampant in the system of procurement and distribution, given its huge size and therefore PDS being criticized as poorly designed with targeting errors, corruption prone, leaky and a drain on fiscal capacity

of the government. One of the major challenges for various schemes in a targeted program is the identification of beneficiaries. The criteria for identification of poor households are often vague and due to political favoritism, the poor are being left out of schemes meant for them. The PDS entitlements are universal in states like Tamil Nadu, Chhattisgarh, Himachal Pradesh and parts Odisha and therefore better performance with lower rates of leakages. Most of the states still continue targeted PDS despite the success of universal PDS. However, it is expected to expand the share of targeted beneficiaries across most of the poorer regions. **(Pingali et al., 2019a)**. Access to the Public Distribution System (PDS) has contributed to enhancement of dietary diversity as PDS beneficiaries are better able to afford diverse food items. In contrast, low social status in the form of affiliation to scheduled castes/scheduled tribes (SC/ST) diminished diversity scores.**(Parappurathu et al., 2015).**

Dietary diversity is one of the commonly used indicators for the assessment of healthy dietary habits and maybe defined as the variety of foods across and within food groups capable of ensuring adequate intake of essential nutrients that promote good health. Changes in dietary pattern is positively associated with increased incidences of overweight, obesity, cardiovascular diseases, etc**. (Vellaichamy et al., 2018)**. The Minimum Dietary Diversity for women of reproductive age (WRA) is a food group diversity indicator that helps in reflecting the micronutrient adequacy which is key dimension of diet quality. The groups of women of reproductive age (WRA) if consume food items from at least five of the ten food groups are likely to have higher micronutrient adequacy. A higher prevalence of MDD-W is considered as proxy for better micronutrient adequacy among WRA in population.**(FAO & FHI 360, 2016)**. However, specific food groups are particularly lacking such as Vitamin A rich fruits and vegetables, animal sources and nuts and oilseeds. It is important to investigate the composition of women's diet by analysis of individual food group consumption to promote greater diversity.**(Adubra et al., 2019)**

Spatial mapping can bring a major difference through identifying the trends and patterns in food security as well as dietary diversity and helps in improving the decision-making for

improving the food and nutrition security and therefore, the study aims to analyze food and nutrition security with help of spatial mapping.

❖ RATIONALE

- As per the current progress towards achieving SDG-2, India is off-track in achieving the goal by 2030.
- Spatial mapping is a useful technique to identify the hotspots of undernutrition, hunger, food deserts and food swamps.

Therefore, can be used for effective utilization of resources and effective strategic planning towards improved food and nutrition security

I. BROAD OBJECTIVE

- To analyze food & nutrition security and dietary diversity through spatial mapping for selected population groups using secondary data source.

II. SPECIFIC OBJECTIVES

- To perform spatial mapping of agroclimatic zones of India and sub-agroclimatic zones of Gujarat.
- To perform spatial mapping of agroclimatic features and crop patterns (Rabi & Kharif) of districts of Gujarat.
- To perform spatial mapping of coverage and utilization of food safety net programs (ICDS, MDM, TPDS) using secondary data source.
- To perform spatial mapping of dietary diversity in women from various states of India using secondary data source.

- To perform spatial mapping of consumption of fat, sugar and ultra-processed foods and prevalence of overweight, obesity and NCDs in adult population from various states of India using secondary data source.
- To perform spatial mapping of food and nutrition security in population at national level, state of Gujarat and districts of Gujarat using secondary data source.
- To study the association between agrobiodiversity, dietary diversity, utilization of food safety net programs and food and nutrition security

REVIEW

OF

LITERATURE

2. REVIEW OF LITERATURE

❖ The review of literature is followed by the following chapter heads:

2.1 Food and nutrition security.

- ✓ Introduction
- ✓ Overview of food and nutrition security.
- ✓ Linkages between food security and its determinants.
- ✓ Spatial mapping of Food and Nutrition Security.

2.2 Food and Nutrition Security and Climate Change.

- ✓ Linkages between climatic change and food security.
- ✓ Linkages between climate change and dietary diversity.
- ✓ Agroclimatic Zones of India.
- ✓ Spatial mapping of agroclimatic zones.

2.3 Food Safety Net Programs.

- ✓ ICDS
- ✓ MDM
- ✓ TPDS
- ✓ Utilization and coverage of ICDS, MDM & TPDS in India.
- ✓ Role of ICDS, MDM & TPDS in improving food security and malnutrition.

2.4 Food security and undernutrition.

- ✓ Food Security & its association with malnutrition.
- ✓ Linkages between Dietary Diversity and Undernutrition.
- ✓ Spatial mapping of dietary diversity & associated factors.

2.5 Food security and dietary diversity.

- ✓ Food security & its association with dietary diversity.
- ✓ Minimum Dietary Diversity for Women (MDDW).

2.1 Food and Nutrition Security.

"Food and Nutrition Security is achieved, if adequate food (quantity, quality, safety, socio-cultural acceptability) is **available** and **accessible** for and satisfactorily **utilized** by all individuals at all times to live a healthy and happy life**."** **(Food and Agriculture Organization of the United Nations, 2006)**

- Overview of food and nutrition security.

Five years after the world committed to end hunger, food insecurity and all forms of malnutrition, an estimated 2 billion people in the world did not have access to safe, nutritious and sufficient food and 750 billion people were exposed to severe levels of food insecurity showing an upward trend during 2019. The current estimate for 2019 has revealed that an additional 60 million people have been affected by hunger since 2014. The COVID-19 pandemic is likely to add an additional 83 to 132 million people to the ranks of undernourished in 2020. **(FAO, IFAD, UNICEF, WFP and WHO. 2020. The State of Food Security and Nutrition in the World 2020).**

Figure 2.1- Prevalence of undernourishment in world.

Source:- **(FAO, 2020)**

Sustainable Development Goals (SDG 2) aims to end all forms of hunger and malnutrition by 2030 and ensure access to sufficient food throughout the year. The promotion of sustainable agriculture will aid in achieving the goal. The first target (2.1) includes prevalence of undernourishment and moderate or severe food insecurity. Globally, nearly 690 million people are hungry and India has 189.2 undernourished people. The prevalence of moderate and severe levels of food insecurity is estimated to be 25.9 percent in 2019 for world as whole. More than one-fifth people in Asia are food insecure and if the recent trends are not reversed, the SDG 2.1 Zero Hunger target will not be met by 2030. **(FAO, 2020)**

Ending hunger and malnutrition requires sustained policy discipline for food and nutrition security pointing towards a diverse set of requirements. In many developing countries, there is a lack of reliable, regularly produced, and spatially disaggregated data as they often rely on household data. Spatially targeted FNS interventions using geographic targeting is a cost-effective alternative to other methods, such as targeting based on household

characteristics. Food and nutrition security interventions which are spatially targeted based on household characteristics can be a cost-effective alternative to other methods **(Marivoet et al., 2019).**

Sustainable food security is achieved when agriculture can produce adequate food grain as well as raw material to meet nutritional needs for population. There is a high variation in weather and geographical parameters across states in India. Agricultural biodiversity enhances livelihoods security of farming community and also contributes more nutritious diets. The influence of climatic and non-climatic factors on sustainable food security when assessed in India by a state-wise FSI (Food Security Index) using a composite Z-index approach, there existed significant food inequalities across Indian states due to climatic change and variation in socio-economic variables. Poverty is significantly associated with food security and is most detrimental factor to sustain food security.**(Ajay Kumar et al., 2017)**

The five common characteristics strongly associated with experiencing food insecurity when identified using Food Insecurity Experience Scale (FIES) globally in 134 countries to were: - less social capital, low education levels, weak social networks, unemployment and low household income. Over economic development rankings, there exists significant heterogeneity in determinants of food security therefore country specific policies should be encouraged rather than a blanket approach.**(Smith et al., 2017)**

While, Food Security Index (FSI) using district-level secondary data for 2016 and indicator approach for districts of Gujarat reported the highest food security status for Ahmedabad (0.507) and the lowest for Porbandar (0.236). The major indicators influencing food security status among districts of Gujarat were identified such as for lower food availability lower per capita availability of food grains, vegetables, fruits, oilseeds, spices and condiments. There was existence of significant food inequality due to variations in socioeconomic variables across districts of Gujarat.**(Singh & Singh, 2019).**

Food security is a multidimensional phenomenon and lack of access to sufficient quantity of nutritious food being a key component of food security is a potential risk factor for child

and adult malnutrition. There are multiple pathways that link the food insecurity with malnutrition such as dietary diversity. Dietary diversity plays a mediating role for the same as food insecure households have larger chances to have children who have lower nutrient intakes. **(Maitra, 2018)**

The association between calorie intake and socio-economic factors differ even from region to region within a country. Therefore, the government can directly support low-income households by allocation of the subsidies based on geo-location of vulnerable households. The implementation of spatially targeted approach rather than one size-fits-all policies would decrease the geographic disparities of food security. (**Pakravan-Charvadeh et al., 2020)**. Identification of location and size of urban food deserts can be done using simple and cost-effective methods using income, location of food stores, population and on the ground verification.**(Slater et al., 2017).**

2.2 Food and Nutrition Security and Climate Change

Climate variability and extremes are among the key drivers behind rise in global hunger and leading cause of severe food crisis. The dimensions of food security – food availability, access, utilization and stability are undermined by the cumulative effect of changes. Nutrition being highly susceptible to climatic changes bear a heavy burden leading to impaired nutrition and dietary diversity of foods produced and consumed. The other underlying causes of malnutrition relating to child feeding and care, health services as well as environmental health are also reinforced by climate variability. (**FAO, IFAD, UNICEF, WFP and WHO. 2018).**

India has variety of climates such as in the tropical in south to temperature and alpine in the Himalayan north with elevated areas receiving sustained snowfall during the winter months. The climates of India are mainly classified into four groups- Tropical Dry, Tropical Wet, Mountain and Sub-Tropical Humid**. (Ministry of Statistics and The World Food Programme, 2019)**

The fluctuations in minimum and maximum temperature and uncertainty in patterns of rainfall in India negatively impact the food security. The adverse effects of changes in climate in farming can be diminished by initiation of season-wise crop specific policies by Indian farmers. The measures such as change in cropping pattern or dual cropping system and change in sowing time can be used for policies specific for season-wise farming**. (Ajay Kumar et al., 2017)**

- **Agroclimatic Zones and its association with food security.**

Food Security is directly dependent on agricultural production. Agricultural biodiversity with appropriate use contributes to more nutritious diets and encourages the livelihoods security of the farming community. Soil quality, soil fertility, arable land, irrigation facilities and climate change are the strategic determinants of agricultural production. There exists high variation in weather and geographical parameters across India. Nearly half of Indian population is dependent upon climate-sensitive sectors such as agriculture. Climatic factors affects the food security in several ways such as changes in rainfall pattern during crop season have a negative effect on yield and increase in minimum and maximum temperature also negatively influences the food security.**(Ajay Kumar et al., 2017)**

Agroclimatic zone is a land unit in terms of major climates suitable for a certain range of crops and cultivars. India has been divided into 15 agroclimatic **zones** by the Planning Commission based on soils, physiography, geological formation, cropping pattern, climate, and mineral resources for agriculture planning and future strategies development and irrigation development. **(Ministry of Statistics and The World Food Programme, 2019).** The classification of states by agro climatic zones in India are shown in table 2.1

Gujarat comes under **13th agroclimatic zone (**Gujarat Plains & Hills Region) and is further divided into **sub-agroclimatic** zones. The cropping pattern of Gujarat includes mainly Kharif crops: - sorghum, Bajra, Maize, Paddy, Groundnut and Rabi crops: - cotton, wheat, mustard, cumin and vegetables. Sugarcane is also grown in some districts. (https://farmech.dac.gov.in/FarmerGuide/GJ/index1.html)

Table 2.1- Classification of states by agro climatic zones of India.

Sr. No	Agroclimatic Regions/zones	States
1	Western Himalayan Region	Jammu and Kashmir, Himachal Pradesh, Uttarakhand
2	Eastern Himalayan Region	Assam, West Bengal, Mizoram, Manipur, Andhra Pradesh, Tripura, Meghalaya, Sikkim,
3	Lower Gangetic Plains Region	West Bengal
4	Middle Gangetic Plains Region	Uttar Pradesh, Jharkhand, Bihar
5	Upper Gangetic Plains Region	Uttar Pradesh
6	Trans-Gangetic Plains Region	Punjab, Delhi, Haryana and Rajasthan
7	Eastern Plateau and Hills Region	Maharashtra, Jharkhand, Chhattisgarh, Orissa, and West Bengal
8	Central Plateau and Hills Region	Madhya Pradesh, Uttar Pradesh, Rajasthan & Chhattisgarh
9	Western Plateau and Hills Region	Maharashtra, Chhattisgarh, Madhya Pradesh & Rajasthan
10	Southern Plateau and Hills Region	Andhra Pradesh, Tamil Nadu, Karnataka, Telangana, Chhattisgarh
11	East Coast Plains and Hills Region	Orissa, Tamil Nadu, Andhra Pradesh & Pondicherry
12	West Coast Plains and Ghat Region	Tamil Nadu, Kerala, Karnataka, Goa, Gujarat, Maharashtra
13	Gujarat Plains and Hills Region	Gujarat, Rajasthan, Madhya Pradesh, Maharashtra
14	Western Dry Region	Rajasthan
15	The Islands Region	Andaman and Nicobar & Lakshadweep

The agroclimatic zones of Gujarat are as follows-

I.	South Gujarat (Heavy rainfall)	V.	North- West Zone
II.	South Gujarat	VI.	North Saurashtra
III.	Middle Gujarat	VII.	South Saurashtra
IV.	North Gujarat	VIII.	Bhal & Coastal Area

Agroecology was found to be one of the significant determinants of household food security. The determinants of household food security among the selected non-farm households under changing climate and examination of food security status when studied revealed that a shift in agroecological zones would increase the probability of being food insecure household by 2.5016. By supporting as well as promoting smallholders for optimal land allocation decision for improved soil and nutrient management that would further improve agricultural productivity. **(Amare & Simane, 2017)**

Improved global cropland data can be an essential ingredient for food security but lack of accurate maps and particularly the spatial distribution of major crops types could impede efforts to improve food security. **(See et al., 2015).** Mapping of agroclimatic zones permit recognizing areas with different potential products according to the climate change environmental conditions.(**Alwan et al., 2019)**

The agroecosystems play an important role especially for farmers and subsistence farming in determining food insecurity status. The spatial analysis of household food insecurity with respect to agroecosystems vary from area to area as local crop productivity might fluctuate the seasonality which is based on suitability of harvest period. The food and nutrition security is affected even in areas with high crop production and therefore food insecurity interventions are necessary for such areas also. The areas with poor agroecological conditions and low climate adaptivity experience higher household food insecurity. To develop interventions at micro-level and allocate the resources it is important to identify the vulnerable hotspots using spatial analysis based on agroecosystems and household food insecurity**.(Alemu et at., 2017)**

2.3 Food Safety Net Programs

Food safety net programs are a basis to improve food and nutrition security status among population. By reviewing the utilization and coverage of these programs can help us identify the vulnerable areas of food insecurity. India has enacted the following food-based safety nets to improve food and nutrition security:

2.3.1 Integrated Child Development Scheme (ICDS),

2.3.2 Mid-day Meal Program (MDM) and

2.3.3 Targeted Public Distribution System (TPDS)

2.3.1 ICDS

ICDS began in 1975 with an aim to provide nutritional assistance to pregnant and lactating mothers and children under six years of age. The performance of ICDS has made a remarkable improvement in last decade driven by advocacy efforts for prioritizing nutrition on the national agenda. However, concerns about political will, inadequate infrastructure, issues of unskilled and under-paid staff still exist about ICDS implementation.(**Pingali et al., 2019a)**

As per NFHS-4, India is suffering from high burden of maternal and child undernutrition. On examining the utilization of ICDS by NFHS survey, service utilization by mothers during pregnancy was higher for rural areas than urban areas and a lower uptake of services related to health and nutrition education in pregnancy and early childhood. One in every two mother-child pairs did not avail any benefits from ICDS in urban areas of India.**(Rajpal et al., 2020b).**

The prevalence of malnutrition was found to be less among children receiving supplementary nutrition when compared to those who did not in Patiala. Gender, immunization status, birth order and maternal educational status were significantly associated with the nutritional status however socio-economic status of family was not significantly associated. The proportion of children immunized who were underweight was

lower (31.34%) than the proportion among unimmunized children (38.91%). **(I. Jain et al., 2020)**

The IEC and BCC activities should be strengthened to bridge the gap in awareness for services and beneficiaries under ICDS scheme. In cross-sectional study of Tamil Nadu, it was revealed that beneficiaries not utilizing ICDS services, 48.5% were unaware about the scheme while 51.5% were aware yet not utilizing the ICDS services. **(Chitra A et al., 2018)**

The reasons behind non participation of adolescent girls in ICDS scheme and gaps in KAP practices were studied using sequential explanatory mixed method in urban Rishikesh. Among the 400 adolescent girls, about 15 (3.75%) had visited AWC for supplementary nutrition whereas only 13 (3.25%) had visited for IFA supplementation. The barriers to poor utilization were found to be lack of awareness, poor supply of IFA/THR, poor monitoring and inadequate health education sessions**. (S. Chowdhury & Chakraborty, 2017).**

While assessing the utilization of supplementary nutrition service at rural areas of Bareilly district, maximum utilization was by lactating mothers (85%) followed by pregnant women (83.6%) and adolescent girls (78.8%). The maximum service gap was found in children of age group >3 years. Also, the major reason provided by the beneficiaries was disliking the taste of supplementary food for not consuming the same.**(Khan et al., 2016)** While in Odisha, more than 85% of the AWCs did not have designated building for daily functioning which resulted in **poor implementation of program** due to inadequate infrastructure and logistic supply. (**Sahoo et al**., **2016)**

2.3.2 MDM

The Mid-day Meal scheme, a school meal programme of the Government of India provides free lunches to children in primary and upper primary classes on working days. The programme was designed with the view to improve the nutritional status of school age

children in India and has several benefits such as encouraging children from disadvantaged sections for schools and improved regularity.**(Sulaiman, 2020)**

The MDM intake by students in total days and impact of MDM in physical growth of students was assessed in Surendranagar city, Gujarat. Surendranagar is one of the districts with low literacy rates and enrolment rates were lowest among the Saurashtra municipalities. As per BMI calculations, height and weight were calculated for students (class VIII) and attendance number of students were collected from general register of schools.

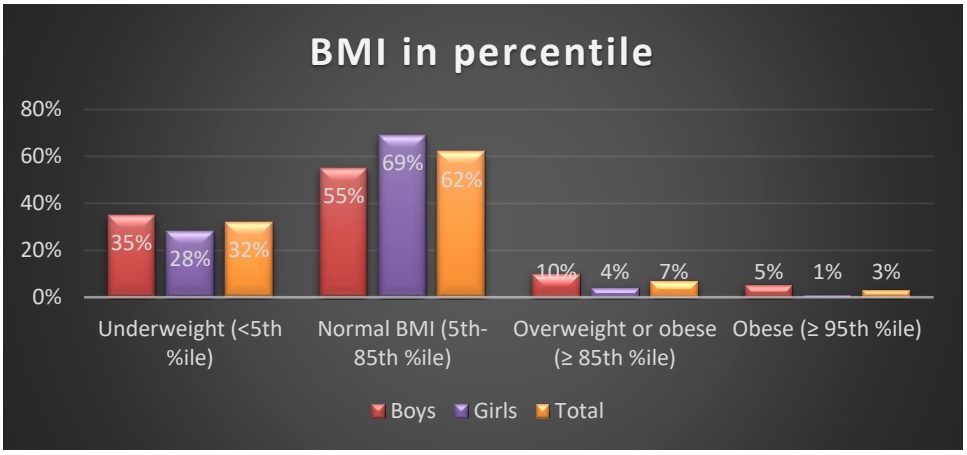
Table 2.2- MDM intake of students in percent (%)

Gender	Percent of days the students had MDM (2017-18)			N
	≤200	201-220	≥221	
Boys	11.69%	32.66%	55.65%	100%
Girls	8.68%	23.97%	67.35%	100%
Total	10.20%	28.37%	63.27%	100%

Table-1

As per table, majority of the students had MDM for more than 220 days which fulfilled the criteria of MDM guidelines.

Figure 2.2– BMI in percentile for boys and girls receiving MDM.



Majority of girls and boys fall under the normal BMI range and least fall under obese category as per data. Therefore, physical growth of majority of students according to age were appropriate due to regularity in school and intake of MDM.**(Jadeja & Talegaonkar, 2020)**

Universal primary education and MDM have been achieved in last decade and MDM is providing hot cooked meals to every day to about 100 million children. Pulse and vegetable content are inadequate while cereal content is adequate. Effective co-ordination between school-health services and MDM can bring a substantial improvement in nutritional status of children through identification at school level.**(Ramachandran, 2019)**

The major ingredient for MDM is a cereal i.e., wheat and rice and some quantities of legumes and vegetables. Taking into consideration the undernutrition status among children and adolescents, the nutrient content of the MDM meal should be improved by including traditional and locally available crops such as millets. The impact on nutritional outcomes of children by regular consumption of millet-based recipe, and its acceptance as a staple as well as sustainability of these formulations was studied in four public schools of Bengaluru. The intervention group provided with millet-based recipes (idli, khichdi, upma & bisibella bath) significantly improved Z-scores for stunting and BMI of children than the control group on usual fortified rice-based meals.

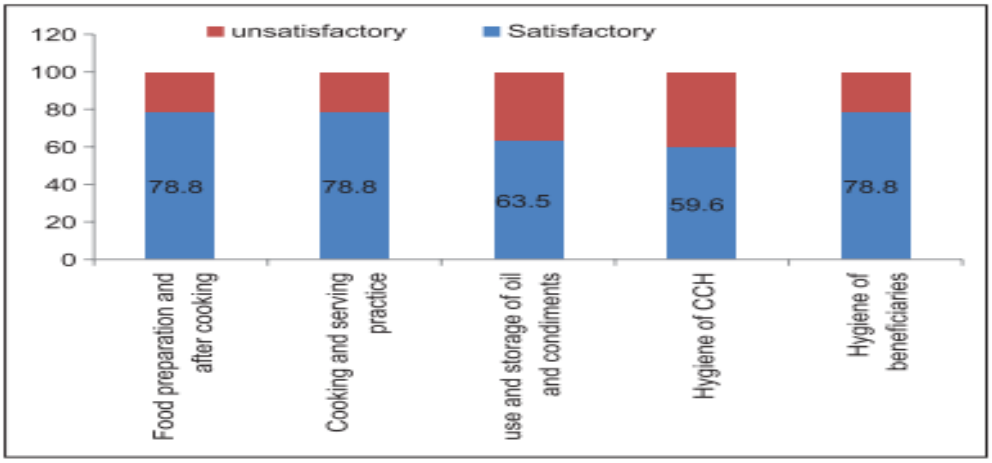
Figure 2.3 – Paired t test for change in mean Z scores for undernutrition indicators from baseline to end line by treatment status for intervention of millet-based recipes for MDM.

	Height for Age Z-Score			BMI for Age Z-Score		
	Δ [End line–Baseline]	*t*-Statistic	*p*-Value	Δ [End Line–Baseline]	*t*-Statistic	*p*-Value
Treated (n =136)	0.074	5.204	0.000	0.166	2.817	0.003
Control (n = 107)	0.044	0.3842	0.351	−0.004	−0.028	0.511

NB: Δ indicates the change in mean. One-tailed *p*-values are presented. The end line was three months after the baseline.

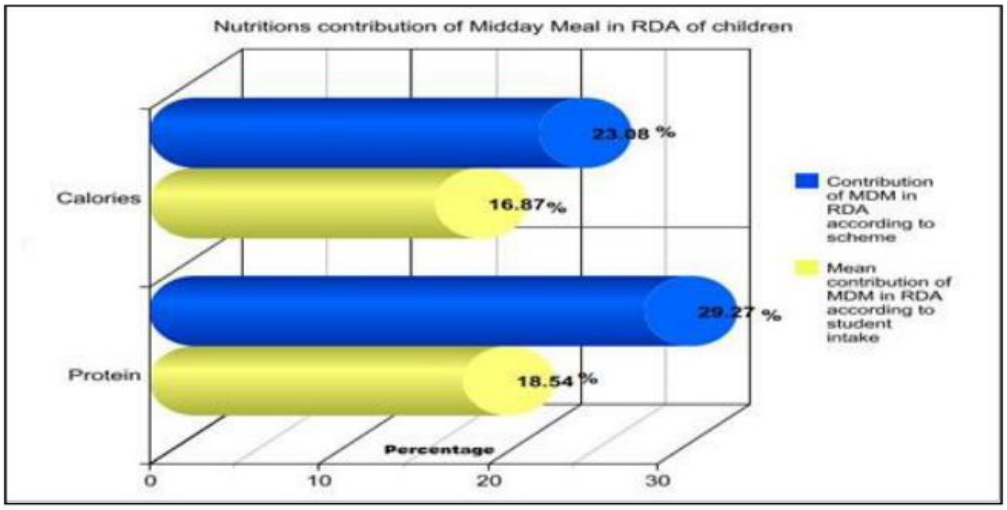
The meals were highly acceptable and enjoyed by the children. The millets can be a cost-effective way if are given government pricing support was suggested. **(Anitha et al., 2019)** The ignorance of poor quality and bad management in MDM was revealed by various reports of MDM. The safety of food served in MDM was assessed in upper primary schools in Kolkata by observational study with a cross-sectional design. Among the total eligible students (5972), MDM was availed by only 56.7% on the day of visit. The government schools had satisfactory cooking and services than government aided schools as shown in Figure The CCH should undergo training program for proper hygiene and should be provided with necessary equipment. **(Sembagamuthu et al., 2019)**

Figure 2.4- Distribution of MDM schools according to their food safety measures (n=52)



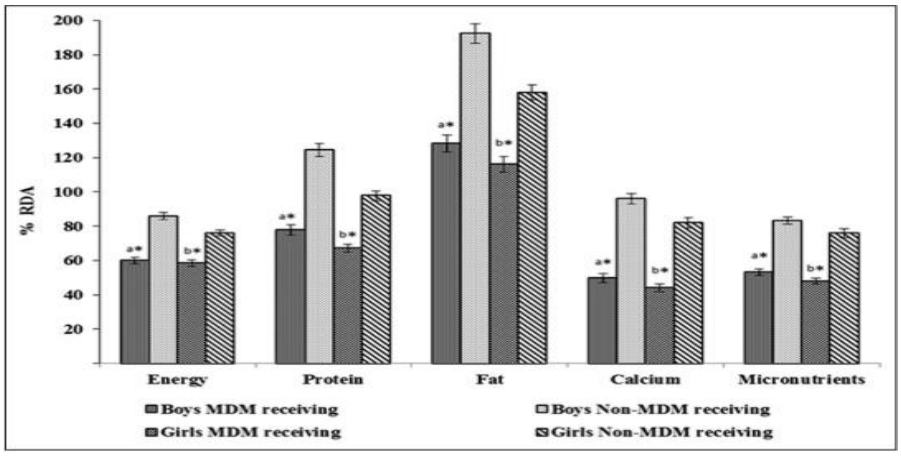
The impact of MDM on nutritional status of school going children of Muzaffarpur town of Bihar was assessed through calculation of BMI and nutrient value by using Diet Cal Software. The thinness level was 50.91% in boys and 41.82% in girls whereas severe thinness was 20% in boys and 12.73% in girls. The contribution of MDM in RDA was only 16.87% instead of 23.08% and 18.54% protein instead of 29.27%.

Figure 2.5 – Contribution of MDM in RDA of children.



There was a large gap observed between the actual intake of primary school children and MDM scheme intake. The micronutrient contribution was negligible through MDM. Therefore, the diet plan should be changed to provide adequate amount of nutrient intake. **(Mall, 2017).** Similar, cross-sectional study was conducted in Ahmedabad and Patan districts of Gujarat with two groups of adolescents i.e., MDM receiving and non-MDM receiving. The nutrient intake using student's t-test and percentage of stunting, wasting and anemia using chi-square test were compared between both the groups of adolescents. **(P. P. Patel et al., 2016)**

Figure 2.6 – Nutrient intake of MDM receiving and non-MDM receiving boys and girls.



Nutrient intake of both the groups expressed in % RDA. A*Values are significantly different between MDM receiving and non-MDM receiving boys ($p<0.05$). b*Values are significantly different between MDM receiving and non-MDM receiving girls ($p<0.05$)
The percentage of stunting and wasting were significantly higher in MDM receiving adolescents than non-MDM receiving adolescents and nutrient intake were also significantly different for both groups.(P. P. Patel et al., 2016)

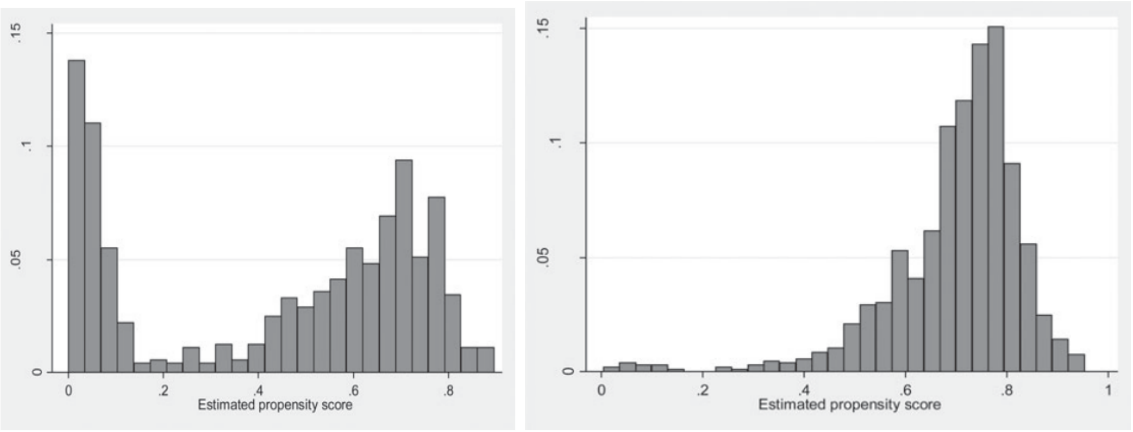
2.3.3 TPDS

NFSA plays a key role in responding to food insecurity. India continues to be home to large population of hungry and malnourished people while PDS forms a cornerstone of government food and nutrition policy. There persists **lack of published literature in areas of PDS** and food insecurity in India. The PDS can be an effective solution to improve hunger and malnutrition if the **operational inefficiencies** and **environmental footprints** are addressed by adequate policy reforms. The PDS was not working effectively with large amounts of food not reaching the intended recipients, and significant wastage and **barriers** like presence of illegal (or ghost) cards. **(George & McKay, 2019).**

The government of India initiated e-governance to maintain the accountability of food security program such as TPDS. The use of ICTs can bridge the transparency gap between the beneficiaries and public administration but the gap also remains between the actual use and planned e-governance initiatives. In Chhattisgarh, with the help of quality management tools such as various charts, diagrams, tables and techniques, the various challenges faced in the adoption of the new technology (POS devices) in food security system by the salespeople of fair price shops were identified. The priority challenges were lack of infrastructure which compromised more than 33% of total challenges and design of the device hardware was second most priority area identified while process design which constituted more than 15% of total challenges was third significant priority area to be focused upon. **(Chhabra et al., 2018)**.
The evidence shows that faster progress in achieving household food security could be done by improving the delivery care quality of food safety net programs. In case of Bihar,

which had been considered as one of worst state in delivery of PDS few years ago was analyzed. The study analyzed the impact of PDS on household gains in calorie intake using probit regression and estimation of propensity scores for control and treatment groups.

Figure 2.7– Estimated Propensity score for PDS and non PDS households.



For non-PDS households For PDS households

Therefore, it clearly shows the importance of PDS revival for enhancement of calorie-intake in BPL households in Bihar. The results supported that with better governance and focused expansion to vulnerable areas, PDS could play a vital role in improving malnutrition and hunger at household level.**(Anjani Kumar et al., 2016)**

The role of TPDS in food & nutrition security in adults of slums of Vadodara showed good availability (75% FPS had subsidized grains at first week of month) and accessibility (92% households were holding ration cards). Beneficiaries utilizing TPDS showed improved food diversity. Majority (75%) of FPS were not following proper storage facilities to store grains which further infested the grains available in FPS. **(Chandorkar & Ahuja, 2018).** Also, mapping of food and nutrition security and its association with nutritional status of vulnerable groups in rural Vadodara showed that Food and Nutrition Security was compromised due to poor utilization of Safety Net programs. The village was found to be moderate to severe insecure due to poor accessibility, utilization and stability of other dimensions. (**Chandorkar & Shah, 2017).** While another study on mapping of food and nutrition security and its association with nutritional status of most vulnerable groups in lig households of urban Vadodara showed that availability was good but accessibility and

utilization were limited which affected the stability**.** Unacceptability of ICDS services was one of the major reasons for limited access and utilization. **(Chandorkar & John, 2017)**

2.4 Food security and its association with undernutrition.

In India, the prevalence of under-five **stunting** and **wasting** remains **high** at 37.9% and 20.85% respectively as of 2015. (India Country Profile, GNR,2020). For decreasing child stunting and low birthweight and on increasing exclusive breastfeeding for the first six months of life progress is being made on. The prevalence of both child overweight and adult obesity is increasing in almost all regions; however, the prevalence of wasting is above the targets. Poor IYCF practices have been identified as one of the main causes of undernutrition. **(FAO, IFAD, UNICEF, WFP and WHO. 2020. The State of Food Security and Nutrition in the World 2020).**

A spatial and multilevel analysis using secondary data to identify the risk factors for stunting among under-5 children was performed in Ethiopia. The population based cross sectional study using multilevel logistic regression was applied to assess factors at individual and household level. With increase by a month in age of a children, the risk of stunting increased by 4% and male children were 89% more likely than females to be stunted. The geo-spatial analysis helped in identification of hotspot areas and cold spot areas of stunting. **(Hailu et al., 2020)**

Minimum dietary diversity includes at least four food groups out of seven to maintain proper growth and development of an infant. But not every infant can meet these criteria such as in Tanzania. Undernutrition can be caused due to poorly or inadequately diversified diet which can lead to several infections to children. The association between child diet diversity and nutritional status was studied using the secondary data analysis of Tanzania Demographic Health Survey (TDHS) 2015-16 data. The results revealed that majority (74%) of children did not meet recommended MDD and only 26% children received a proper diversified diet. It also showed that lesser the number of food groups consumed

more likelihood of being undernourished children. Therefore, dietary diversity acted as a protective factor for children against stunting and underweight. **(Khamis et al., 2019)**

Childhood stunting continues to rise in India with several identified hot spot states and districts from central as well as eastern regions. The study identified high prevalence of childhood stunting with 146 hot spots and 130 cold spots. With expanding the existing evidence, the risk factors and protective factors for childhood stunting were identified using spatial analysis. Dietary diversity was found to be one of the protective factors against childhood stunting. The strongest risk factor identified was maternal short stature for childhood stunting. The risk of childhood stunting associated with climate change was also highlighted such as extreme temperature and droughts and floods which reduce the food availability as well as dietary diversity.(**Gupta & Santhya, 2020)**

The child growth failure (CGF) indicators stunting, wasting and underweight trends were assessed under National Nutrition Mission (NNM) for all districts in India. The trends for CGF indicators were assessed from 2000 to 2017, aggregated from 5*5 km grid estimates across all districts through various survey datasets with subnational geographical information. The states were categorized using their Socio-demographic Index (SDI) levels and inequality assessed using coefficient of variation (CV). On projecting the prevalence of CGF indicators for districts up to 2030, it was observed that to achieve the NNM 2022 targets for stunting 82.6% and for underweight 98.5% of districts in India require a higher rate of improvement and all the districts of India need higher rate of improvement to achieve WHO 2030 target for wasting. A poor correlation was reported at district level estimates between major national surveys for CGF indicators in India. **(Hemalatha et al., 2020)**

Using a composite index named MANUSH, **(Jain & Agnihotri, 2020)** aimed to estimate the triple burden of malnutrition at district and state level in India in under five children using spatial analysis through QGIS version 3.4.0. The differences and inequalities in three different time frames, i.e., NFHS-3 (2005-06), NFHS-4 (2015-16) and CNNS (2016-18) were compared at national and subnational level. The study strongly highlighted the lack

of priority on reducing wasting and overweight/obese children under National Nutrition Mission,2018 targets. Geographical variations and heterogeneities observed led to identification of clusters of high burden and low burden districts with spatial maps.

Spatial distribution of prevalence of under 5 obesity was performed in Peru. Using a GIS tool, the data of National Institute of Health from Peru was georeferenced and maps were generated which successfully identified the hotspots and clusters at regional and outliers at district level. GIS technology would help in better allocation of resources by health government and non-governmental entities was recommended. **(Sotomayor-beltran, 2018)**

2.5 Food security and its association with dietary diversity.

Dietary changes is one of the factor influencing food security status along with increasing population, income inequality, climate change and urbanization. **(Singh & Singh, 2019)**

A consistent positive association is found between dietary diversity and better child health outcomes. Using bivariate and multivariate analysis it was found that there is a general trend towards higher dietary diversity as the child grows in age. The household wealth also correlated with weight for height and height for age. Maternal education also positively affects the dietary diversity. Nutrition awareness should be encouraged as an integral part in school. The government should imply more in national school feeding program to diversify the diet of school children in Ghana.**(Frempong & Annim, 2017)**

The dietary transition through household consumption survey data between 1993 to 2012 reported Indian diets to be slowly diversifying and shifting away from cereals to high milk consumption. However, the micro nutrient rich food groups vitamin A rich fruits and vegetables, egg and meat are progressing slowly. The diets are majorly cereal and dairy focused or diets with high processed foods content. There exist major gap in micro nutrient rich foods intake and there is a need for regionally differentiated strategies for improved diets**.(Tak et al., 2019)**

The Minimum Dietary Diversity for women of reproductive age (WRA) is a food group diversity indicator that helps in reflecting the micronutrient adequacy which is key dimension of diet quality. The groups of WRA when consume food items from at least five of the ten food groups are likely to have higher micronutrient adequacy. A higher prevalence of MDD-W is considered as proxy for better micronutrient adequacy among WRA in population. The groups of WRA which consume five or more of the ten groups are also highly likely to consume at least one animal source food and either pulses or nuts & seeds and food items from two or more of fruit or vegetable food groups.**(FAO & FHI 360, 2016).** The evidence reports that women consume less diverse diets than other household members. The non-staple food groups like Vitamin A rich fruits and vegetables, green leafy vegetables, dairy and eggs were lacking in diets of women. The gender differences were associated with the intrahousehold food allocation. There is a lack of primary data to assess the dietary gap for women's diet which can help in identification of food groups for interventions. **(S. Gupta et al., 2020)**

Educational status of women, no of household members, sex of the head of household and household wealth index are reported to be associated with women's dietary diversity. The farm production diversity and women' dietary diversity also significantly correlate. The association of lower dietary diversity among food insecure households was found significant and the lower dietary diversity was related to less consumption of nutritious foods, Vit A rich fruits and vegetables, and animal sources. Therefore, it is important to investigate the composition of women's diet by analysis of individual food group consumption to promote greater diversity. **(Adubra et al., 2019)**

The Geographic Information System (GIS) was reported to be helpful for better stakeholder engagement and resource engagement in national health programmes. The spatial maps can help in identification of health service gaps, improved prioritization and monitoring of results. **(Robin et al., 2019)**

The present study also performs spatial mapping of food and nutrition security in India. The role of three major components agriculture, health and nutrition and their contribution towards improving food and nutrition security has been studied.

METHODOLOGY

3. METHODOLOGY

Overview of the chapter

3.1 General Information

3.2 Ethical approval

3.3 Study Design

3.4 Secondary Data Sources

3.4.1 Agroclimatic zones and cropping pattern

3.4.2 Food Safety Net Programs (ICDS, MDM, TPDS)

3.4.3 Dietary Diversity of Women (MDDW)

3.5 Data Analysis

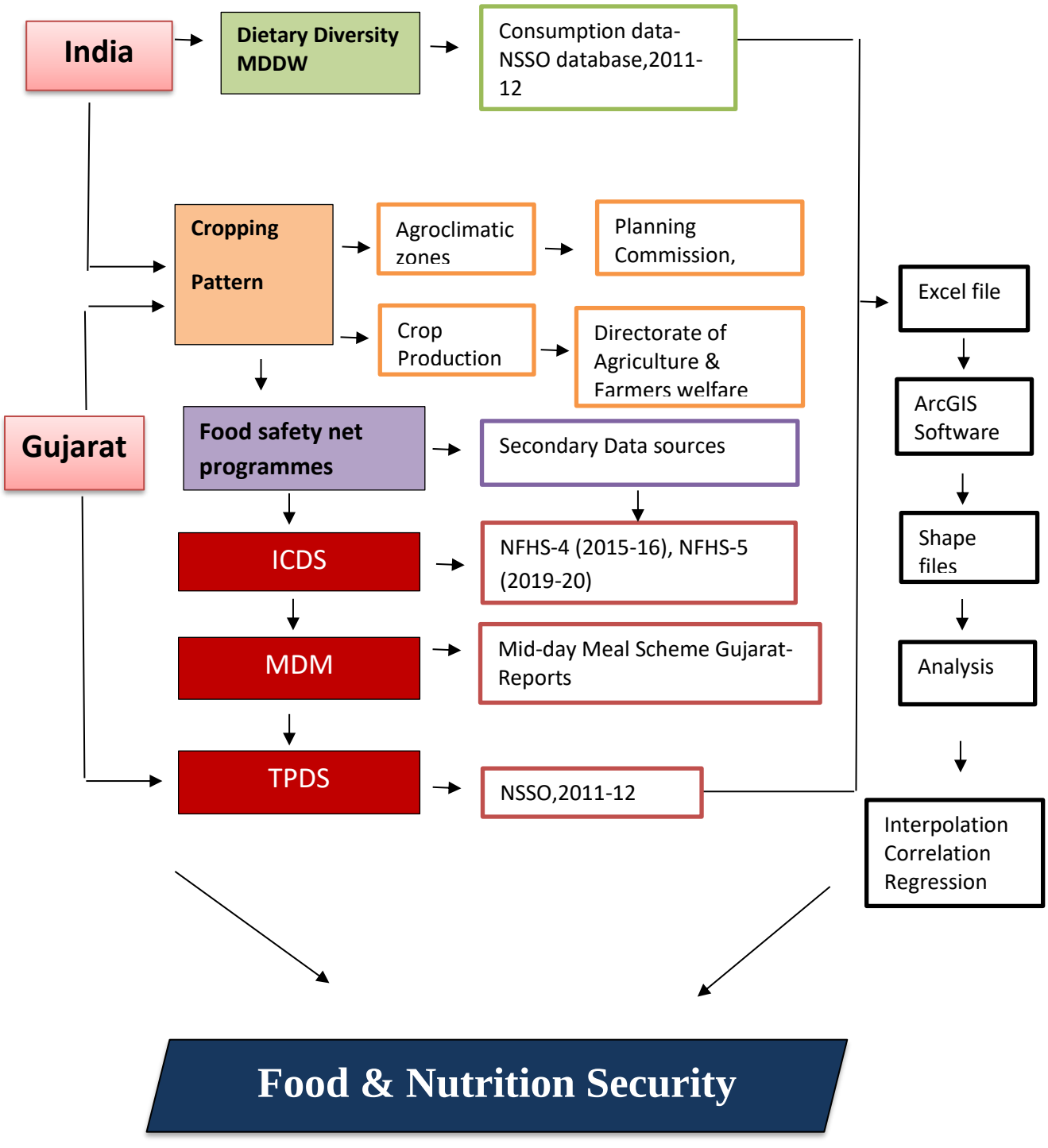
3.1 General Information

An exploratory study was conducted to perform spatial mapping of food and nutrition security and its associated nutrition indicators at national level, various states and districts of Gujarat using secondary data source.

3.2 Ethical Approval

The study was approved by the institutional review board of the department of Foods and Nutrition, Faculty of Family and Community Sciences, The Maharaja Sayajirao University of Baroda. The ethical approval number of the study is **IECHR/FCSc/2020/55.**

3.3 Study Design



3.4 Secondary Data Sources

3.4.1 Agroclimatic zones and cropping pattern

- Agrobiodiversity was analyzed through identification of agroclimatic zones of India by Planning Commission, 1989 and sub-agroclimatic zones of Gujarat from Ministry of Earth Science, Indian Meteorological Dept, Meteorological Centre, Ahmedabad
- The cropping patterns of Rabi & Kharif crops were analyzed at national and district level of Gujarat on crop area, production and yield from Directorate of Agriculture and Farmers Welfare. **(Basuki, 2019)**
- The per capita availability was calculated by dividing production estimates of food grains and pulses with the population estimates for the year 2018, 2019 and 2020.
- The production estimates were included from report Agriculture Statistics at Glance, 2019 published by Directorate of Economics and Statistics. The population estimates for states were included from the 'Population Estimates for India and States 2011-2036', Census of India 2011.
- The per capita availability was first calculated as per capita availability in kg/year and was further converted into grams/day.

3.4.2 Food Safety Net Programs

The utilization and of food safety net programs ICDS, MDM and TPDS were analyses using secondary data sources. The data sources are represented in table 3.1.

Table 3.1- Secondary data sources for food safety net programs (ICDS, MDM, TPDS)

Sr. No	Food Safety Net Programs	Indicators	Data Source
1.	ICDS	• Maternal Health (maternity care) • Delivery Care. • Child immunization and Vit A supplementation • Infant and child feeding practices • Nutritional Status of children under-5 years of age. • Nutritional Status of adult population. (women) • Anemia among children and women of reproductive age.	NFHS-4 (2015-16) NFHS-5 (2018-19)
2	Mid-day Meal	• Review the number of meals served in schools of blocks of Vadodara district in year 2019. Note: - As it was not feasible to review the number of meals served in the entire year, as a sample one working day from third week of each month has been considered.	Mid-day Meal Scheme-Government of Gujarat. https://mdm.gujarat.gov.in/
3.	TPDS	• Per capita consumption of commodities (rice, wheat and sugar) provided by PDS at state level.	NSSO Database (2011-12)

The permission to access DHS data was obtained and the letter of permission is attached in Annexure 1. (https://www.dhsprogram.com/data/dataset_admin/login_main.cfm)

3.4.3. Minimum Dietary Diversity for Women (MDD-W)

- MDD-W is a dichotomous indicator of whether or not women 15–49 years of age have consumed at least five out of ten defined food groups the previous day or night. **(Adubra et al., 2019)**
- The proportion of women 15–49 years of age who reach this minimum in a population can be used as a proxy indicator for higher micronutrient adequacy, one important dimension of diet quality. **(Adubra et al., 2019)**
- The ten food groups are
    1. Grains, white roots and tubers, and plantains
    2. Pulses (beans, peas and lentils)
    3. Nuts and seeds
    4. Dairy
    5. Meat, fish, and poultry
    6. Eggs
    7. Dark green leafy vegetables
    8. Other vitamin A rich fruits and vegetables
    9. Other vegetables
    10. Other fruits

- The dietary intake data was analyzed from the Household Consumption & Expenditure Survey conducted by National Sample Survey Organization (NSSO), India in 2011-12. This survey is conducted every five years since 1972-73 but as the recent report of this survey was unavailable, the last round of this survey was considered.
- The NSS 68th round survey was carried out during July 2011- June 2012 covering data on (1) Household Consumer Expenditure (2) Employment and Unemployment.
- The survey report has provided data on consumption patterns of 14 food groups and 18 non-food groups.

Table 3.2- Food groups under NSSO data base 2011-12.

14 food groups	
1.	Cereals
2.	Gram
3.	Cereal Substitute
4.	Pulse & pulse products
5.	Milk & milk products
6.	Edible Oil
7.	Egg, fish and meat
8.	Vegetables
9.	Fruits (fresh)
10.	Fruits (dry)
11.	Sugar
12.	Salt
13.	Spices
14.	Beverages and processed foods.

- The estimates are provided at State and UT level for rural and urban sectors separately.
- According to the MDD-W food groups, the foods were further classified. Data on consumption of rice, wheat and sugar from PDS and other sources were pooled for analysis.
- The average monthly per capita consumption in kilogram per 30 days was converted to average monthly intake (kg/30 days) accordingly for women using consumer unit i.e., 0.8 for women. The average daily intake (gm/day) per consumer unit (0.8) for women was further calculated. The frequency of food consumed was calculated as below:
- Food Frequency= Grams of food consumed / Portion size of the food group **(Sauvageot et al., 2013)**

Table 3.3. Portion size of each food group according to ICMR Dietary Guideline for Indians.

Food Group	Portion size
Cereals	30 g
Pulses	30 g
Eggs	50 g
Meat/ chicken/ fish	50 g
Milk and milk products	100 ml
Roots and tubers	100 g
Green leafy vegetables	100 g
Other vegetables	100 g
Fruits	100 g
Nuts (My plate)	20 g

Source: ICMR Dietary Guideline for Indians- A Manual **(Kamala K, Bhaskaram P, Bhat RV, 2011)**

- The food frequency method was adopted from **(Sauvageot et al., 2013)** . The range for each frequency option were the following: -

Table 3.4 Food frequency scores for MDDW.

Frequency	Score	Range
Never	0	0
Rarely (1 to 3 times a month)	1	0.0001-0.066
Often (1 to 4 times a week)	2	0.067-0.571
Usually (1 or 2 times a day)	3	≥0.572

- The food with score 3 (consumed usually) were considered for MDD-W score and was calculated at state level for both urban and rural areas.
- The women who consumed five or more food groups out of ten reflect good micronutrient adequacy in their diets.

3.5 Data Analysis

- The spatial analysis was performed using GIS software Arc GIS version 10.5.
- ArcGIS is a geographic information system (GIS) for working with spatial maps and geographic information maintained by the Environmental Systems Research Institute (ESRI).
- The data was converted into shapefiles and was further analyzed using Arc GIS.
- The statistical analysis was performed using Microsoft Excel and Statistical Package for Social Sciences (SPSS) version 26.0.

❖ Limitation of the study

The study has been performed using different secondary data sources for different time periods as the secondary data was not available for all the indicators/parameters studied from a single source and at a single point of time.

RESULTS

AND

DISCUSSION

4. RESULTS & DISCUSSION

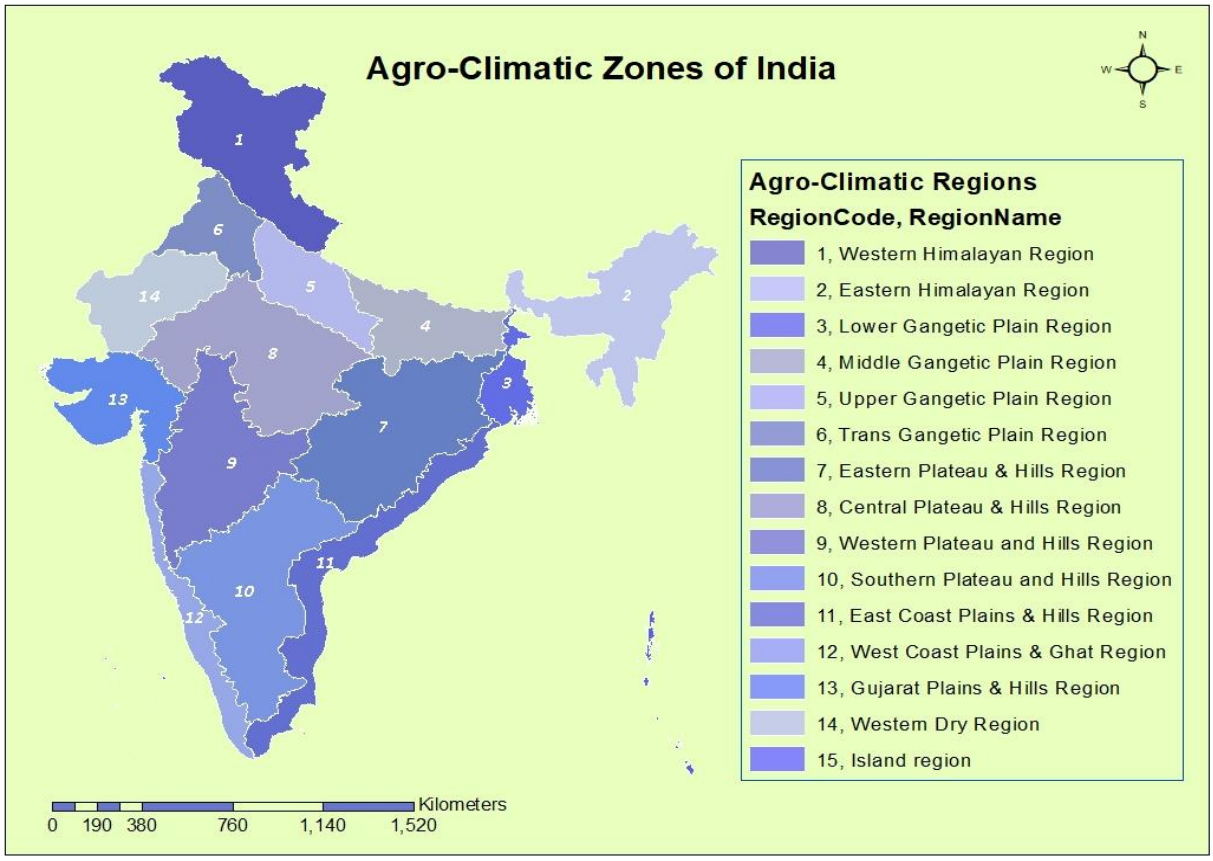
India has positively progressed on several health outcomes, but the state of food and nutrition security demands more work in the country. The Sustainable Development Goals (SDGs) are to be achieved by 2030 and the SDG 2 aims to 'End hunger, achieve food security and improved nutrition through sustainable agriculture.' Therefore, we need to make progress in broadly three major components namely food security, sustainable agriculture and improved nutrition in order to achieve the target. This study also aims to study the association between agriculture, nutrition and food security to achieve food and nutrition security in the country. Since adequate data for consumption of fat, sugar and ultra-processed foods was not available, analysis of their association with prevalence of obesity, overweight and NCD in adult population in various states of India could not be performed.

❖ Agro-Climatic Zones (ACZ) of India

Food Security is directly dependent on agricultural production. Agricultural biodiversity with appropriate use contributes to diets that are more nutritious and encourages the livelihood security of the farming community. Soil quality, soil fertility, arable land, irrigation facilities and climate change are the strategic determinants of agricultural production. There exists high variation in weather and geographical parameters across India. Nearly half of Indian population is dependent upon climate-sensitive sectors such as agriculture. Climatic factors affect the food security in several ways such as changes in rainfall pattern during crop season have a negative effect on yield and increase in minimum and maximum temperature also negatively influences the food security.(Ajay Kumar et al., 2017) Agro- Climatic Regional Planning (ACRP) is a distinctive planning approach aiming at scientific utilization of available natural and manmade resources. As a first step, India is divided into 15 regions classified based on several agro-climatic features such as soil type, temperature, water and rainfall. These regions are known as Agro-climatic Zones. **(Sandhu et al 2016)** Geographic Information System (GIS) is an important tool that helps in integration of many types of spatial information such as agro-climatic zone, soil

management, land use etc., to extract useful information. **(Prabhavati et al., 2015).** Figure 4.1 depicts the 15 agro-climatic zones of India and table 4.1 presents the cropping pattern in these Agro-climatic Zones (ACZ).

Figure 4.1- Agro-Climatic Zones of India



Source: - Planning Commission,1989

The major cropping systems are rice-wheat system in Indo-Gangetic Plains (IGP); rice-rice, rice-fallow, rice-other systems in eastern India; coarse cereal and pulse systems more concentrated in northern Karnataka, western Maharashtra and Rajasthan and scattered throughout the country and cotton-oilseed systems in western and central India. In western IGP, rice and wheat yields are highest but their intensive farming system are straining natural resources whereas in eastern IGP rice-wheat yields are lagging due to unfavorable agro-climatic conditions and poor investment in agricultural infrastructure. **(TCI (Tata–Cornell Institute). 2020. Food, Agriculture,and Nutrition in India 2020: Levaraging Agriculture to Achieve Zero Hunger. Ithaca, NY: TCI)**

Table 4.1- State-wise major crops grown in different Agro- Climatic Zones of India

State	ACZ	Major Crops
Andhra Pradesh	X	Kharif- Cotton, groundnut, paddy Rabi- Paddy, sunflower Other-Black gram, tobacco, sugarcane
Arunachal Pradesh	II	Pineapple, banana, orange, peach, apple, plum, vegetables, coffee
Assam	II	Paddy, mango, guava, jack fruit, banana, citrus, litchi, bear, pears, bear, potato, tomato, vegetable and tea.
Bihar	IV	Makhana, litchi, guava, mango, banana, onion, potato, tomato, brinjal, lady's finger, paddy, jute, wheat, maize & oilseeds.
Chhattisgarh	VII, VIII, IX, X	Paddy, maize, wheat, groundnut, pulses & oilseeds
Gujarat	XIII	Kharif- Bajra, great millet, maize, paddy, groundnut Rabi- Wheat, cotton, cumin, mustard Other- Potato, sesame, rapeseed & mustard, castor, onion, tobacco, sapota, cauliflower etc.
Haryana	VI	Rice, wheat, bajra, maize Kharif- Sugarcane, groundnut, paddy and maize
Himachal Pradesh	I	Wheat, rice, maize, barley, seed-potato, vegetables, ginger, mushrooms, hops, olives, fig, chicory seeds & apples
Jammu & Kashmir	I	Rice, barley, maize, wheat, apples
Jharkhand	VII	Paddy, maize, pulses, groundnut, sunflower, fruits
Karnataka	X, XII	Paddy, jowar, maize, bajra, great millet, sunflower, groundnut, cotton & soyabean, chilies, onion, sugarcane
Kerala	XII	Kharif- paddy, banana, ginger Rabi- Paddy, pea, ginger; Zaid- Tapioca
Madhya Pradesh	VIII, IX, XIII	Soyabean, gram and pulses Kharif- paddy, maize, soybean, tur, bajra etc. Rabi- Wheat, jowar, bajra, mustard, cotton, vegetables.

Maharashtra	VII, IX, XII, XIII	Jowar, arhar, groundnut, soybean, sunflower, sugarcane, cotton, vegetables, turmeric, fruits like banana, orange, mango, grape and cashew.
Manipur	II	Mango, guava, jack fruit, litchi, banana, citrus, papaya, pears, vegetables, potato, tomato, spices, roots & tubers, mushroom
Meghalaya	II	Maize and rice, oranges (khasi mandarin), banana, pineapple, jack fruits, plums, pears & peaches. Turmeric, black pepper, ginger, areca nut, strawberry.
Mizoram	II	Paddy, sugarcane, tapioca, cotton, mustard, oilseeds, sesame, soybean & pulses like French and rice beans, cowpea
Nagaland	II	Coffee, tea & cardamom, potato & sugarcane, carrots, chilies, melon, onion, spinach leaf, brinjal, cucumber, tomato & mustard.
Punjab	VI	Wheat, maize, rice, pearl millet, barley, cotton, sugarcane & fruit
Rajasthan	VI, VIII, XIV	Kharif- Bajra, jowar, maize, pulses, groundnut Rabi- Wheat, barley, pulses, gram, oilseeds
Sikkim	II	Orchids
Tamil Nadu	X, XI, XII	paddy, jowar, groundnut, black gram, cotton, coconut, sugarcane, tapioca, turmeric, tea, coffee etc.
Tripura	II	Pineapples, Jack fruit, oranges, cashewnut, coconut, tea, rubber, plantains etc.
Uttar Pradesh	IV, V, VIII	Kharif- Maize, rice, moong bean, pigeon pea Rabi- Wheat, green peas, lentil, Bengal gram, rapeseed and mustard Sugarcane
Uttarakhand	I	Paddy, wheat, maize, manduwa, sanwa, urad, masoor, rajma, pea, mustard, groundnut & soyabean
West Bengal	III	Rice, wheat, pulses, groundnut, mustard, jute, sugarcane, potato, vegetables, fruits

Source- **https://farmech.dac.gov.in/FarmerGuide/India.html#**

Figure 4.2- Agro- Climatic Zones (ACZ) of Gujarat

Source- Ministry of Earth Science, Indian Meteorological Dept, Meteorological Centre, Ahmedabad

The state of Gujarat is located between 20° 1' and 24° 7' N latitude and 68° 4' and 74° 4' longitude with an area of 19.6 mha contributing for 6% of geographic area of India. It was traditionally divided into three regions (i) the main land plains that extended from Ran of Kachchh and the Aravalli hills in north to Daman ganga in South, (ii) the rocky areas of Kachchh and hilly peninsular regions of Saurashtra, (iii) the north eastern hill tract. Recently, it has been further divided into sub agro-climatic zones on the basis of agriculture and climatic characteristics.**(Choudhary, 2018)**

The agro-climatic zones of Gujarat are as follows-

V. South Gujarat (Heavy rainfall)
VI. South Gujarat
VII. Middle Gujarat
VIII. North Gujarat
IX. North- West Zone

VI. Northern Saurashtra
VII. Southern Saurashtra
VIII. Bhal and Coastal Area

Table 4.2- District-wise major crops grown in various Agro- Climatic Zones of Gujarat

ACZ	Major districts	Major crops
I	Navsari	Kharif Paddy, Summer Paddy, Summer Pulse, Sugarcane, Summer Okra, Cowpea, Vegetables- brinjal & chilli, Fruits- mango & sapota, Tropical tubers- elephant foot & yam.
II	Tapi, Bharuch Surat Narmada	Cucurbit crops, Cotton, Rice, Pigeon Pea Sugarcane, Okra, Rice, Sesame, Green gram -
III	Anand, Mahisagar, Kheda, Chhota Udepur, Panchmahal, Vadodara, Dahod	Banana, Chilli, Tomato, Brinjal, Summer Okra, Summer Mungbean, Summer Pearl millet, Summer groundnut, Vine vegetables, Cowpea, Mango, Papaya, Cluster bean, Green gram
IV	Banaskantha, Gandhinagar, Mehsana, Aravalli, Patan, Sabarkantha	Cotton, Summer groundnut, Summer pearl millet, green gram vegetables, Mango, Papaya, Sapota, Lemon, Pomegranate,
V	Kachchh (Bhachau)	Summer groundnut, Summer pearl millet, Hybrid Cotton, Green gram, Mango, Papaya, Lemon, Sapota, Pomegranate, Summer vegetable crops,
VI	Rajkot, Morbi, Surendranagar, Devbhumi Dwarka, Jamnagar, Amreli	Summer groundnut, Kharif groundnut, Cotton, Pearl millet, pulses, ridge gourd, bottle gourd, sponge gourd, bitter gourd, cluster beans, watermelon, ladyfinger, brinjal, tomato, chilli, lemon, drumstick, sugarcane, banana, pomegranate.
VII	Gir Somnath, Junagadh, Porbandar	Summer Groundnut, Summer Sesame, Summer Green gram, Summer Black gram, Mango, Brinjal, Tomato, Castor
VIII	Ahmedabad, Bhavnagar, Botad	Sesame, Brinjal, Chilli, Green gram, Black gram, Pearl millet, Groundnut.

Source- **http://www.imdahm.gov.in/aau.htm**

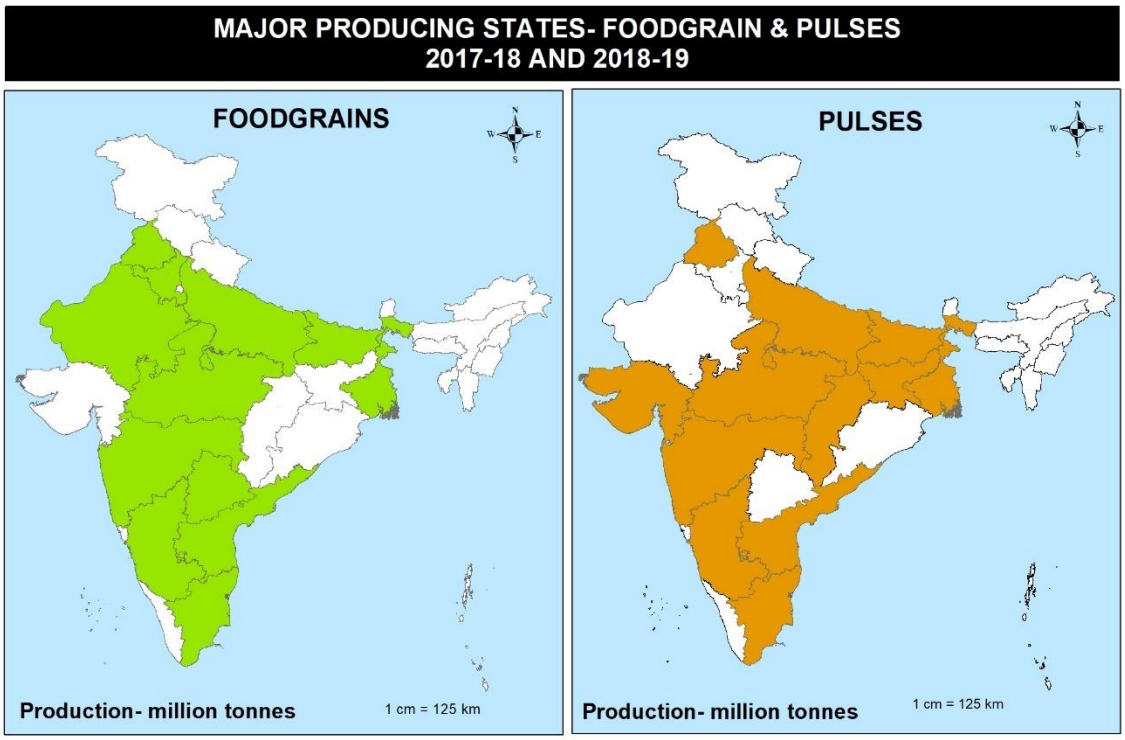
Therefore, agro-climatic classification aids farmers to grow crops according to the climatic conditions of the region. **(Adnan et al., 2017)** Investments in sustainable land management practices increased the adaptive capacity to the adverse effect of climate change and variability among smallholder farmers. In addition, adoption of small-scale irrigation, employing agronomic practices and soil conservation were found to be important factors influencing food production and household food security. **(Amare & Simane, 2017)**. Among smallholder farmers, the farm production systems with high agro-biodiversity contributed more towards food security as compared to zones with low crop diversity and richness.**(Mburu et al., 2016).** Climate change also has the potential to influence the nutritional status of children in different ways such as by affecting food security status, dietary diversity, disease burden and other socio-economic conditions. **(Alemu et al., 2017)** Therefore, the future policy should address the situation of food and nutrition security by stimulating and tailoring agricultural diversification through shifts in cropping patterns such as cereal-legume rotations for more sustainable, stress-tolerant, diversified and resource-saving options.**(Mittal & Hariharan, 2016)**

- **Production and availability of food grains and pulses in 2017-18 and 2018-19.**

The study examines the composition of food grain and pulse production during 2017-18 and 2018-19 at state level in India. The estimates of production are provided from the report 'Agriculture Statistics at a Glance,2019' published by Directorate of Economics and Statistics. The Directorate of Economics and Statistics (DES) releases the area, production and yield estimates for principal crops of food grains, oilseeds, fibers, sugarcane and other important horticulture and commercial crops. The net availability of food grains is obtained from Gross Production (-) seed, feed and wastage (-) exports (+) imports (+/-) and change in stocks. The per capita availability (PCA) has been estimated as the net availability of food grains divided by the population estimates of a particular year. However, the PCA in this study has been calculated at state level and takes into consideration the production and population estimate of each state and do not take into account the seed, feed, wastage,

imports, exports and change in stocks. Therefore, the estimates are not strictly representing the actual value of consumption.

Figure 4.3– Major producing states- Food grains & Pulses, 2017-18 and 2018-19



Source- Agriculture Statistics at Glance 2019, Directorate of Agriculture & Statistics.

Figure 4.3 represents the major producting states for food grains and pulses during the year 2017-18 and 2018-19. The highest producing state for foograins is Uttar Pradesh with 54.63 million tonnes in 2018-19 and 51.37 million tonnes in 2017-18 followed by Madhya Pradesh, Punjab, Rajasthan and West Bengal. Among foodgrains, the highest wheat producing states are Uttar Pradesh, Punjab and Madhya Pradesh and highest rice producing states are West Bengal, Uttar Pradesh and Punjab. Whereas, major pulses producing state is Madhya Pradesh with 7.81 million tonnes during 2018-19 which has decreased since 2017-18 with 8.11 million tonnes.**(MoAFW, 2019)**. The state level per capita availability of foodgrains and pulses is represented in table 4.3.

Table 4.3- Per capita availability of food grains and pulses (per day) for 2018, 2019 & 2020

Per capita availability (grams/day)						
	Food grains (grams/day)			Pulses (grams/day)		
State/ UT	2018	2019	2020 (P)	2018	2019	2020 (P)
All India	598.15	592.04	610.90	53.34	45.83	47.28
Andhra Pradesh	644.94	571.75	648.29	64.57	39.01	61.21
Arunachal Pradesh	667.42	671.87	679.81	25.03	22.06	25.78
Assam	451.35	441.50	418.35	9.46	9.17	8.47
Bihar	402.53	363.01	326.26	10.73	10.55	7.67
Chhattisgarh	583.96	730.71	715.53	53.90	51.96	23.01
Goa	195.39	189.42	168.64	8.74	11.38	6.90
Gujarat	317.76	278.17	328.81	38.25	27.86	42.64
Haryana	1592.23	1758.73	1706.93	6.82	7.96	6.15
Himachal Pradesh	565.83	567.00	574.26	21.84	20.39	20.71
Jammu & Kashmir	331.06	395.77	346.79	2.18	2.22	9.17
Jharkhand	452.52	326.94	351.03	63.09	54.63	59.69
Karnataka	498.90	457.01	532.29	82.56	74.45	89.77
Kerala	41.28	45.57	47.46	0.16	0.18	0.17
Madhya Pradesh	1146.31	1088.21	1116.89	277.97	204.25	136.88
Maharashtra	302.77	233.29	287.53	76.52	60.73	83.79
Manipur	636.33	441.34	372.05	27.05	26.31	22.24
Meghalaya	313.55	223.72	306.63	10.33	11.48	10.21
Mizoram	173.91	178.42	175.74	12.03	13.76	12.60
Nagaland	717.80	718.24	720.51	59.86	59.71	59.61
Odisha	442.15	510.13	549.73	26.56	25.28	26.33
Punjab	2955.31	2916.71	2739.57	2.47	2.56	2.68
Rajasthan	726.62	764.86	823.61	123.99	135.07	159.46
Sikkim	395.69	383.55	379.96	21.52	20.04	20.79
Tamil Nadu	391.42	377.82	407.90	20.33	20.04	21.91
Telangana	703.03	687.41	818.90	38.36	32.61	40.42
Tripura	598.73	579.65	585.63	13.53	13.11	12.81
Uttar Pradesh	642.50	674.31	684.01	27.52	29.72	29.80
Uttarakhand	479.07	466.73	463.80	13.64	13.77	14.21
West Bengal	483.24	531.74	531.35	12.71	10.48	10.88
A & N Islands	118.36	80.76	126.16	1.23	1.07	2.07
Chandigarh	0.61	0.65	16.49	0.00	0.00	0.00
D & N Haveli	202.59	193.92	202.39	13.98	22.79	12.20
Delhi	15.37	14.98	14.68	0.00	0.00	0.02
Daman & Diu	21.16	17.58	19.51	0.00	0.00	3.58
Puducherry	84.08	119.80	109.81	2.31	1.24	0.95

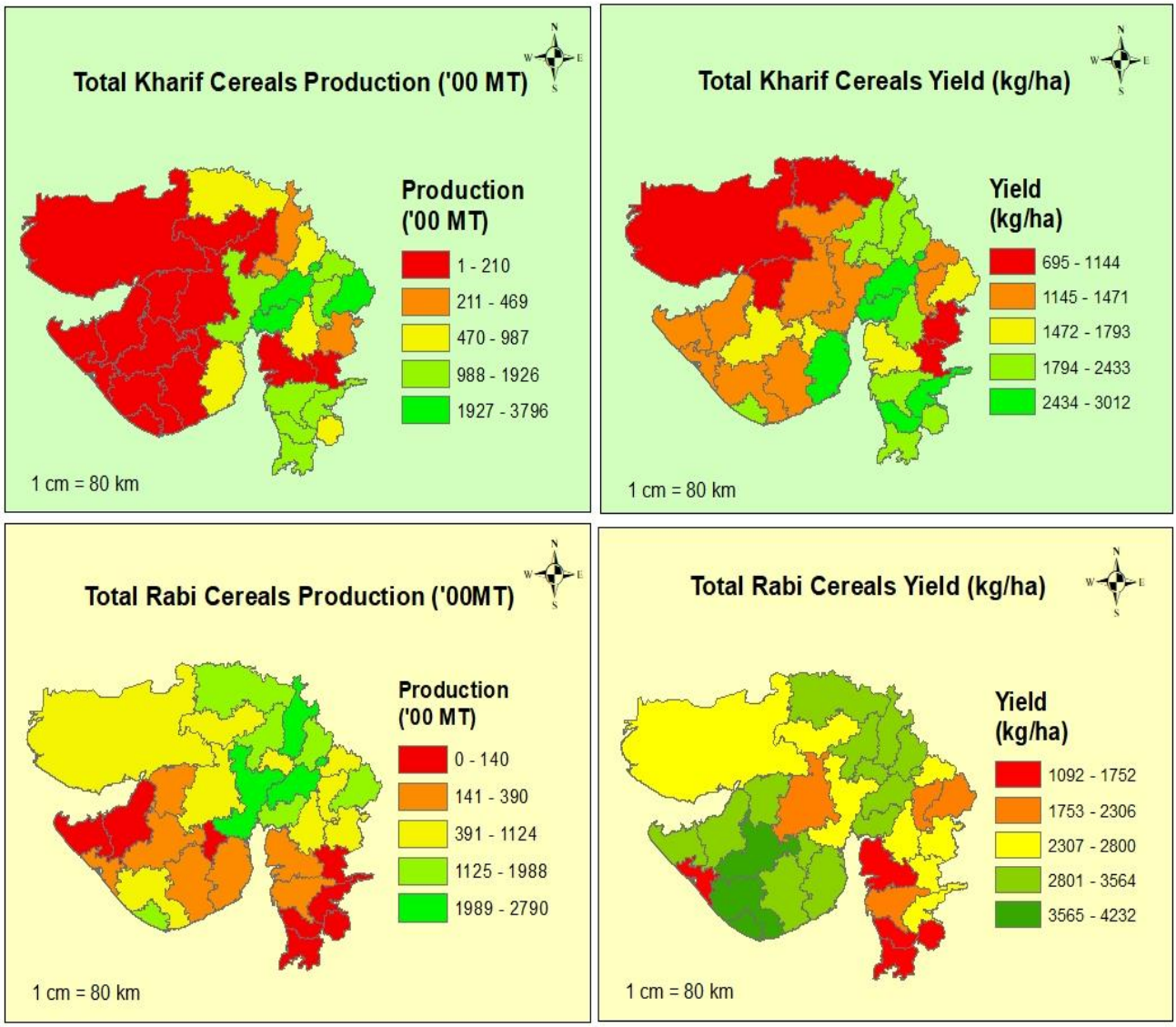
(P)- Provisional figures are based on 4th advance estimates of production for 2019-20.

The per capita availability of foodgrains and its distribution can help in addressing the major issues collectively such as nutrition and hunger and extreme poverty in India. Since last five years, the per capita availability of foodgrains has increased upto 492 grams/day in 2019 while per capita availability of pulses has shown decrease from 54.7 grams/day in 2017 to 51.3 and 47.9 grams/day in 2018 and 2019 respectively. Despite the huge increase in production of wheat, rice and other cereals, the per capita net availability has not increased at the desired same level due to population growth, food losses and wastage and exports. **(Ministry of Statistics and The World Food Programme, 2019) (MoAFW, 2019).** The estimated per capita avaialbility in table 4.3 also showed similar trend with per capita availability kg/day decreasing for foodgrains and pulses in 2019 and showed an upward trend in 2020. Majority of the states also showed a downward trend in 2019 and a sharp increase in 2020. The states of Assam, Bihar, Chhattisgarh, Goa, Manipur, Meghalaya, annd Puducherry (UT) showed declining per capita availability of foodgrains and pulses since 2018. The decrease in availability of pulses is led by increasing population and low productivity growth of pulses and the increasing demand leading to high price volatility. The import of pulses have played a significant role since 2000-01 in improving the availability of pulses. The factors such as low yields, low landholding size, higher agro climatic risk and poor connectivity hinder the market access of pulse farmers. **(Abraham & Pingali, 2021)** India is having a demand-supply gap in pulses and therefore needs to import more to make up upto 4 Metric Ton deficit and therefore it becomes prudent to increase domestic production as per capita availability meets the norm of 40 g per day only after imports.The self sufficiency demands more focus on the research and development for pulses in several terms such as yield potential, growing days, fortification etc.**(Rampal, 2017)**

➢ Scenario in Gujarat

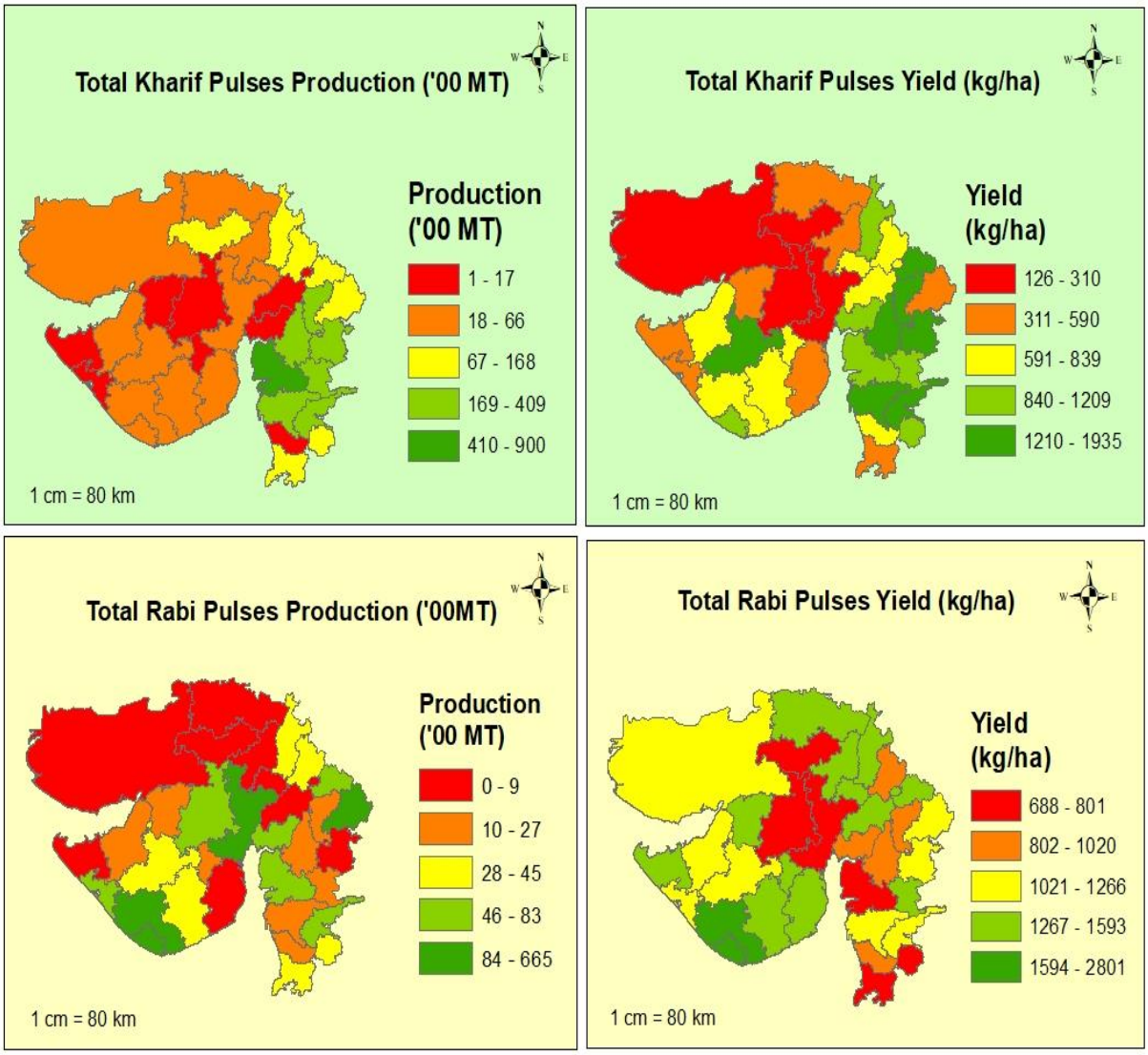
The production and yield of foodgrains and pulses in kharif and rabi season in 2018-19 in Gujarat are represented in Figure 4.4

Figure 4.4 – Total kharif and rabi cereal production and yield in Gujarat, 2018-19.



In Gujarat, the cereal production has shown a decline from 68259 million tonnes in 2017-18 to 61333 million tonnes in 2018-19. The above Figure represents the production and yield estimates for the year 2018-19 for Rabi and Kharif cereals. The districts producing majorly in kharif season are Kheda followed by Anand, Dahod and Tapi while those with predominant production in Rabi season are Ahmedabad, Sabarkantha, Kheda and Mehsana. The production and yields for cereals are higher for majority of districts in the Rabi season as compared to Kharif season.

Figure 4.5 – Total kharif and rabi pulse production and yield in Gujarat, 2018-19.

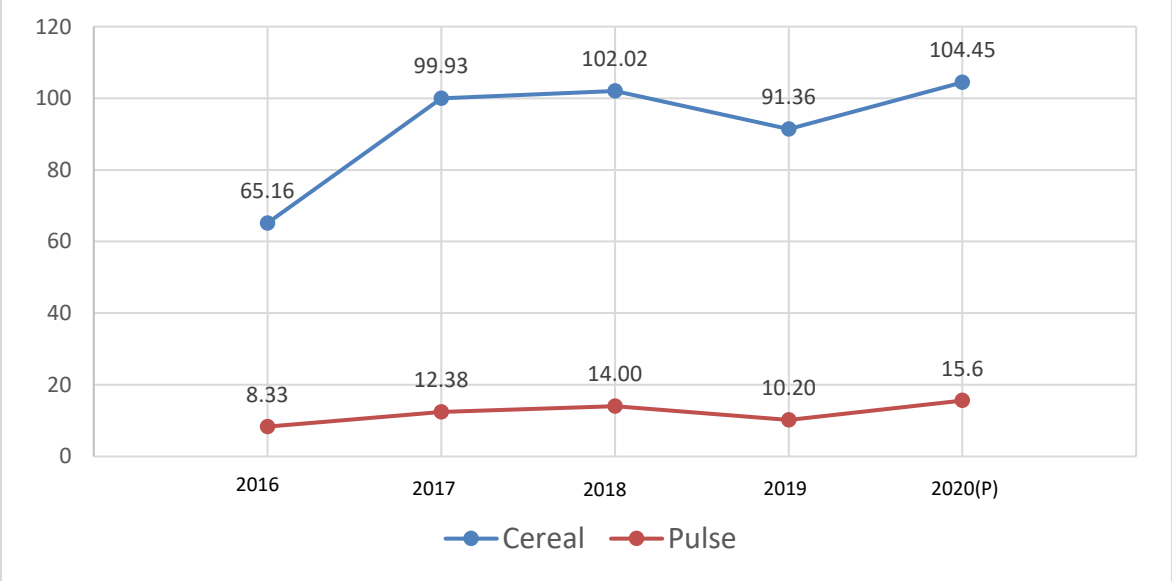


Pulses are an important source of proteins of many diets across the globe and have great ability to improve human health, protect the environment and contributing to global food security. In recent times, the pulses have been into focus due to continuous price swings.

The stagnant productivity of pulses with declining availability has lead to substantial demand supply gap affecting nutritional security of a large population for whom they serve as cheapest source of protein. Pulses are leguminious crops which yield between 1 and 12 grains/seeds of variable shape, size and color within a pod.Though pulses are grown in

both seasons, rabi pulses account for more than 60 percent of total production**. (Mohanty & Satyasai, 2016)** The major kharif pulses include arhar (pigeonpea/redgram), mungbean (greengram), urdbean (blackgram), horsegram and moth. The rabi/summer season pulses are gram (bengalgram/chickpea), field pea (matar/batri), lentil (masur), mung, urd, rajmah etc. The gram crop occupies the major share among rabi followed by lentil and field pea whereas tur/arhar occupies the major share among kharif followed by urdbean and mungbean. Pulses also help in mitigating the climate change and can make agriculture more sustainable with multiple functions such as ability to biologically fix nitrogen and some species are able to free the soil bound phosphorous. The food legume plays a major role in improving food and nutritional security as the dried seeds of pulses can be stored for long periods without compromising the nutritional value and helps in increasing food availability until next arrivals.**(Directorate of Pulses Development, 2015)** In Gujarat, the highest kharif pulse producing district is Bharuch followed by Vadodara and Chhotaudepur and highest rabi producing and district is Junagadh followed by Dahod, Gir Somnath and Ahmedabad in the year 2018-19 as shown in Figure 4.5. In Gujarat gram is majorly grown in Dahod, Panchmahal, Ahmedabad in middle Gujarat, Patan district of north Gujarat and in Saurashtra region in Junagadh, Jamnagar, Surendranagar and Porbandar districts.**(Dhandhalya et al., 2015)**

Figure 4.6- Per Capita Availability kg/year of Cereals and Pulses in Gujarat



*Note- (P) The per capita availability for year 2020 are provisional based on the 4th advance estimates of production during 2019-20.

The figure 4.6 represents the per capita avaialbility of cereals and pulses in Gujarat from year 2016 to 2020. In Gujarat, the per capita availability in kg per year for cereals and pulses showed an upward trend since year 2016 but declined during the year 2019. The estimated per capita availability for the year 2020 have shown progress and increased for both cereals and pulses. Encouraging the production and consumption of pulses would be important for the three fold objective to end hunger, achieve food security and improved nutrition, and promote sustainable agriculture under the second Sustainable Development Goal. **(Rampal, 2017)**

❖ Food Safety Net Programs

The food-based safety net programs ICDS, MDM and PDS provide food assistance at various stages of life with a life cycle approach towards food security. Under the National Food Security Act (NFSA), these food safety net programs provide nutritional support to pregnant and lactating mothers, infants, school going children and even senior citizens. The effects of these programs on nutrition remains unclear in India. The evidence is limited due to lack of availability of longitudinal data, appropriate period for analysis, the choice of metrics for evaluation of the impact and different geographical contexts**.** (Pingali et al., 2019a)**.** This study also aims to study the role of food-based safety net programs in improving food and nutrition security in India.

I. Integrated Child Development Services (ICDS)

ICDS program was launched in 1975 with an aim to improve healthcare, early childhood care, education and nutrition. Data from NFHS 4 (2015-16) on the rural and urban uptake of ANC service utilization at pregnancy, breastfeeding and age-appropriate feeding at 7-72 months for children shows sub-optimal utilization of these services. The utilization of

services by pregnant mothers was higher by 20 percentage points for rural areas as compared to urban areas. One out of every two mother-child pairs in urban areas did not avail the benefits from ICDS. (Rajpal et al., 2020a)**.** The change in utilization of ICDS services in the state of Gujarat has been studied using NFHS-4 (2015-16) and NFHS 5 (2019-20) in the present investigation.

▪ Maternal Health

➢ Antenatal Care (ANC)

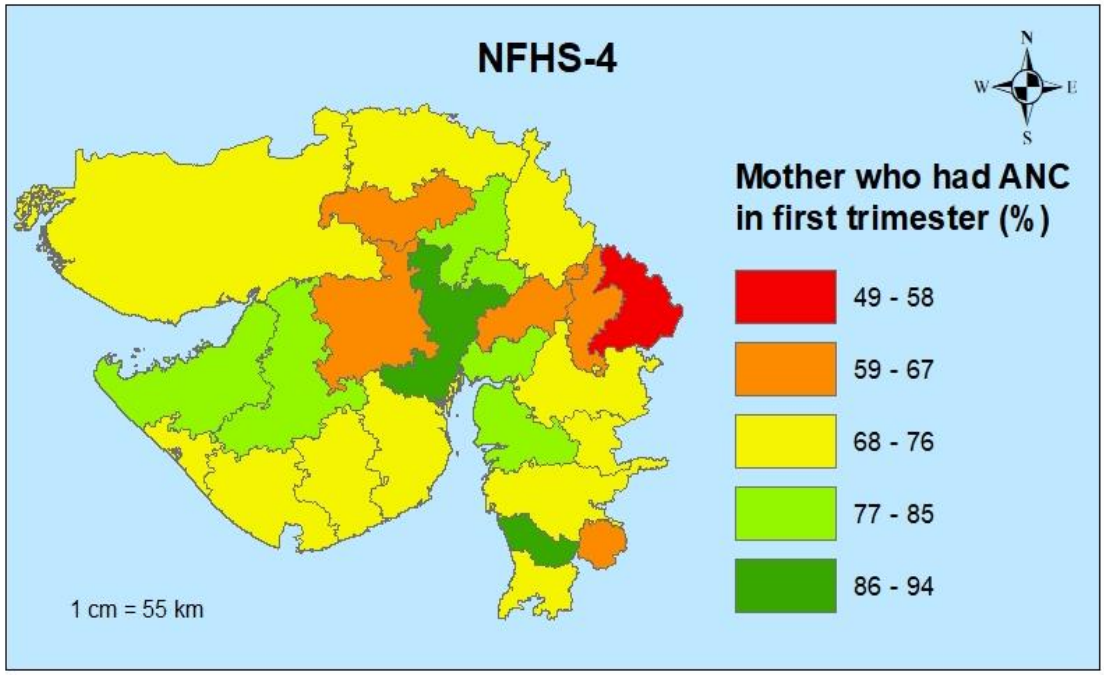
In Gujarat, 96 % of the mothers who gave birth in last five years preceding the survey, had registered pregnancy for most recent live birth and 98 percent mothers had received the Mother and Child Protection Card (MCP Card).

The Figure 4.7 represents the percentage of mothers from Gujarat who received antenatal care checkup in their first trimester of pregnancy. The data show that since NFHS-4, the percentage of mothers who had ANC in their first trimester has increased from 74 percent to 79 percent. It has increased up to 83.7% for urban and 76.4% for rural Gujarat. The districts such as Patan, Kachchh, Rajkot, Amreli, Dangs, Vadodara, Anand, Surat, Valsad, Jamnagar, Junagadh, Surendranagar and Panch Mahals have shown increase in percentage of mothers who had ANC in first trimester. The aspirational districts Dahod and Narmada have also shown progress in 2018-19 as compared to 2015-16. While, Ahmedabad, Mehsana, Bharuch, and Aravalli districts have shown decline in percentage of mothers who had ANC in their first trimester since 2015-16.

The Figure 4.8 represents the percentage of mothers who received at least four ANC visits in Gujarat. The percentage of mothers who had at least 4 ANC has increased from 70.5% (NFHS-4) to 76.9% (NFHS-5) in Gujarat. Navsari district has the highest (94.7%) where as Banaskantha district has the lowest (56.1%) percentage of mothers who had at least four antenatal care visits in 2019-20. Kachchh, Patan, Surat, Valsad, Navsari, Dangs, Dahod, Tapi, Amreli and Panch Mahals have shown significant increase whereas Bharuch, Anand

and Vadodara have shown decline in percentage of mothers having at least four ANCs as compared to previous survey.

Figure 4.7- Mothers who had ANC in first trimester (%) in Gujarat.



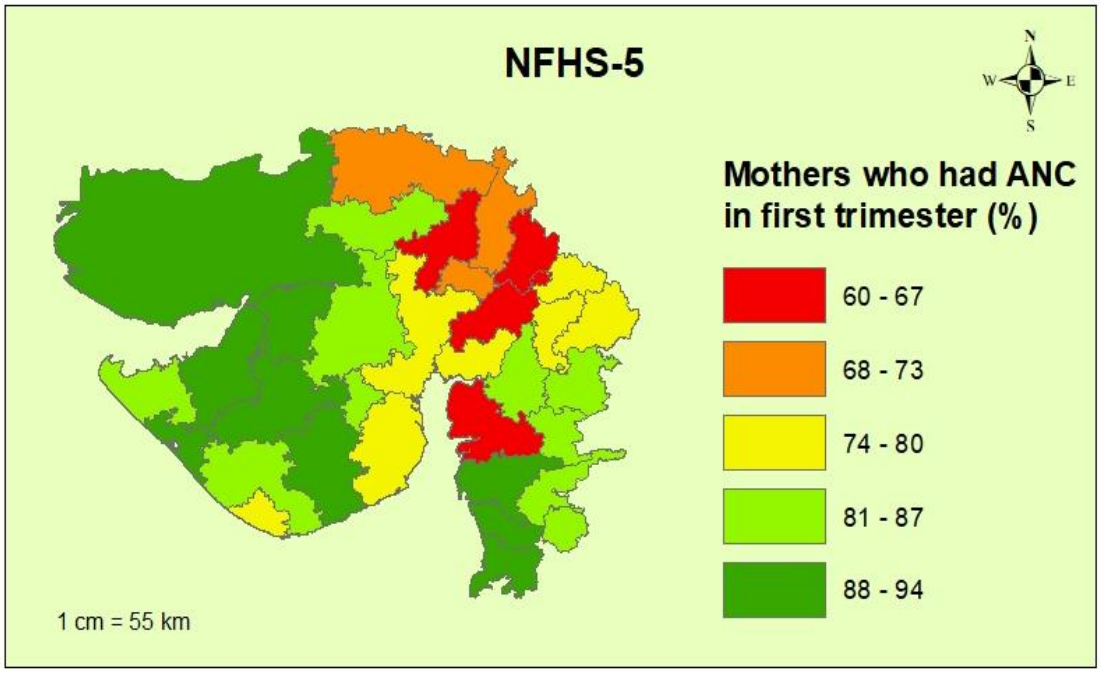
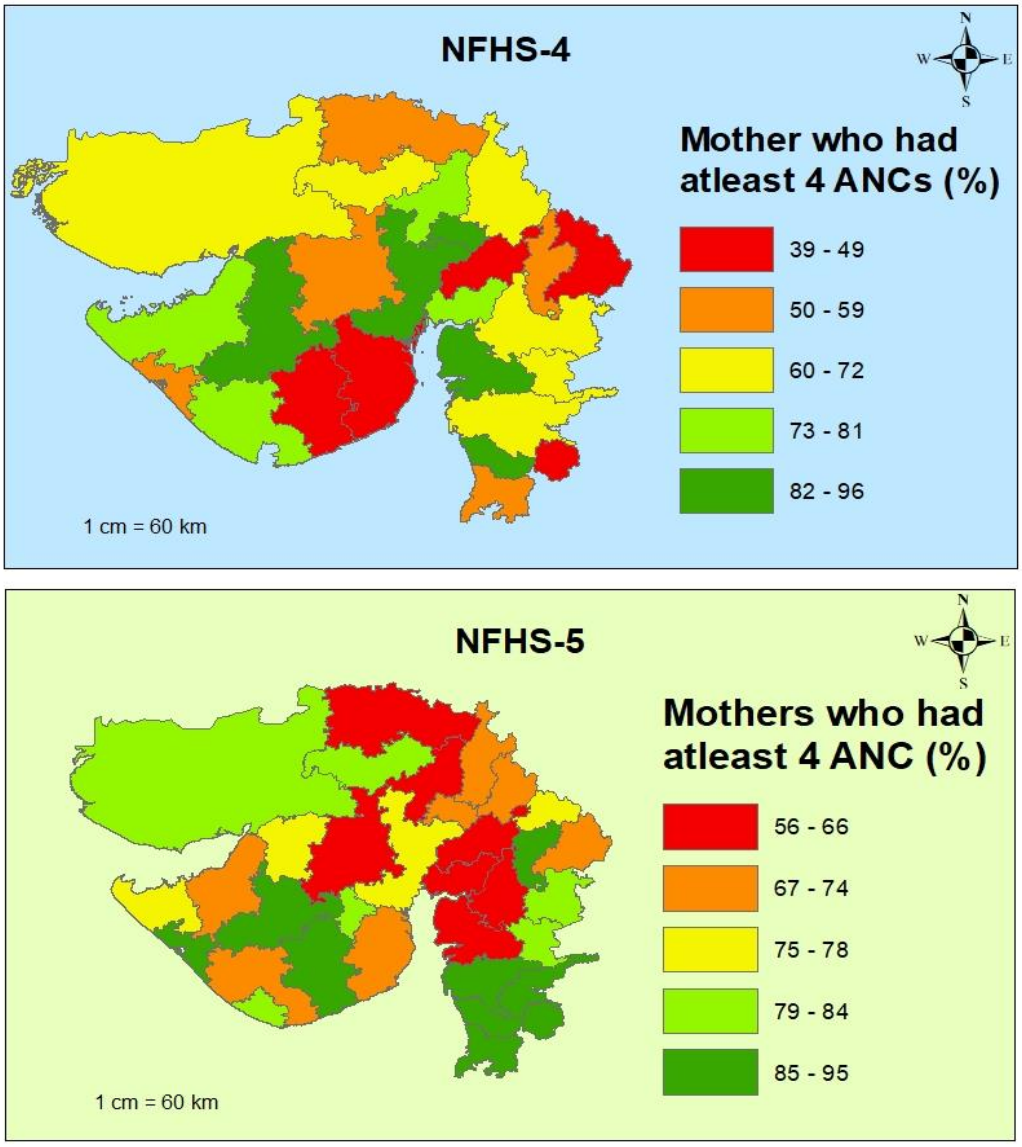


Figure 4.8- Mothers who had at least four ANCs (%) in Gujarat.

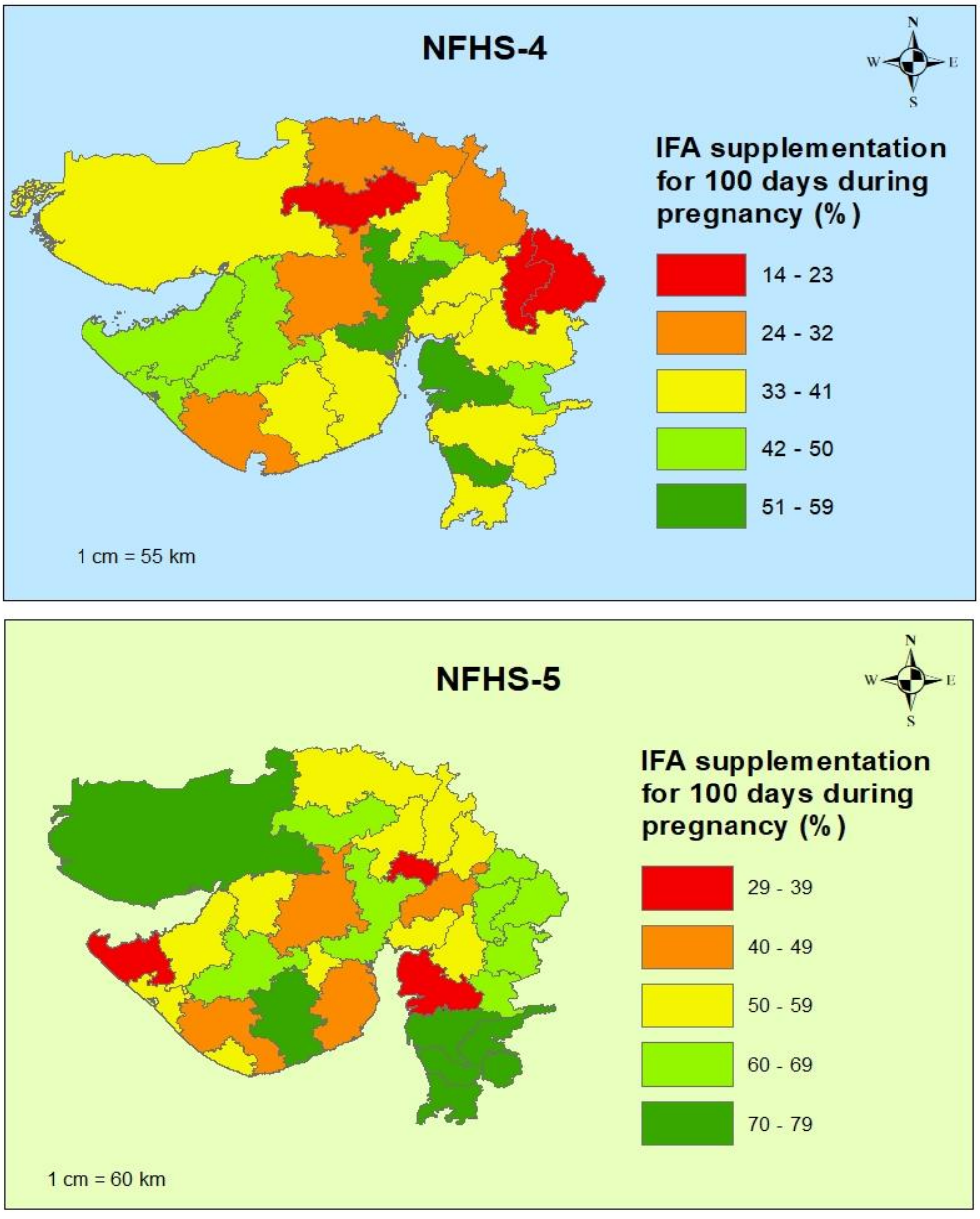


Barriers and promoters such as physical access, sociodemographic and reproductive factors that affect the utilization of antenatal care among women were identified for different countries. It was reported that maternal age, education, number of living children, previous obstetrical history, socio-economic status, support from spouse, distance from the health facility and quality of care were the major factors associated with the utilization of antenatal care. **(Aziz Ali et al., 2018)** Similar findings were also reported by **(Tsegaye & Ayalew, 2020).**

- **Iron folic acid (IFA) Supplementation: -**

In Gujarat, there has been an increase in percentage of mothers (from 37% to 60%) who consumed IFA supplements for 100 days during their pregnancy whereas only 43 percent consumed for 180 days or more as newly recommended. Kachchh, Patan, Dahod, Amreli and Panch Mahal district have progressed significantly as compared to NFHS-4.

Figure 4.9- IFA Supplementation for 100 days during pregnancy (%) in Gujarat.



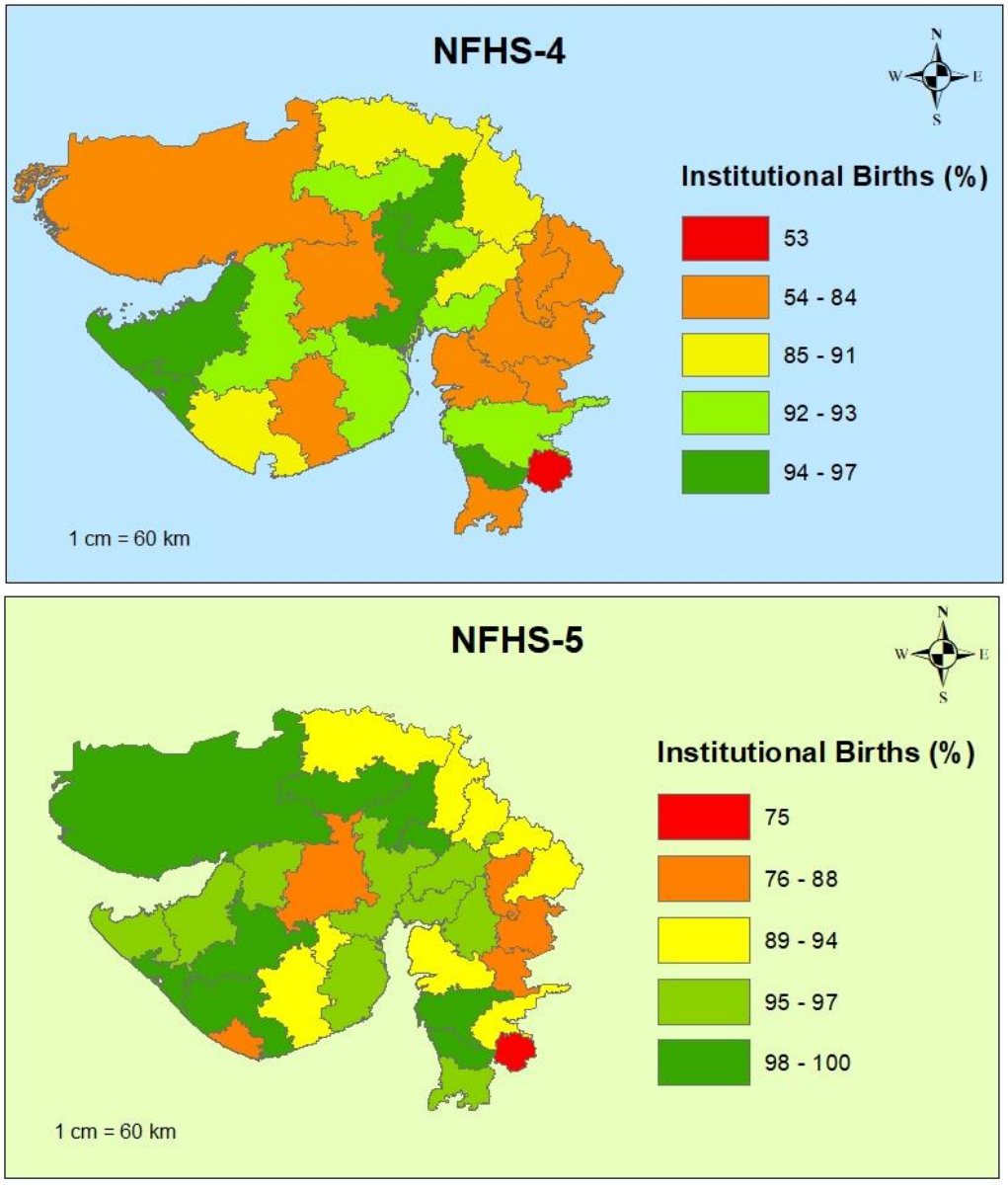
Surat, Navsari, Valsad, Tapi, Dangs district have highest percentage of mothers consuming IFA supplements for 100 days as per NFHS-5 as shown in Figure 4.9. However, the prevalence of anemia (<11 g/dl) in pregnant women and in women aged 15-49 years in Gujarat has shown an upward trend (from 51% to 63% and from 55% to 65% respectively) despite increase in percentage of women consuming IFA for 100 days or more in NFHS-5. (Rai et al., 2018) showed IFA supplementation has been ineffective in reducing the burden of iron deficiency anemia (IDA) among women in India. The common reasons for the same can be irregular consumption of IFA due to side effects, poor compliance etc. The last round of NFHS data calls for a reality check and introduction of a nutrition awareness intervention including intense monitoring of IFA distribution and uptake especially among prospective mothers and pregnant women.

- **Delivery Care**

In Gujarat, there has been an increase in percentage of births in a health facility from 89 percent (NFHS-4) to 94 percent (NFHS-5). Ninety-four percent of births took place in a health facility majorly being government facility and six percent at home. The Sustainable Development Goal (SDG) target aims to reduce maternal mortality ratio (MMR) to reach 70 per 100,000 live births by 2030. Proper delivery care and delivery in a health facility is an effective way to improve maternal and newborn health. Lower rates of maternal mortality were observed in mothers delivering in an institution. The policies should aim to improve the utilization of institutional delivery by focusing on first-time mother and targeting disadvantaged mothers from poor families, rural areas, illiterate and Muslim and scheduled castes.**(Dixit & Dwivedi, 2017).**

In Gujarat, 'Chiranjeevi Yojana (CY) a large public-private partnership program was initiated statewide in 2007 with an aim to provide free institutional childbirth services for eligible women from socially disadvantaged groups in private health facilities.**(Yasobant et al., 2016)**.

Figure 4.10- Institutional Births (%) in Gujarat.



The highest institutional deliveries were for Porbandar (100%), Rajkot, Navsari and Patan (99%) and Gandhinagar, Surat and Kachchh (98%). Institutional births are likely to be more common in women who received antenatal care, primi- parous women, urban women and women with 10 or more years of schooling. Among women who had live birth in a health facility in five years preceding the survey, financial assistance under Janani Suraksha Yojana (JSY) was provided to 15 percent women. Urban women are less likely (9%) than rural women (19%) to receive financial assistance under JSY. Also, scheduled

tribe women were more likely (24%) to receive financial assistance under JSY than any other caste. Institutional births showed protective response against neonatal mortality in a multivariable analysis among tribal or below poverty line women with obstetric complications during pregnancy. These women had lower odds of having a neonatal death than who delivered at home. The overall Neonatal mortality ratio (NMR) was 25 deaths per 1000 live births.**(Altman et al., 2017)**

- **Child Health**

- **Vaccination**

The coverage of all basic vaccinations showed an encouraging progress from (50% to 76%) between NFHS-4 and NFHS-5. It was higher for rural areas than urban areas and higher for boys than girls. Utilization was higher among scheduled tribes than in other caste/tribe children. There was also an increase in full coverage of doses namely, three doses of DPT (73-86%), BCG (88% to 95%), measles (75% to 87%) and polio vaccine (62% to 80%). Eighty five percent of the children received all three doses of Hepatitis B vaccine. Panch Mahals, Navsari, Junagadh and Surat districts had higher percent (94-95%) of children receiving all basic vaccinations whereas Banaskantha reported the lowest coverage (44%) in 2019-20.

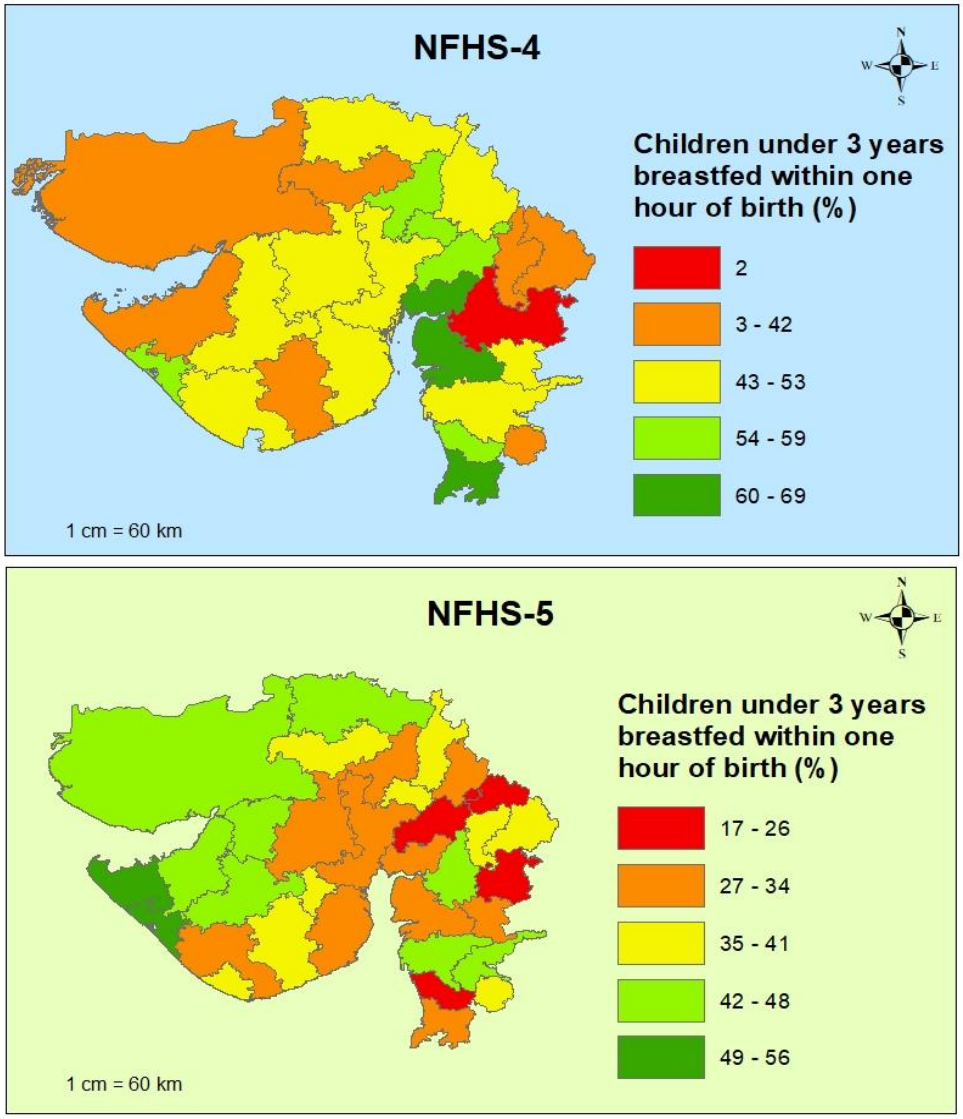
- **Anganwadi Centre (AWC) Services**

Among all the services provided, 60 percent of children received any kind of service in 12 months preceding the survey from the AWC. The common services received by age eligible children were growth monitoring (69%), supplementary food (66%), immunization (60%) and health checkups (65%). The service for early childhood care is least likely to be received (58%).

➢ **Breastfeeding among children.**

Despite breastfeeding being nearly universal in Gujarat, only 65 percent of the children were exclusively breastfed for 6 months in 2019-20 as recommended by World Health Organization. In the year 2018-19, the percentage of children under 3 years of age have declined by 12 percent (from 50% to 38%) since 2015-16, while exclusive breastfeeding rates have increased by around 10 percent.

Figure 4.11- Children under 3 years of age breastfed within one hour of birth (%) in Gujarat.



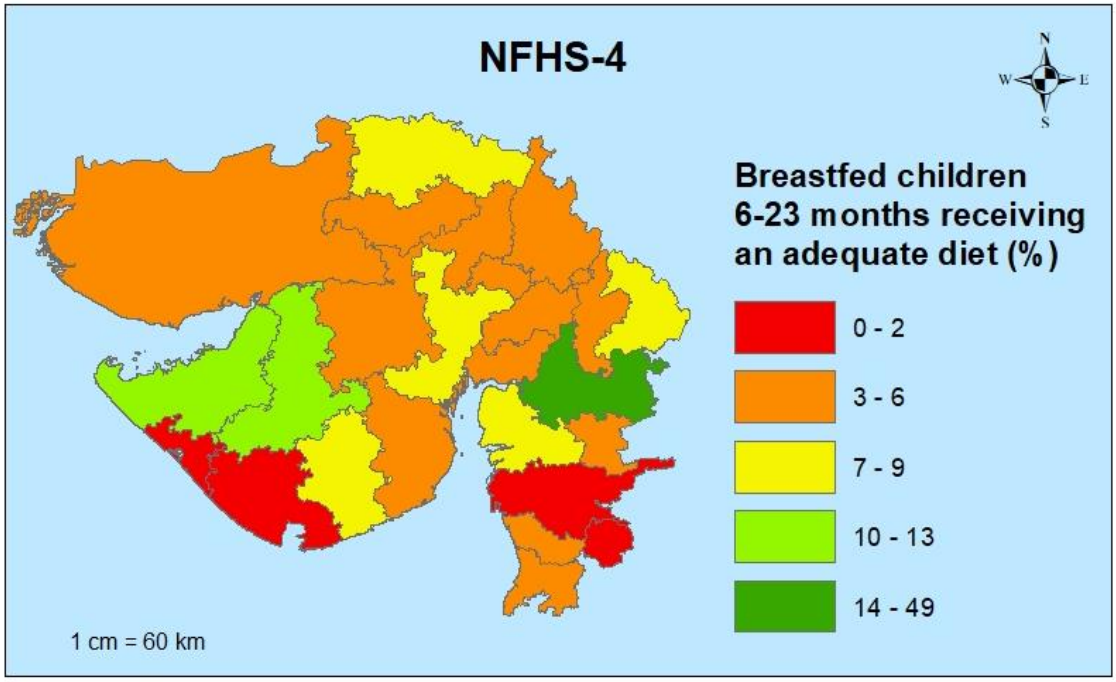
In Gujarat, only 38 percent of the children were put to breast within first hour of birth while 86 percent were put to breast during the first day of life. As shown in Figure 4.10, a large percentage of infants are deprived of first milk (colostrum) which is highly nutritious and confers immunity too. Vadodara district has shown significant improvement in early initiation of breastfeeding (from 2.1% to 44.6%) while significant decline has been reported from Navsari (from 58.2% to 17%), Anand (from 67.2% to 33.7%) and Kheda (from 58.8% to 25.8%). Some of the well performing districts in 2015-16 namely, Anand, Bharuch, Valsad, Mehsana, Gandhinagar and Kheda showed sharp decline in 2018-19. Besides early initiation of breastfeeding exclusive breastfeeding too is important. The prelacteals should be avoided even if regular milk flow is not established during the first three days as they affect the suckling frequency of the infant. However, 17 percent of the infants were found to receive prelacteals during the first three days in Gujarat. **(Indian Institute of Population Sciences, 2020).** The timely initiation of breastfeeding was found to be less among women with no schooling, births delivered by unskilled health personnel and home deliveries according to the NFHS-4 report. The timely initiation of breastfeeding and exclusive breastfeeding could help in 20% less deaths in newborn and 13% less deaths in under-five and also reduction in neonatal mortality.**(Kamal et al., 2020)**

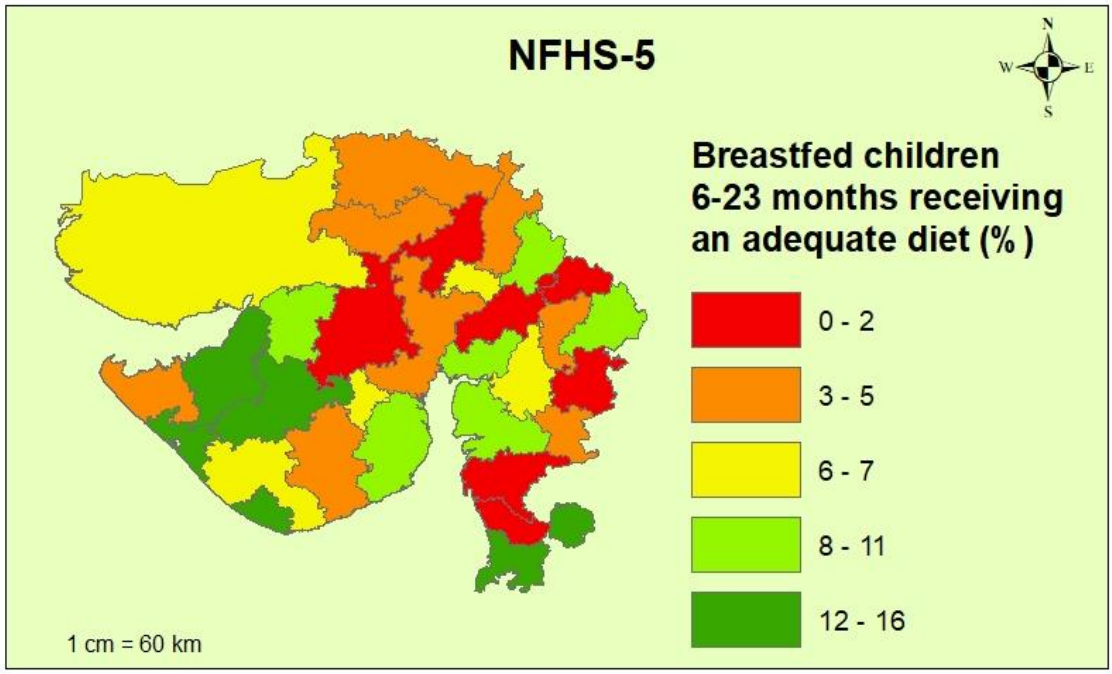
- **Complementary Feeding-**

The World Health Organization (WHO) recommends that infant's energy and nutrient needs start exceeding above breastmilk around 7 months and can be met through complementary feeding. The meal frequency and adequacy of dietary diversity are measured as key IYCF indicators in NFHS among both breastfed and non-breastfed children. An adequate diet refers to breastfed children receiving 4 or more food groups and a minimum meal frequency and non-breastfed children fed with a minimum of 3 Infant and Young Child Feeding Practices along with other milk or milk products at least twice a day. A minimum meal frequency refers to receiving solid or semi-solid food at least twice a day for breastfed infants 6-8 months and at least three times a day for breastfed children 9-23 months, and solid or semi-solid foods from at least four food groups not including the milk or milk products food group).**(Indian Institute of Population Sciences, 2020).**

In Gujarat, as per NFHS-5 only 23% of children, aged 6-23 months were fed recommended minimum number of times per day and 16% were being fed from appropriate number of food groups.

- **Figure 4.13– Breastfed children 6-23 months of age receiving an adequate diet (%) in Gujarat.**





In Gujarat stagnation in percentage of breastfed children receiving an adequate diet has been reported since 2015-16 while an improvement in non-breastfed children receiving an adequate diet (3% to 6%) is reported during the same period. Although there has been progress at the district level, the percentage of breastfed children (6-23 months) receiving an adequate diet shows a decline in majority of the districts (Figure 4.11). Vadodara has shown major decline from 49.4 percent being highest in NFHS-4 to 6.6 percent in NFHS-5. The districts which showed an upward trend were the Dangs (from 2% to 14.7%), Valsad (from 5% to 14.5%) and Gir Somnath having highest percentage of (16%) children age 6-23 months receiving an adequate diet (NFHS-5). While, Surendranagar, Mehsana, Kheda, Mahisagar, Surat, Valsad and Chota Udepur have the lowest number of breastfed children receiving an adequate diet. In India, variation in timely introduction of complementary foods (solid, semi-solid or soft) among 6-8 months old infants has been observed across regions. The same being highest in the southern region (61%) and lowest (38%) in Central and Northern regions. Minimum dietary diversity (MDD) was highest in South (33%) and lowest in Central India (12%). The promoters of desirable IYCF were found to be higher Household Wealth Index (introduction of Complementary Foods) in North and Eastern region, higher maternal education (MDD) in North and Central region and ANC visits >/= 4 for all the indicators across the regions. Thus, an improvement in complementary feeding practices can be achieved through national and sub national efforts by targeting vulnerable mothers, including those with limited health service contacts and no education. **(Dhami et al., 2019)**

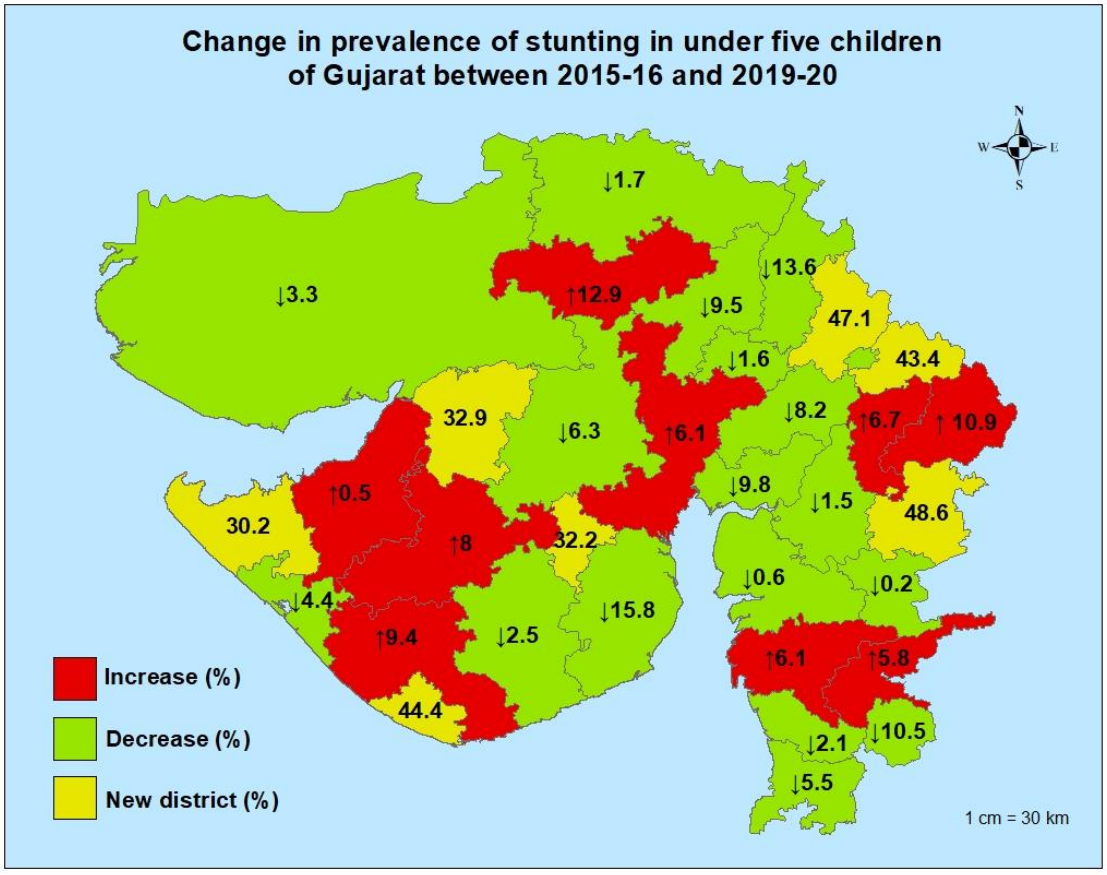
▪ Nutritional Status of Children

In Gujarat, 39 percent of under five children are stunted or too short for their age (below -2 standard deviation), 25 percent children under five years are wasted or too thin for their height and 11 percent are severely wasted. Also, underweight including both chronic and acute undernutrition is reported among 40 percent of the under five children.

➢ Prevalence of stunting in under five children.

In Gujarat, the percentage of children under 5 years who are stunted (39%) has largely remained unchanged since NFHS-4. The districts which showed a sharp increase in under five stunting were Dahod (from 44.4% to 55.3%), Patan (from 37.6% to 50.5%), Rajkot (from 30.9% to 38.9%), Tapi (36% to 42%), Surat (from 30-36%) and Porbandar (from 18% to 23%). Figure 4.13 presents the shift in prevalence of stunting in the various districts across Gujarat state.

Figure 4.13- Change in prevalence of stunting in children under 5 years across various districts of Gujarat from 2015-16 to 2019-20



Remarkable reduction in prevalence of stunting was seen in Kheda (from 45.5% to 37.3%), Mehsana (from 40.5% to 31%), Sabarkantha (from 50.6% to 37%) and Dangs (48% to 38%) while other districts show near stagnation between 2015-16 and 2019-20. The risk of

stunting and underweight was found significantly ($p<0.01$) higher in children from rural areas, children with illiterate parents, nuclear families, children belonging to lower and middle income groups, children of nuclear families, and children belonging to SC and ST communities in Surat**.(Mallikharjun & K, 2016)**

Table 4.4–Correlation between under-five stunting and associated indicators.

Indicators showing correlation with under five stunting (%)	NFHS-4	NFHS-5
HHs with improved sanitation facility (%)	-0.531**	-0.605**
HHs with clean fuel for cooking (%)	-0.495*	-0.582**
Women who are literate (%)	-0.390*	-0.554**
Mothers who had at least 4 antenatal care visits (%)	-0.397*	
Mothers who had full ANC (%)	-0.403*	
Institutional births (%)	-0.503**	-0.356*
Under five underweight children (%)	0.829**	0.665**
Women having BMI below normal (<18.5 kg/m2) (%)	0.628**	0.694**
Women who are overweight or obese BMI ≥ 25.0 kg/m2 (%)	-0.563**	-0.626**
Children age 6 to 59 months who are anemic less than 11.0 g per dl (%)		0.482**
Non pregnant women age 15to49 years who are anemic less than 12.0 g per dl (%)		0.573**
All women age 15-49 years who are anemic (%)		0.578**
All women age 15-19 years who are anemic (%)		0.479**

**. Correlation is significant at the 0.01 level (2-tailed)

*. Correlation is significant at the 0.05 level (2-tailed)

A significant positive correlation was observed between stunting and maternal nutritional status in terms of low BMI and anemia among women. The factors such as improved sanitation, clean fuel for cooking, literacy among women, institutional births, overweight/obesity in women showed a negative correlation with stunting. Therefore, targeted efforts at improving the maternal health status and other associated factors can bring about reduction in prevalence of under 5 stunting in Gujarat. Other potential risk

factors for stunting are - IYCF practices, WASH practices and household food insecurity. **(Rana et al., 2019)** Higher maternal education levels were found to be associated with lower risks of stunting in analysis of 62 low to middle income countries and their demographic health survey.**(Vollmer et al., 2017).** The occurrence of stunting was reported to be inversely proportional to wealth quintiles of families and educational status of the parents.**(Dhirar et al., 2018)** Spatial clustering of districts in India for determinants of childhood malnutrition reported BMI and educational status of mother to be positively associated. The major drivers of premature mortality and infection were lack of clean water and improved sanitation. An integrated approach should be adopted by government and international funding agencies coordinating towards increasing female education, sanitation, poverty reduction and care services provided to mother and child specially in scheduled caste communities and disadvantaged regions.**(Striessnig & Bora, 2020)**

- **Prevalence of wasting and severe Wasting in under five children.**

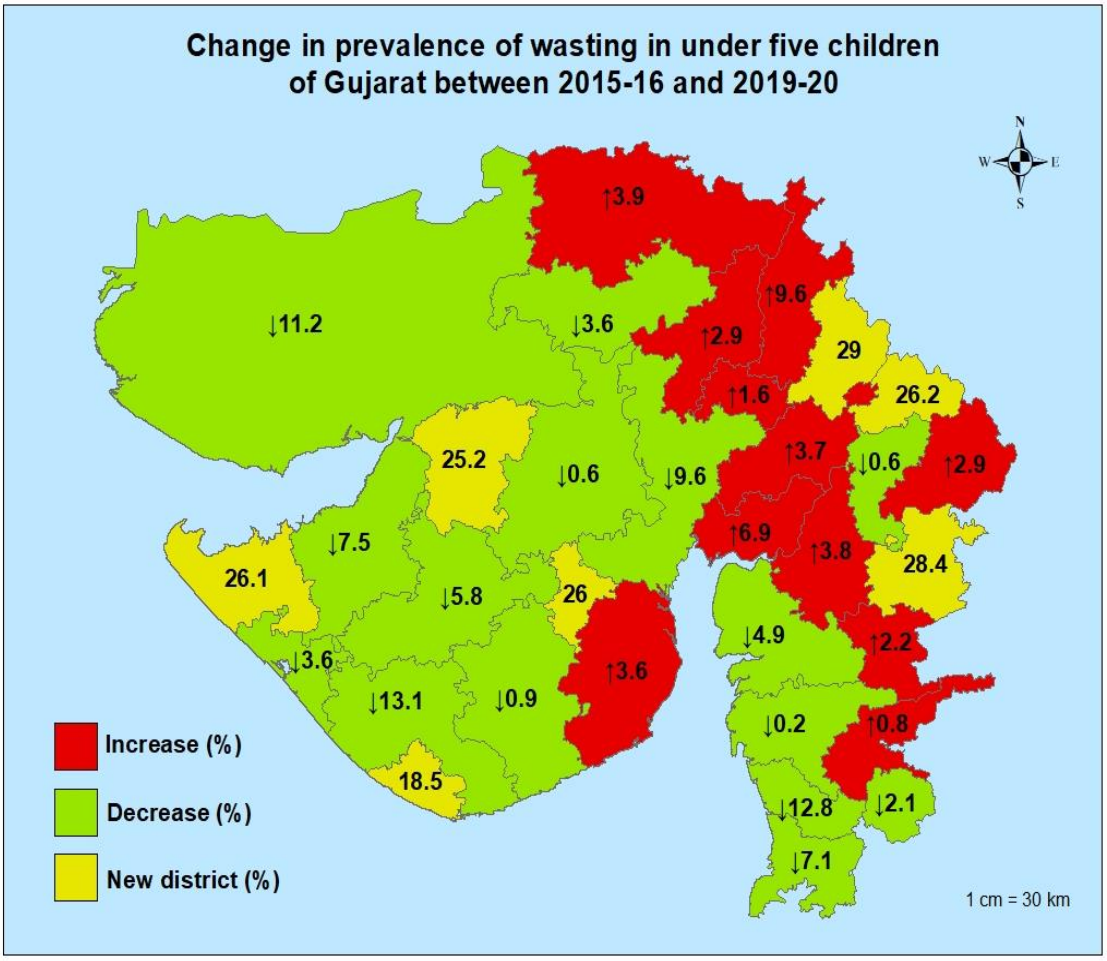
Since NFHS-4, Gujarat has shown a marginal overall decline (from 26% to 25%) in prevalence of wasting in under five children. However, spatial variations are present. The prevalence remains high in many districts of Gujarat, the highest being in The Dangs (41%) despite a reduction from 43% to 41% since NFHS-4. Significant decline in wasting among under-five children was observed in Ahmedabad (from 27% to 17.5%), Jamnagar (from 31% to 24%), Junagadh (30% to 17%), Kachchh (from 31% to 20%), Narmada (from 36% to 26%), Patan (from 24% to 21%) and Valsad (from 30% to 23%) district. Figure 4.13 presents the shift in prevalence of wasting in the various districts across Gujarat state.

The prevalence of wasting in Gujarat (26%) is higher than the national figure of 21%. Looking at the current prevalence rates of wasting and the annual rate of reduction (0.64%), India is far from achieving the Global WHA target 2025 of maintaining and reducing wasting at 5% **(Vakilna & Nambiar, 2020)**

Table 4.5 presents the correlation of wasting and associated indicators. Indicators significantly associated with under-five wasting in Gujarat are -presence of improved

drinking water source and sanitation, institutional births, maternal literacy and normal nutritional status.

- **Figure 4.14– Change in prevalence of wasting in children under 5 years across various districts of Gujarat from 2015-16 to 2019-20**



Factors associated with prevalence of wasting are similar to those for stunting**. (Harding et al., 2018)** have reported similar findings. Maternal characteristics such as low BMI was significantly associated with wasting and such mothers had 38% increased odds of child wasting. Maternal overweight showed a lower likelihood of wasting in children whereas short maternal stature was also associated with wasting in children. Illiterate mothers had higher chances of giving birth to a wasted child in India. **(T. R. Chowdhury et al., 2020)** reported age, gender, household's position in wealth index and geographical distribution

as common determinants of stunting and wasting. The type of toilet facility was found a statistically significant determinant of child wasting.

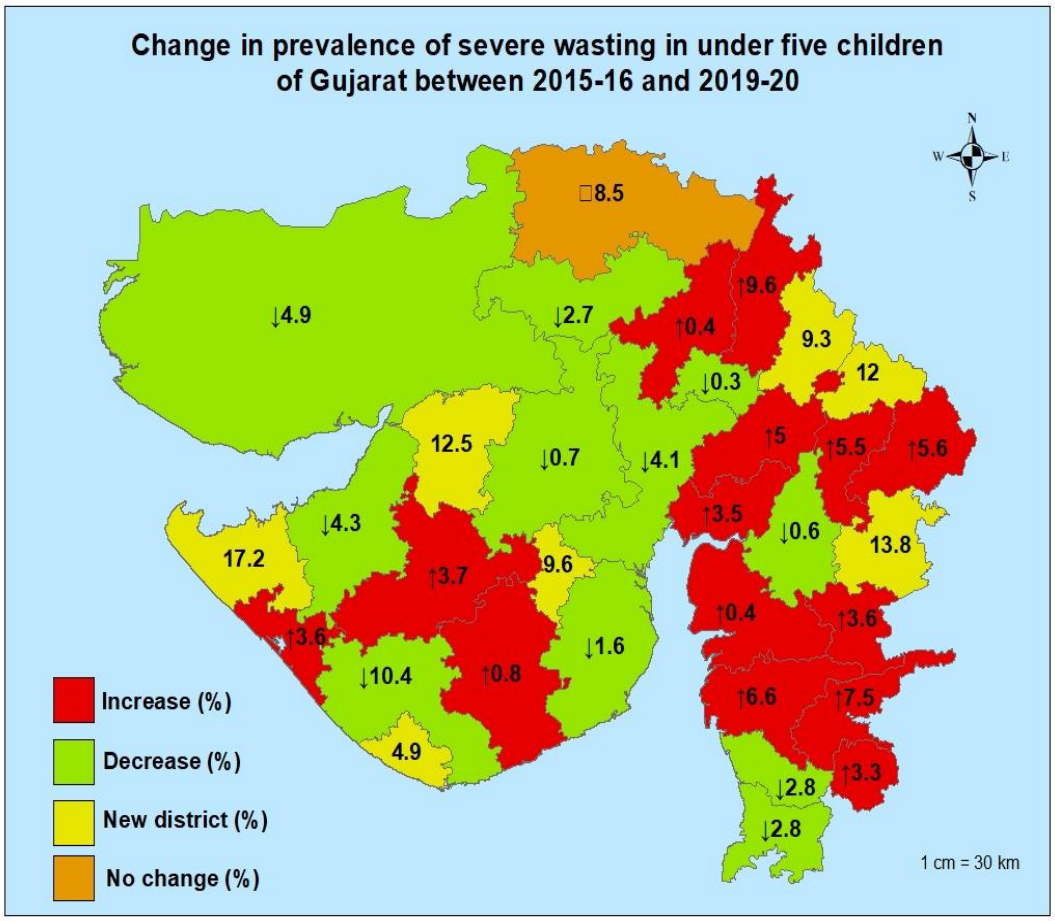
Table 4.5 – Correlation between under-five wasting and associated indicators

Indicators showing correlation with under five wasting (%)	NFHS-4	NFHS-5
HHS with an improved drinking-water source (%)	-0.424*	-0.479**
HHS with improved sanitation facility (%)		-0.385*
Women who are literate (%)		-0.359*
Mothers who received postnatal care from a doctor/nurse/LHV/ANM/midwife/other health personnel within 2 days of delivery (%)	-0.465*	-0.355*
Mothers who received financial assistance under Janani Suraksha Yojana (JSY) delivered in an institution (%)	0.569**	
Institutional births (%)	0.582**	-0.445**
Prevalence of diarrhoea in the 2 weeks preceding the survey (%)		0.415*
Breastfeeding children age 6-23 months receiving an adequate diet (%)	-0.445*	
Children under 5 years who are underweight (%)		0.641**
Women whose Body Mass Index is below normal BMI (<18.5 kg/m2) (%)	0.510**	
Women who are overweight or obese (%)	-0.412*	-0.514**
Children age 6 to 59 months who are anaemic < 11.0 g per dl (%)		0.381*
Non pregnant women age 15t o 49 years who are anaemic < 12.0 g per dl (%)	0.453**	
All women age 15-49 years who are anaemic (%)		0.479**

**. Correlation is significant at the 0.01 level (2-tailed)

*. Correlation is significant at the 0.05 level (2-tailed)

Figure 4.15- Change in prevalence of severe wasting in children under 5 years across various districts of Gujarat from 2015-16 to 2019-20

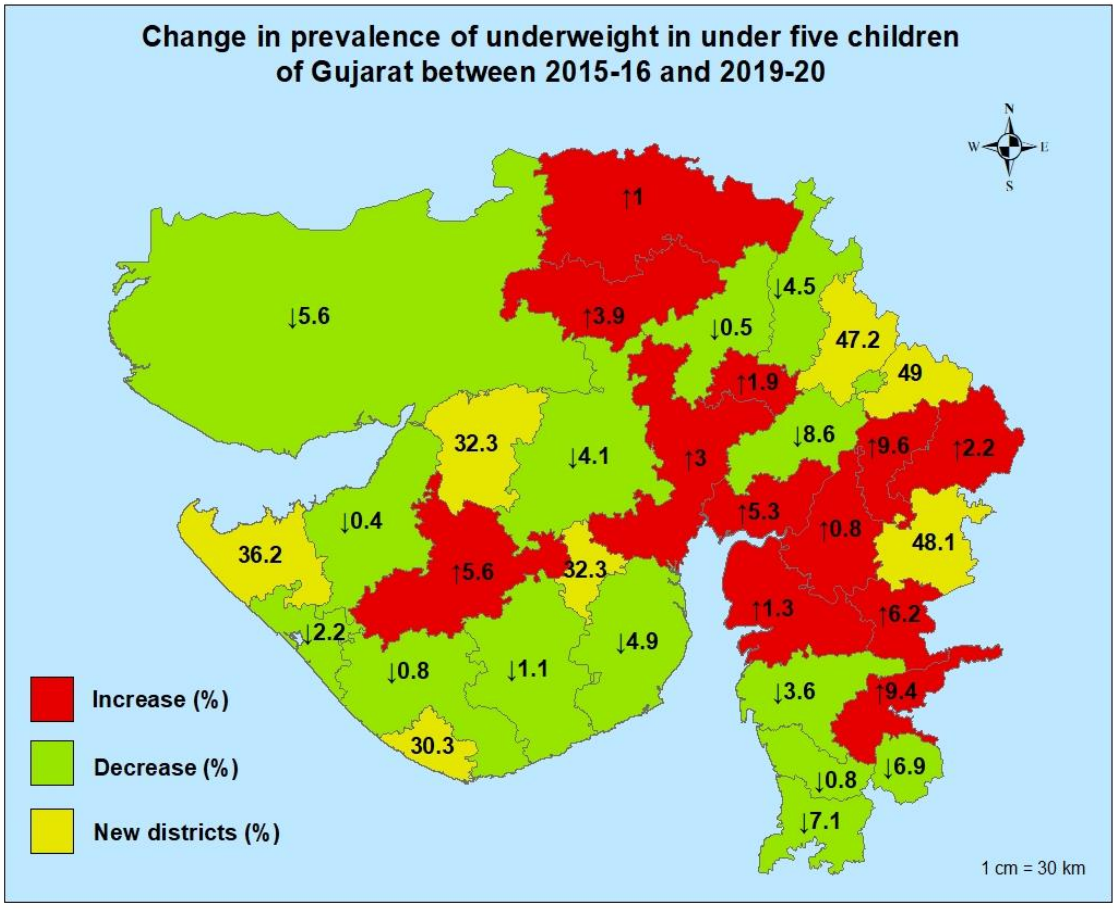


In Gujarat, severe wasting among under five children has increased marginally (from 9.5% to 10.6%) since 2015-16. The decrease in percentage of children under five years who are severely wasted was observed in Ahmedabad (from 11.5% to 7%), Jamnagar (17% to 12%), Kachchh (from 15.5% to 11%), Kheda (from 7% to 12%) and Junagadh (17% to 7%). The highest increase in severe wasting was observed in Banaskantha (9.6%) and Tapi (7.5%) district. While some districts showed an upward trend namely, Anand (from 7% to 11%), Dahod (from 8% to 13%), Kheda (from 7% to 12%), Narmada (from 10% to 13%), Navsari (from 6% to 9%), Surat (8% to 15%), and Porbandar (11% to 14%). Household food insecurity also plays an important role in acute malnutrition other than childhood illnesses and WASH practices. The odds of acutely malnourished child are reported to be higher in food insecure households. Therefore, preventive strategies should focus on addressing household food insecurity and poor WASH practices**. (Rana et al., 2019)**

➢ Prevalence of underweight in under-five children

Percent underweight children increased from 39% to 40% between 2015-16 and 2019-20 in Gujarat. As shown in the figure 4.15, major decline in percentage of underweight children was seen in The Dangs (60% to 53%), Kachchh (39% to 33%), Valsad (42% to 35%), Bhavnagar (43% to 40%), Sabarkantha (45% to 41%), Kheda (48% to 40%) and Surendranagar (46% to 41%) Panch Mahal, Tapi, Rajkot, Narmada and Patan district showed a remarkable increase in underweight children in Gujarat as shown in Figure 4.16.

Figure 4.16- Change in prevalence of underweight among children under five years across various districts of Gujarat from 2015-16 to 2019-20



The occurrence of under-five underweight children in Gujarat showed statistically significant positive correlation with under-five stunting, wasting and anemia among

children aged 5-59 months, anemia in women and low BMI of parents. A negative correlation was observed for factors such as improved sanitation, clean fuel for cooking, literacy among women, antenatal care, institutional births and overweight or obese women.

Table 4.6 –Correlation between under-five underweight and associated indicators

Indicators showing correlation with under five underweight children (%)	**NFHS-4**	**NFHS-5**
Households using improved sanitation facility (%)	-0.658**	-0.647**
Households using clean fuel for cooking (%)	-0.502**	-0.703**
Women who are literate (%)	-0.417*	-0.599**
Mothers who had antenatal check-up in the first trimester (%)	-0.494*	-0.421*
Institutional births (%)	-0.659**	-0.495**
Under-five stunting (%)	0.829**	0.665**
Under-five wasting (%)		0.641**
Women whose Body Mass Index BMI is below normal BMI < 18.5 kg/m2 (%)	0.794**	0.815**
Men whose Body Mass Index BMI is below normal BMI < 18.5 kg/m2 (%)	0.641**	
Women who are overweight or obese BMI ≥ 25.0 kg/m2 (%)	-0.738**	-0.759**
Children age 6 to 59 months who are anemic <11.0 g per dl (%)		0.634**
Non pregnant women age 15to49 years who are anemic <12.0 g per dl (%)		0.726**
All women age 15-49 years who are anemic (%)		0.729**
All women age 15-19 years who are anemic (%)		0.620**

**. Correlation is significant at the 0.01 level (2-tailed)

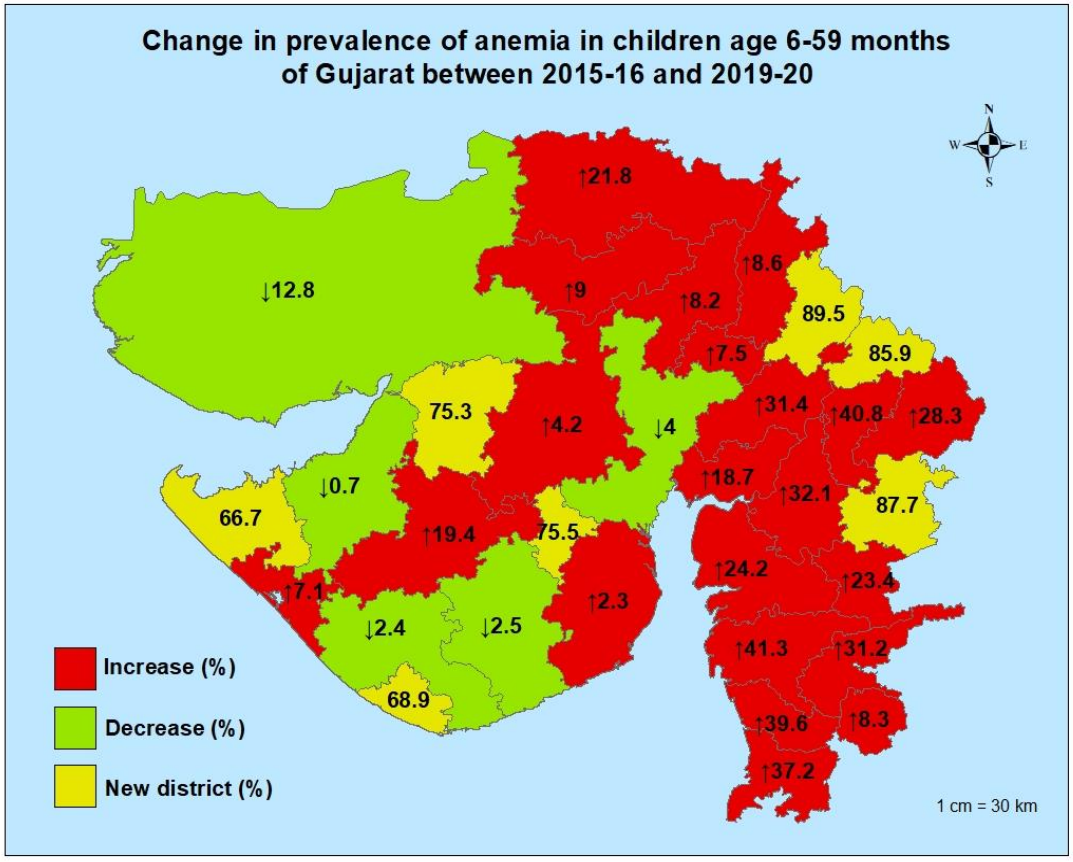
*. Correlation is significant at the 0.05 level (2-tailed)

A positive and significant correlation was found between underweight and stunting at national level in both NFHS-4 and CNNS. It was observed that two-thirds of stunted children were also underweight.**(Ramesh & Johnston, 2021)** Underweight in children was significantly associated with child's age, child's sex, toilet facility and point of use water

treatment**.(Roba et al., 2021).** Food security status, low BMI status of mothers and use of toilet facility have been reported as major predictors of childhood stunting and underweight. It is very important to address maternal nutrition, provide good sanitation facility, improve food security status, control infections and identify the high burden pockets with regional disparities through spatial mapping to comprehensively address child under nutrition**.(Sinha et al.,2018)**

➢ Prevalence of anemia in children aged 6-59 months

Figure 4.17– Change in prevalence of anemia among children (6-59 months) across various districts of Gujarat from 2015-16 to 2019-20



As shown in Figure 4.17, there has been a significant increase in percent prevalence of anemia among children aged 6-59 months in majority of the districts. The highest increase was reported from Surat (42% to 84%) and Panch Mahal (50% to 91%) followed by

Navsari (52% to 75%), Valsad (50% to 88%), Vadodara (54% to 87%), and Kheda (54% to 85%) districts. The sole exception was Kachchh district that recorded a decline of 13% in prevalence of anemia among children (6-59 months). The indicators correlating with the anemia among children age 6-59 months are represented in table 4.7.

Table 4.7- Correlation between anemia among children (6-59 months) and associated indicators

Indicators showing correlation	NFHS-4	NFHS-5
Under five stunting (%)		0.482**
Under five wasting (%)		0.381*
Under five severe wasting (%)	0.426*	
Under five underweight (%)		0.634**
Women with BMI below normal (<18.5 kg/m2) (%)		0.509**
Women who are overweight or obese (%)		-0.529**
Non pregnant women age 15-49 years who are anemic (%)	0.826**	0.799**
Women 15-49 years who are anemic (%)	0.821**	0.803**
Women 15-19 years who are anemic (%)		0.827**
Children breastfed within one hour (%)		-0.347*
ANC checkup in first trimester (%)		-0.365*
Households with improved sanitation facility (%)		-0.521**

**. Correlation is significant at the 0.01 level (2-tailed)

*. Correlation is significant at the 0.05 level (2-tailed)

As shown in the table 4.7, factors such as maternal anemia and under five undernutrition have shown significant correlation with prevalence of anemia among children aged 6-59 months. Also, indicators such as improved sanitation, breastfeeding and ANC checkup in

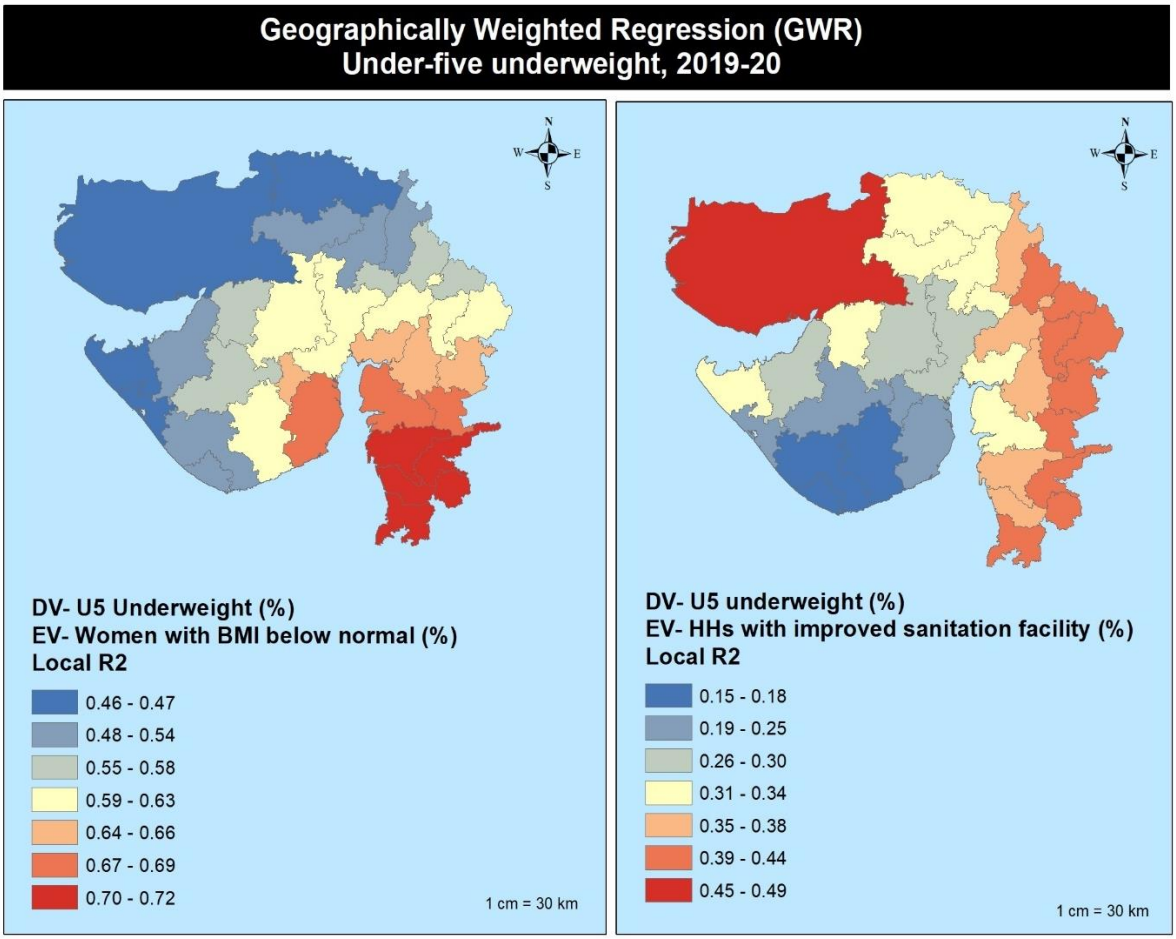
first trimester showed a negative association indicating that improving these would significantly decrease anemia among children age 6-59 months.

The major determinants of childhood anemia were reported to be maternal educational status, maternal health, nutritional intake and household wealth. Anemia was also positively associated with intake of Vitamin A, iron intake and worm infestation.**(Onyeneho et al., 2019)** Anemia is mainly caused due to iron deficiency which may occur due to other reasons such as malabsorption of nutrients in diet and chronic disease. Iron supplementation is required to fulfill the demand of iron. The socioeconomic conditions of households should also be improved besides iron supplementation. **(Bharati et al., 2019).**The rural children are found to be more anemic than urban children. Mother's educational status and occupation of the father also plays a significant role in prevalence of anemia. As anemia has multiple correlates, multiple strategies should be planned to combat the prevalence of anemia.**(Bharati et al., 2015)**

- **Geographically Weighted Regression (GWR)**

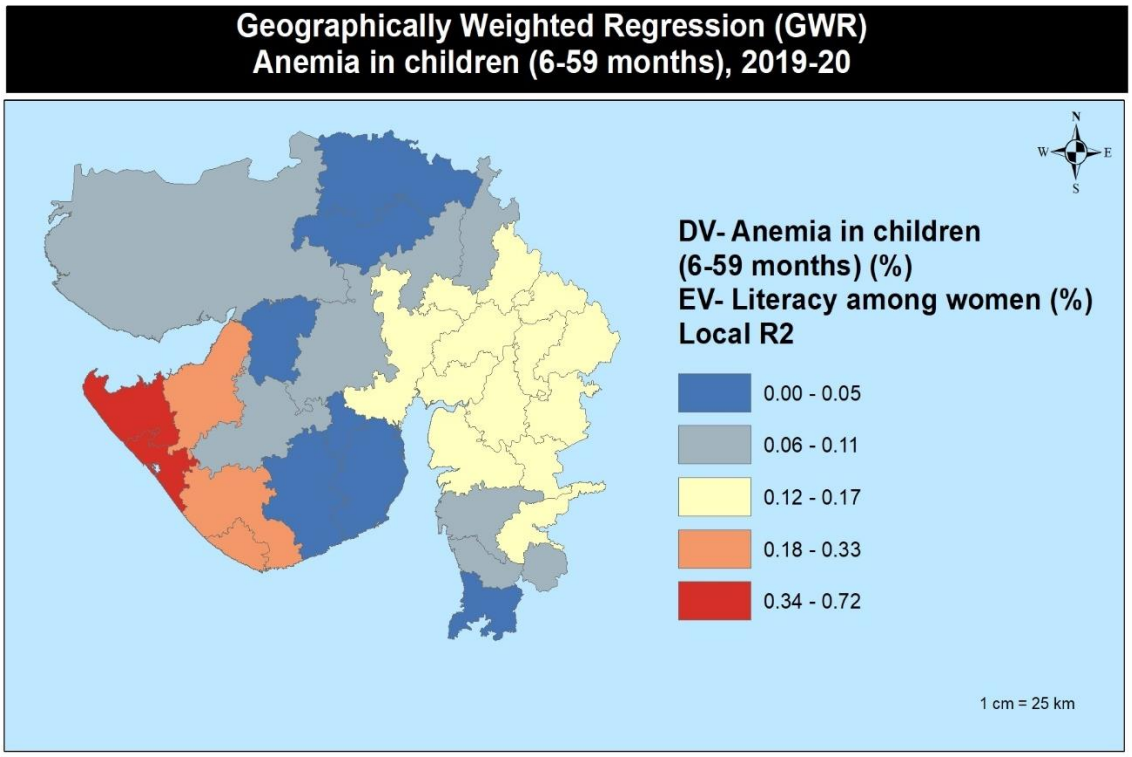
GWR is a local spatial statistical technique that assumes non-stationarity in relationships between dependent variable and explanatory variable(s) which change from location to location. A variable which is a strong predictor in one cluster might not be a strong predictor in another cluster therefore GWR helps in identification of such cluster variations by creating equation for each cluster. In the present study GWR was performed to find associations between undernutrition and different explanatory variables within various districts of Gujarat. The color ramp in the Figures is graduated from light yellow to red. The areas with light shade indicate that particular variable exhibits strong influence on occurrence of undernutrition while dark shade indicate weak or low influence on undernutrition variable.**(Shifti et al., 2020)(Nkeki & Osirike, 2013)** The GWR model was computed using geographically weighted regression extension present in spatial statistics tool box of ArcGIS 10.5. R-squared value acts as a measure of goodness of fit. The value varies from 0.0 to 1.0 and higher values are preferable.

Figure 4.18 -GWR estimates for variables of under-five underweight 2019-20



Model 1 &2 of GWR with local R^2 value ranging from 0.46 to 0.72 predicts association between prevalence of under-weight in children under five years of age with maternal nutritional status in terms of low BMI and improved sanitation. The higher value of R^2 represents strong association and is shown in red color whereas blue color predicts low association in figure 4.18. Model 1 GWR having R^2 0.70-0.72 predicts strong association between maternal nutritional status (low BMI) and prevalence of underweight in the districts of Surat, Tapi, Valsad, Navsari and Dangs. Model 2 GWR with R^2 0.45-0.49 predicts association between prevalence of under-weight in under five children and improved sanitation in households in Kachchh. Therefore, the three GWR models can predict different explanatory variables to be associated the percentage of underweight children in different districts of Gujarat. However, other factors also play a role and should also be considered in reducing the prevalence of under-five underweight in Gujarat.

- **Figure 4.19 – GWR estimates for variables of anemia in children (6-59 months) 2019-20**



Model 1GWR model shown in Figure 4.19 predicts association of literacy among women with anemia in children aged 6-59 months in various districts of Gujarat. Model 1 GWR with R^2 value ranging between 0.34 to 0.72 predicts association between prevalence of anemia in 6-59 months age children and literacy among women and anemia in districts such as Porbandar and Dev Bhumi Dwarka whereas lowest association was predicted in districts of Bhavnagar, Amreli, Valsad, Morbi, Banaskantha and Patan.

However, other factors also play a role and should also be considered in reducing the prevalence of anemia in children in Gujarat. Therefore, by identifying district specific factors can help in location-specific and targeted interventions which can further help in improving anemia in children age 6-59 months.

- **Weighted Sum Analysis of Stunting (%), Wasting (%) and Underweight (%) for under-five children in Gujarat, 2019-20**

The Weighted Sum function in Arc GIS, allows to overlay several rasters, multiplying each by their given weight and summing them together. The weighted sum table can be defined by three properties: a. Raster—The raster being weighted, b. Field—The field of the raster to use for weighting, c. Weight—The weight value by which to multiply the raster. It can be any positive or negative decimal value. **(ESRI, 2016)** In the Figure 4.20, the three rasters for stunting, wasting and underweight have been applied equal weight (=1) and weighted sum analysis of the three was performed**.** The districts with red and orange color have the highest percentage of undernutrition in terms of stunting, wasting and underweight combined.

Figure 4.20 – Weighted Sum of Stunting, Wasting & Underweight for U5 children in Gujarat, 2019-20.

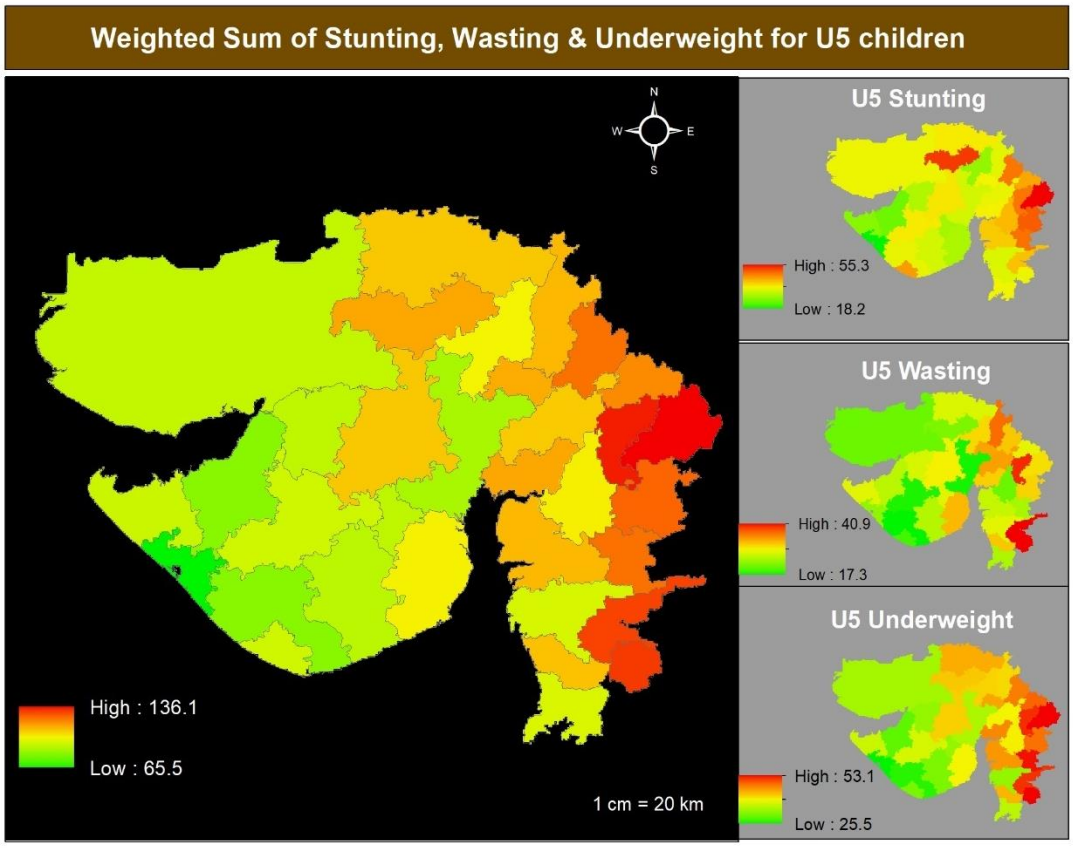


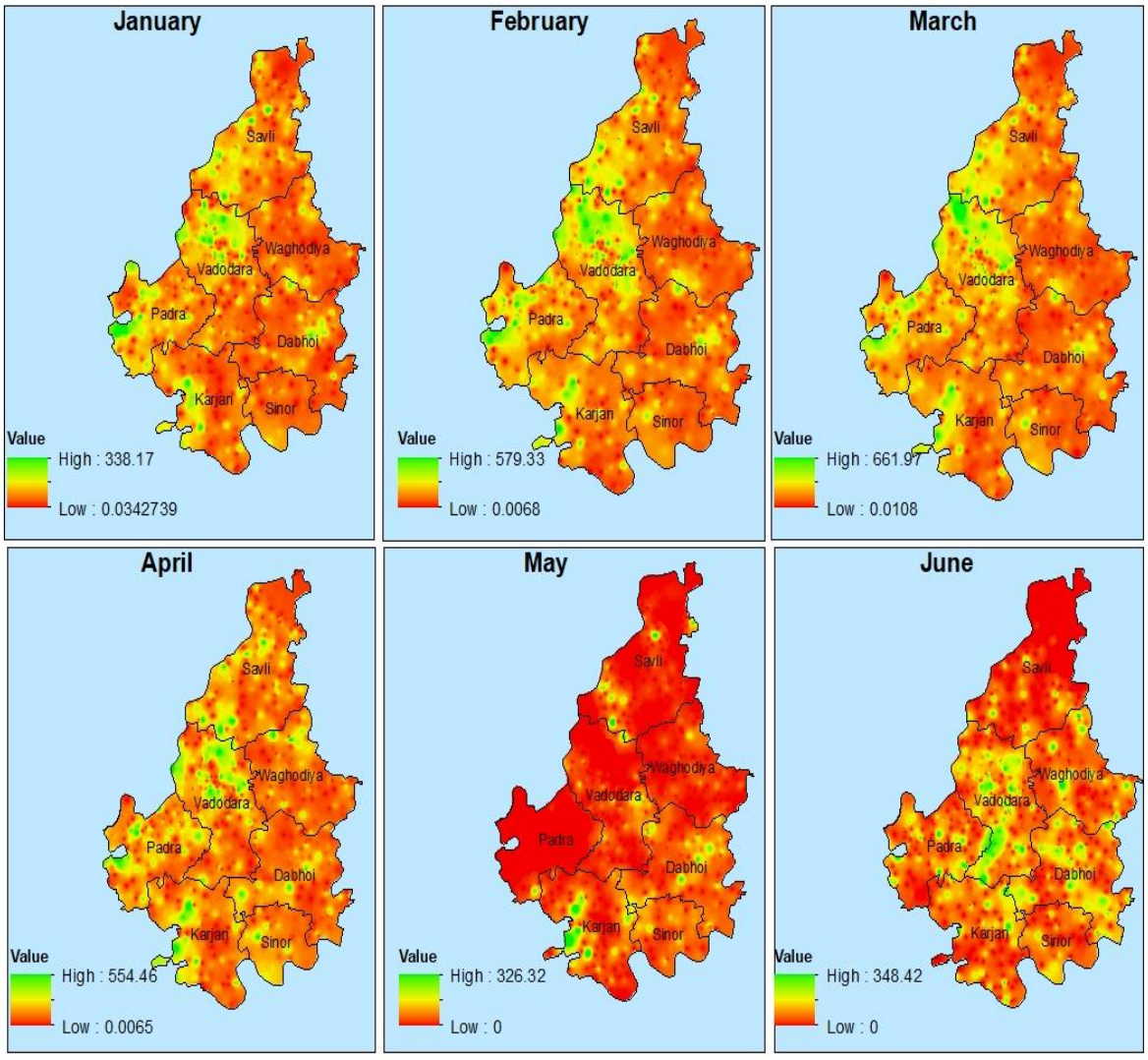
Figure 4.20 shows higher prevalence of undernutrition (stunting, wasting & underweight) in The Dangs, Tapi, Panch Mahals, Aravalli, Mahisagar, Chota Udepur, Narmada and Dahod whereas Jamnagar, Junagadh, Porbandar, Rajkot, Amreli, Dev Bhumi Dwarka, Morbi, Kachchh and Ahmedabad have lower prevalence of undernutrition in terms of stunting, wasting and underweight for the year 2019-20. The other districts have low to moderate undernutrition as shown in lighter shades of yellow and green color in the Figure 4.20. The weighted sum analysis helps in identification of clusters for undernutrition in Gujarat. The policies and strategies should be region specific to improve the status of undernutrition.

II. Mid-day Meal Scheme in Gujarat

To assess the utilization of mid-day meal scheme in Gujarat, there was a lack of recent secondary data and therefore the monitoring data available for the number of meals served under MDM has been considered. As it was not feasible to analyze the data for entire year, the data for one day from third week of each month except for May 2018 has been considered as representative for the blocks of Vadodara district. The point data of locations of the schools providing meals under MDM have been mapped and interpolated through ArcGIS software. Interpolation is a spatial analysis method which predicts the unknown value of any geographical data when the number of sample data points are limited. It assumes that the spatially distributed objects are spatially correlated and have similar characteristics. The inverse distance weighted (IDW) type of interpolation determines the cell values through a linear weighted combination of a set of sample data points. The IDW interpolation has been performed in this study as shown in Figure 4.21 and 4.22.**(ESRI, 2016)** Figure 4.21 and 4.22 represent the interpolation of number of meals served in different blocks of Vadodara district on a day in third week of every month in 2018 using Inverse Distance Weighted (IDW) technique. The number of meals served in 1223 schools out of 1225 schools of Vadodara district have been considered. As shown in Figure 4.21, the number of meals served in schools of Vadodara district have shown similar trends in the first four months of the year. Vadodara, Padra, Savli and Karjan blocks have shown higher number of meals served till April 2018. In the month of May, the schools remain

shut therefore show negligible numbers of meals served and the trend continues in the month of June as the schools reopen. In the latter part of the year, (Figure 4.22) the number of meals served increase reaching the highest number in the month of September and October in all the blocks. Number of meals served decline in the month of November due to school vacations. The spatial mapping for number of meals served during all working days in the year 2018 can represent the better picture of performance of Mid- Day Meal (MDM) Scheme in Vadodara district.

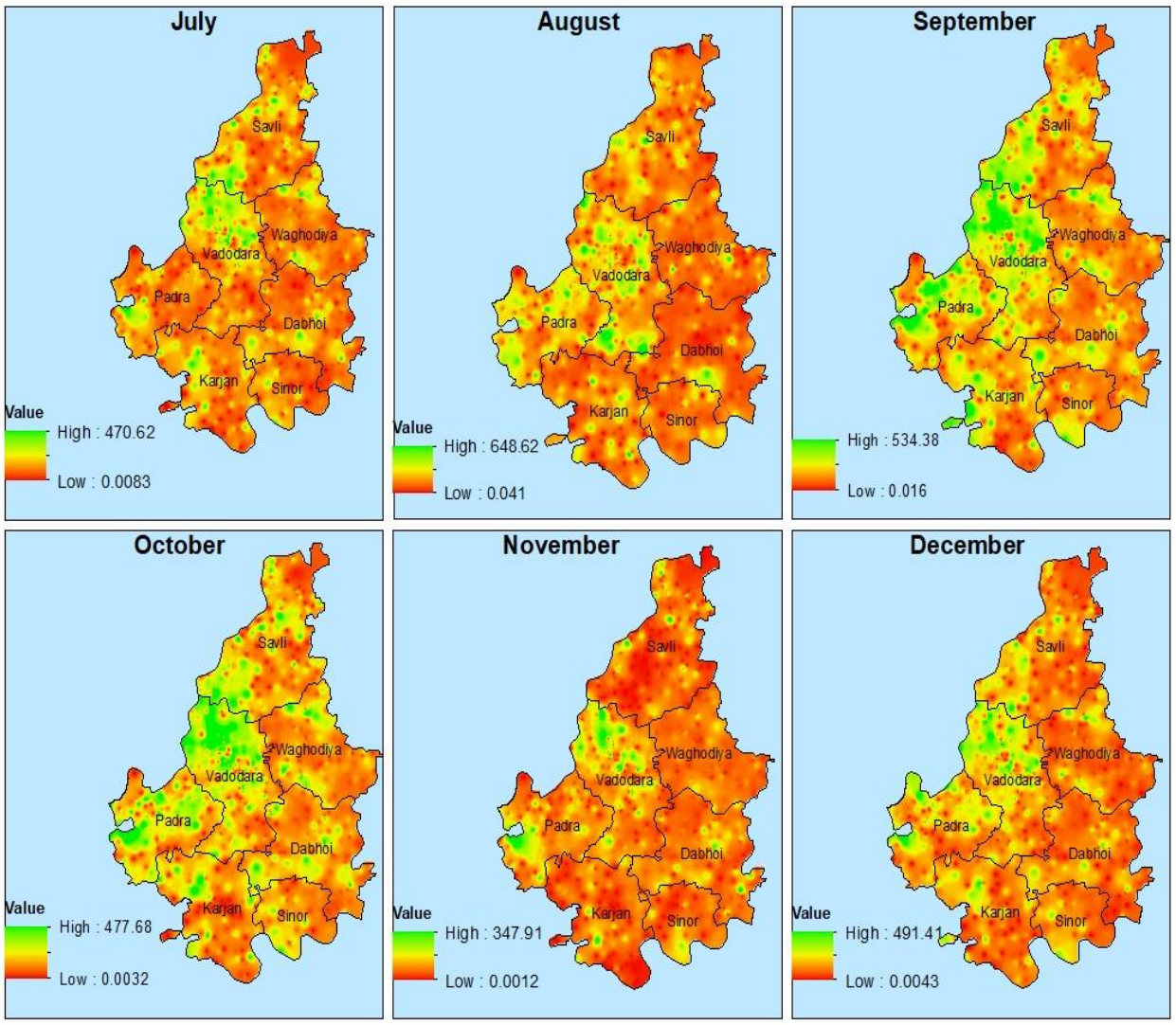
- **Figure 4.21- No of meals served from January to June in blocks of Vadodara district under MDM, 2018.**



Source- https://mdm.gujarat.gov.in/

The MDM scheme show a steady and significant improvement in important parameters and is running successfully in Gujarat.**(Kanubhai Patel & Pancholi, 2018)** Various studies, **(Ramachandran, 2019), (Nath & Nath, 2015), (Jayaraman & Simroth, 2015)** have reported improved school enrolment rate and attendance due to smooth functioning of MDM scheme. The prevalence of undernutrition was reported to be high among the beneficiaries availing MDM in rural Vadodara. The need to improve the knowledge regarding MDM program and sanitation and hygiene practices was observed**. (S. Patel et al., 2019)**

- **Figure 4.22- No of meals served from July to December in blocks of Vadodara district under MDM, 2018.**

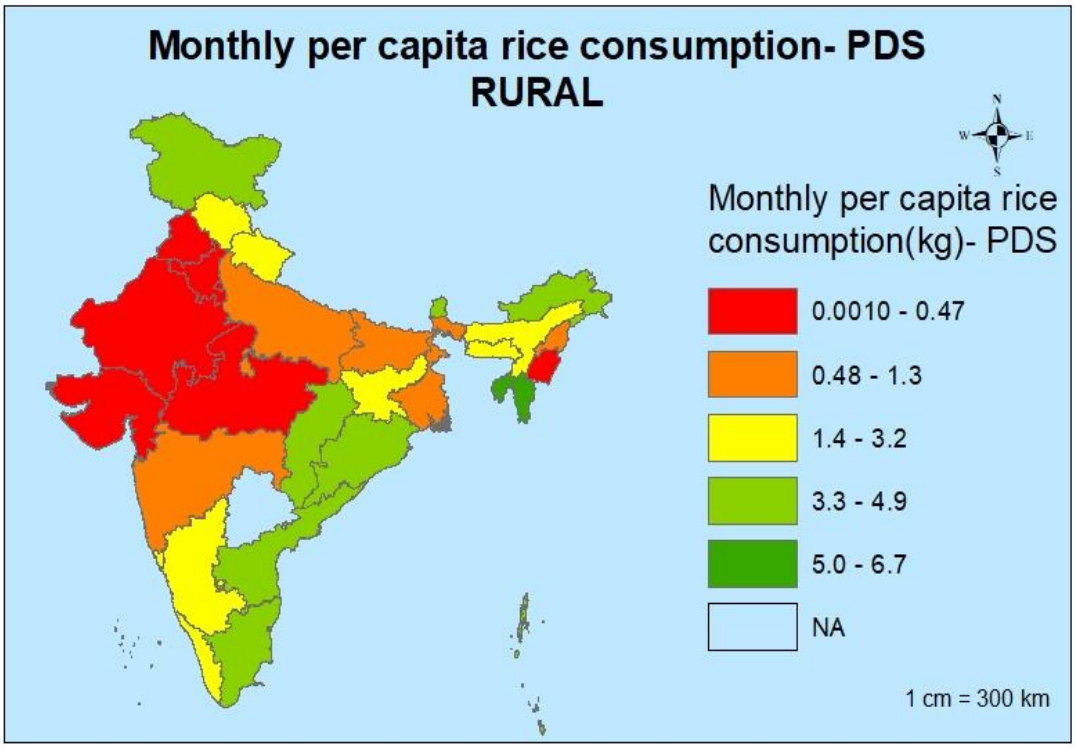


The prevalence of moderate anemia was also found to be higher in children of Vadodara and needs to be improved on priority basis in government primary school children. The strengthening of Mid-day meal program and National Iron Plus Initiative (NIPI) will help in curtailing anemia in children. **(Gandhi & Panchal, 2020)**

III. Utilization of Public Distribution System (PDS), 2011-12

The consumption of three commodities – rice, wheat and sugar from PDS purchase and consumption from other sources were considered. PDS distributes these essential commodities at subsidized rates through ration shops, fair price shops and control shops.

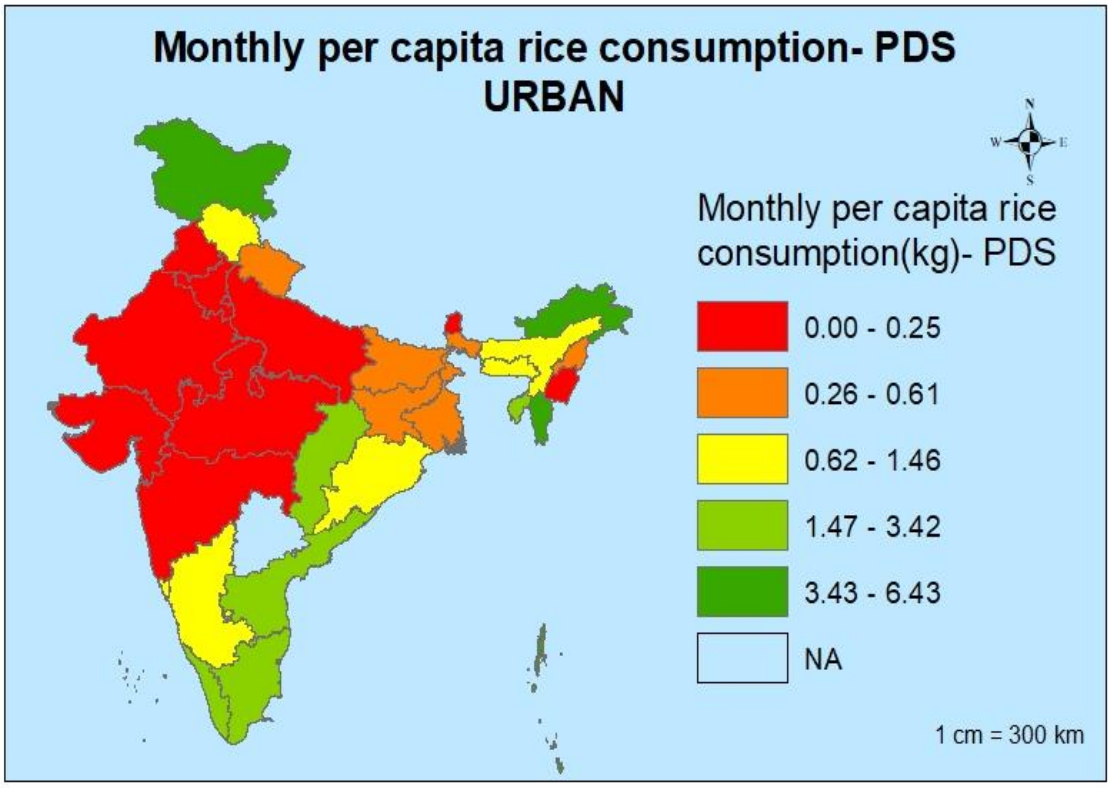
Figure 4.23- Per capita rice consumption from PDS in rural India, 2011-12



The PDS share in rice consumption was about 27.9% in rural sector (1.67 kg out of 5.98 kg/person) and about 19.6 % in urban sector (0.88 kg out of 4.49 kg/person) in 2011-12 as per the NSSO 68th round. The states- Jammu & Kashmir, Mizoram, Chhattisgarh, Kerala,

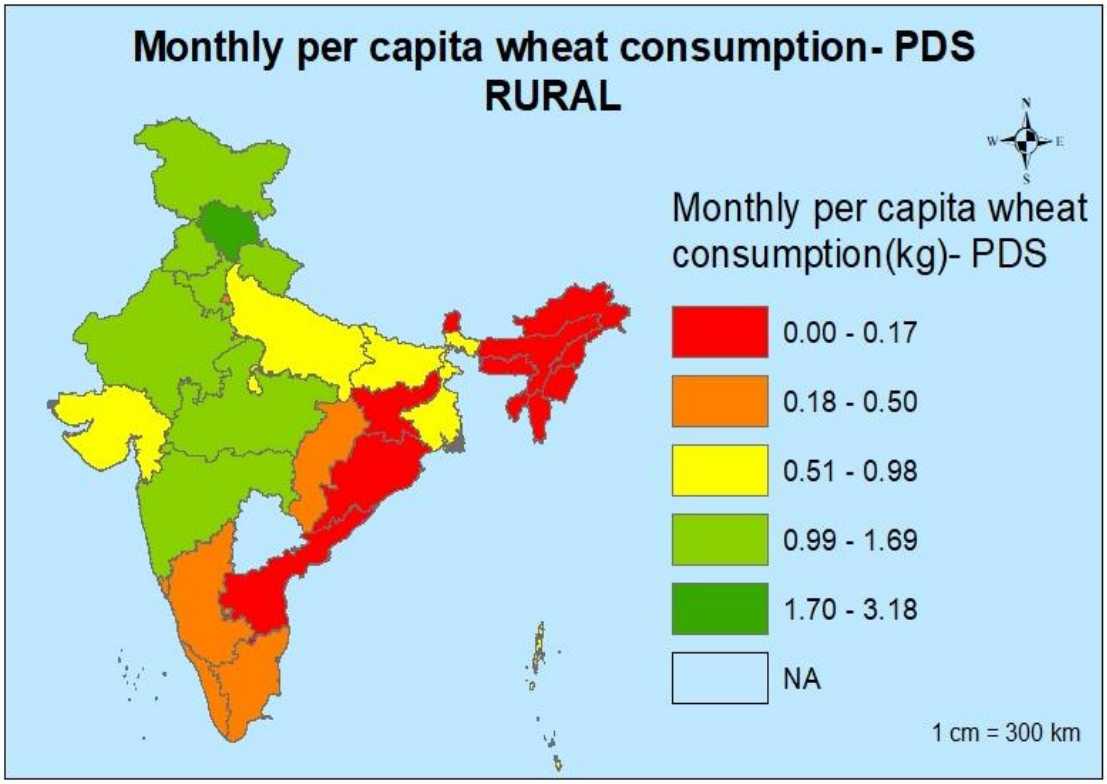
Tamil Nadu, Arunachal Pradesh, Andhra Pradesh, Mizoram and Tripura showed higher per capita rice consumption from PDS in both rural and urban sectors. The percentage of households which reported the consumption of rice from PDS was 46 % rural and 23% in urban India during a 30-day period. The incidence of PDS purchase of rice in rural sector was highest for Tamil Nadu (89%) followed by Andhra Pradesh (87%), Kerala (78%), Karnataka (75%), Chhattisgarh (67%), and Odisha (54%).

Figure 4.23- Per capita rice consumption from PDS in urban India, 2011-12



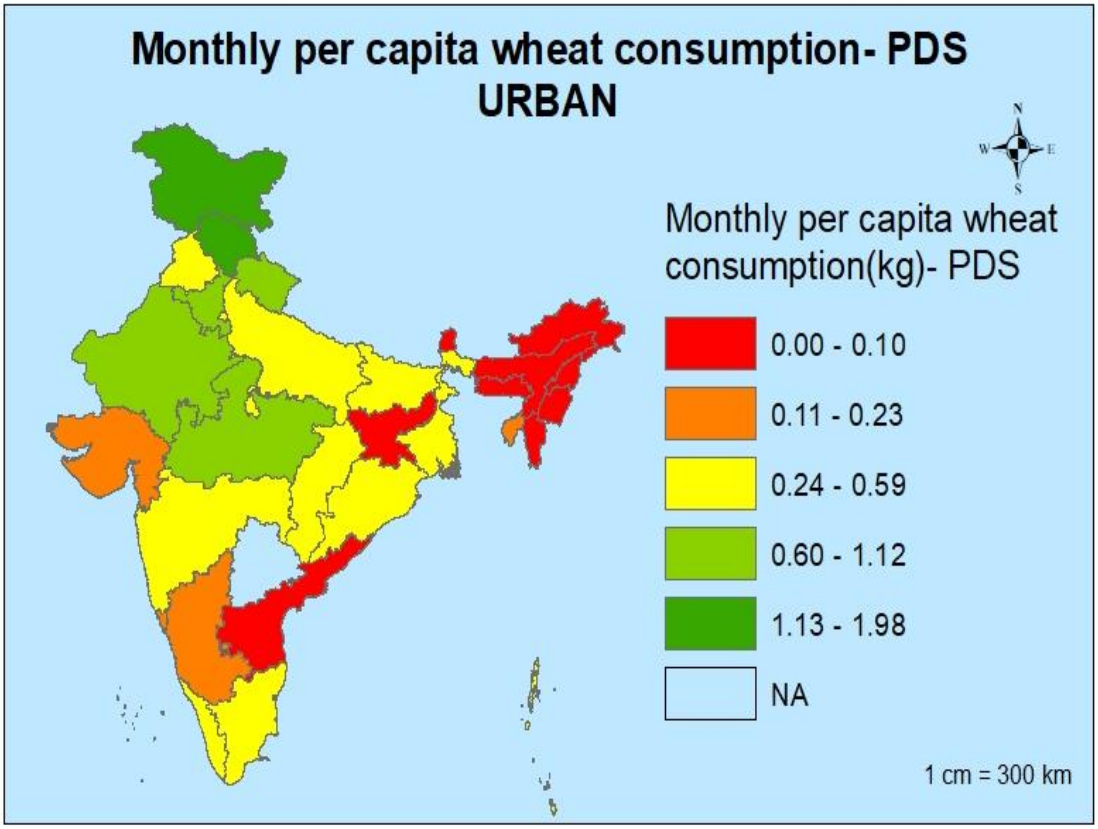
The incidence of PDS purchase of rice for urban sector was highest for Tamil Nadu (67%), followed by Kerala (61%), Andhra Pradesh (45%) and Chhattisgarh (42%). In West Bengal, rice being the main item of cereal consumption showed the lowest share of PDS purchases (rural- 10%, urban- 6%).

Figure 4.25- Per capita wheat consumption from PDS in rural India, 2011-12



The percentage of households reporting consumption of wheat/atta from PDS during a 30-day period was 34% for rural India and 19% for urban India. For the percentage of consumption coming from PDS for households in different fractile classes of monthly per capita expenditure (MPCE), the percentage dropped below 10% for wheat from 7th fractile onwards out of 12 fractile classes. The percentage of consumption was higher for first five fractile classes of MPCE in urban sector where as for rural sector the percentage below 10% was only for highest fractile class of MPCE. The major states reporting higher per capita wheat consumption from PDS in rural and urban sectors are Jammu and Kashmir, Haryana, Himachal Pradesh, Rajasthan and Madhya Pradesh. The highest incidence of PDS purchase among major states where wheat is the major cereal in rural sector was for Maharashtra (40%) followed by Madhya Pradesh (36%) and Gujarat (32%) whereas for urban sector,Madhya Pradesh (23%) showed highest incidence of PDS purchase.

Figure 4.26– Per capita wheat consumption from PDS in urban India, 2011-12.



The wheat consuming states in urban sector reported low proportions of households reporting PDS purchase of wheat in Haryana (9%), Punjab (7%) and Gujarat (6%). The share of PDS in wheat consumption for rural sector was 17.3% and 10.1 % in urban sector. In rural sector, among the pre-dominantly wheat consuming states, highest contribution of PDS purchases was for Maharashtra, Gujarat and Madhya Pradesh whereas in urban sectors also Madhya Pradesh had the highest. States such as Punjab, Rajasthan, Haryana, Uttar Pradesh, Gujarat, Maharashtra reported share from PDS below the national average (10%). PDS purchases have lower share of consumption in predominantly wheat consuming states like Punjab and Haryana when compared to same for rice consumption.

Figure 4.27- Per capita sugar consumption from PDS in rural India, 2011-12

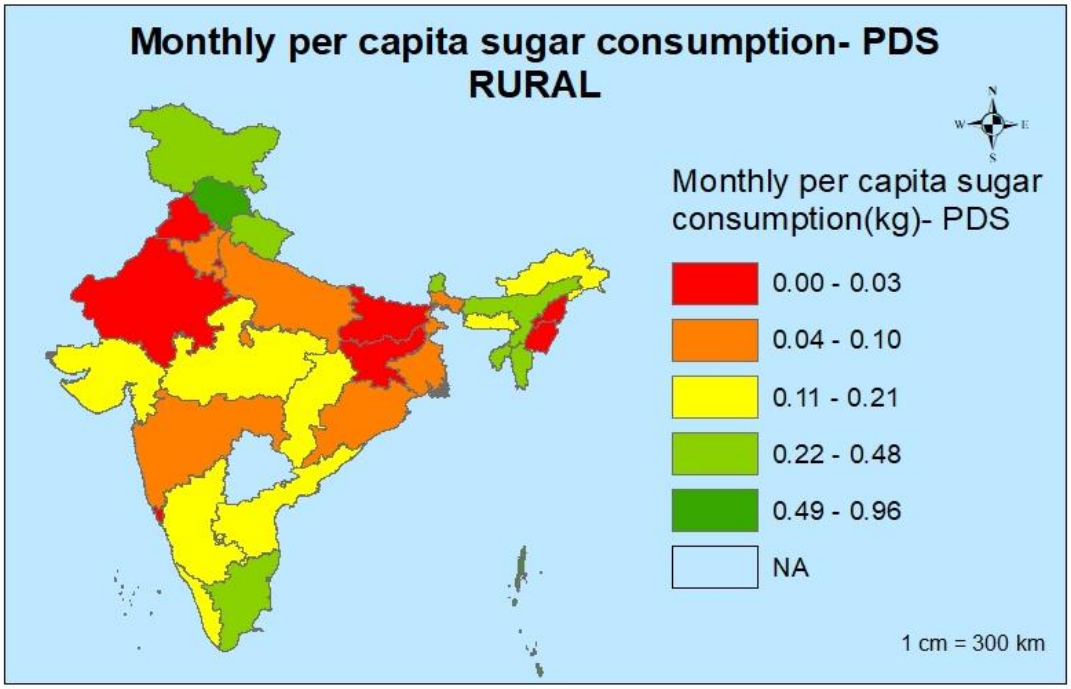
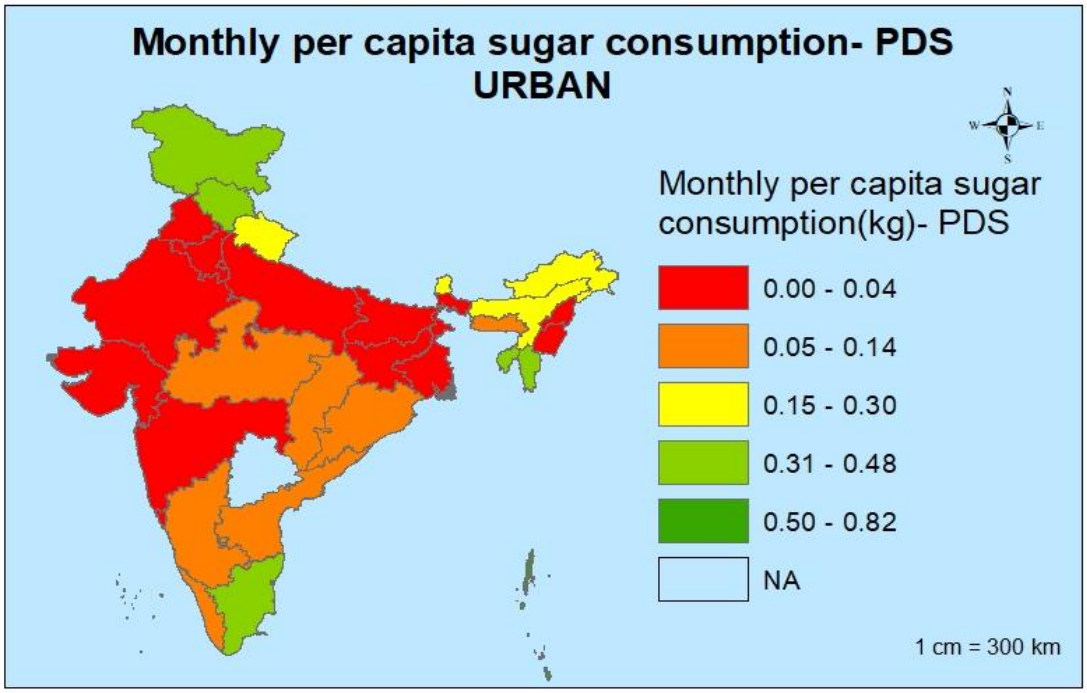


Figure 4.28- Per capita sugar consumption from PDS in urban India, 2011-12



The states reporting high per capita sugar consumption in rural sector are Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Mizoram, Tripura, Assam and Tamil Nadu and same for urban sector except Uttarakhand and Assam.

The proportion of households reporting PDS purchase of sugar was 34% for rural India and from 21% urban India. Tamil Nadu (rural 90% and urban 77%) had the highest proportion followed by Andhra Pradesh, Assam, Karnataka and Chhattisgarh. The states Punjab, Bihar, Jharkhand, Rajasthan, urban areas of Gujarat, Maharashtra, Uttar Pradesh and West Bengal had lower incidence of PDS purchase of sugar.

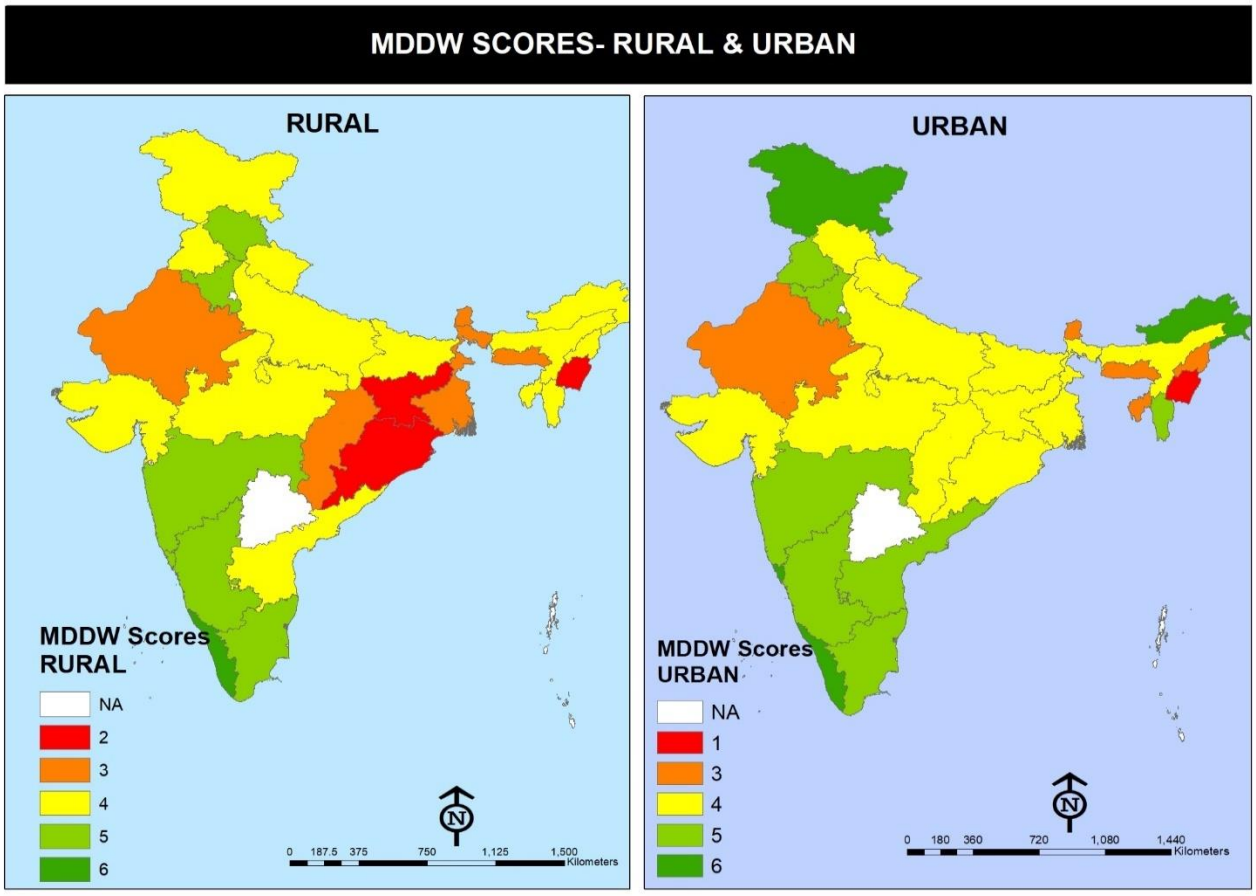
The share of consumption of sugar from PDS was 15.8% for rural India and 10.3% for urban India. Among major states, Tamil Nadu reported highest share (rural 73% and urban 64%) followed by Assam, Chhattisgarh, Odisha and Andhra Pradesh whereas Jharkhand, Bihar, Punjab, Haryana and Rajasthan and urban areas of Gujarat and Uttar Pradesh had lowest (0-2%) share of PDS for sugar.

❖ Minimum Dietary Diversity Scores for Women (MDD-W)

The Minimum Dietary Diversity for women of reproductive age (WRA) is a food group diversity indicator that helps in reflecting the micronutrient adequacy which is key dimension of diet quality. The groups of WRA when consume food items from at least five of the ten food groups are likely to have higher micronutrient adequacy. A higher prevalence of MDD-W is considered as proxy for better micronutrient adequacy among WRA in population. The groups of WRA which consume five or more of the ten groups are also highly likely to consume at least one animal source food and either pulses or nuts & seeds and food items from two or more of fruit or vegetable food groups.**(FAO & FHI 360, 2016)**

Figure 4.29 represents the state wise MDDW scores for rural and urban India in 2011-12.

Figure 4.29- MDDW Scores for rural and urban India, 2011-12.



In rural India, the states in which the women consume food items from at least five food groups were Himachal Pradesh, Haryana, Maharashtra, Karnataka, and Tamil Nadu. In Kerala, the women are observed to consume food items for six out of ten food groups in both rural and urban India. The states having lowest score of only two food groups in rural India are Odisha, Jharkhand and Manipur consuming grains, white roots & tubers, plantains and vegetable food group. In urban India, the states in which women consume food items from at least five food groups were Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, Himachal Pradesh, Haryana and Mizoram. In Jammu & Kashmir and Arunachal Pradesh, Goa and Kerala women have score of six predicting better micronutrient adequacy. Manipur has the lowest score in urban India. The food groups- grains, white roots & tubers, plantains; pulses; dairy; and other vegetables are daily consumed food groups. The consumption of eggs is low in both urban and rural India. In food groups- vitamin A rich

fruits, meat, fish & poultry, green leafy vegetables and other food groups are often (1-4 days in week) consumed in both rural and urban India**.**

(S. Gupta et al., 2020) also report strong evidence for less diverse diet for women than their households. Women consumed on an average 4 food groups in previous 24 hours, while 6 food groups were consumed by other household members. The diets of women were found to be lacking in non-staple food groups such as Vitamin A rich fruits and vegetables, green leafy vegetables, dairy and eggs.

Similar findings were reported in our study also. **(Adubra et al., 2019)** reported that educational status of women, no of household members, sex of the head of household and household wealth index were associated with women's dietary diversity. A positive association between farm production diversity and women' dietary diversity was also reported. The association of lower dietary diversity among food insecure households was found significant and the lower dietary diversity related to less consumption of nutritious foods, Vit A rich fruits and vegetables, and animal sources. Therefore, it is important to investigate the composition of women's diet by analysis of individual food group consumption to promote greater diversity.

SUMMARY
AND
CONCLUSION

5. SUMMARY AND CONCLUSION

The present study was undertaken to perform spatial mapping of food and nutrition security and associated indicators through secondary data source. The three major components agriculture, nutrition, health and food safety programs and their role in improving food and nutrition security has been studied at national level and state of Gujarat. The spatial mapping was performed with software Arc GIS 10.5.

The major cropping systems based on the agro-climatic zones was found to be as follows- rice-wheat in Indo- Gangetic Plains (IGP), rice-rice, rice-fallow, rice-other systems in eastern India; coarse cereal and pulse systems more concentrated in northern Karnataka, western Maharashtra and Rajasthan and scattered throughout the country and cotton-oilseed systems in western and central India. The agroclimatic regional planning was found to be directly associated with food security.

The food availability is an important component of food security. In this study, it was observed through the production and per capita availability (PCA) of food at state level. The estimated PCA showed a decline from 598.15 g/day in 2018 to 592 g/day in 2019 for food grains and from 53 g/day in 2018 to 46 g/day for pulses in India. However, there was an increase in 2020 with PCA of 610g/day for food grains and 47 g/day for pulses. At state level, majority of the states showed similar trends except some states such as Assam, Bihar, Goa, Chhattisgarh, Manipur, Meghalaya and Puducherry (UT) which showed declining PCA since 2018.

In state of Gujarat, the total food production declined from 77686 MT in 2017-18 to 68122 MT in the year 2018-19. The PCA in grams/day showed a decline from 102g/day to 91 g/day and from 14 g/day to 10.20 g/day for cereals and pulses respectively. However, the PCA was estimated to increase in the year 2020 for both cereals and pulses.

Food safety net programs are a basis to improve food security and are representative of accessibility and utilization components of food security. At district level of Gujarat, the health and nutrition services provided by ICDS and their utilization was studied through NFHS-4 and NFHS-5. The maternal health indicators such as antenatal care, antenatal visits, IFA consumption and institutional births have showed progress since 2015-16. The

immunization and Vitamin A supplementation has also increased among children. The prevalence of diarrhea and acute respiratory infection have shown a marginal decrease in 2019-20. The early initiation of breastfeeding within one hour of birth has reduced by 12% whereas exclusive breastfeeding has increased by 10% in 2019-20 and only a marginal increase in total number of children receiving an adequate diet occurred.

The under-five stunting has largely remained unchanged and the under-five wasting showed a marginal decline (1%) in Gujarat since 2015-16. The under-five under-weight also showed a marginal increase (1%) since 2015-16. The major factors that were significantly associated with undernutrition in under-five children were literacy in women, nutritional status of women (low BMI, overweight/obesity), maternal anemia, improved sanitation and drinking water source, institutional births and antenatal care. Anemia among 6-59 months has increased 17% and among women age 15-49 years by 10%.

The weighted sum spatial analysis for stunting, wasting and overweight for under five children in Gujarat identified Tapi, Panch Mahals, Dangs, Aravalli, Mahisagar, Chota Udepur, Narmada and Dahod as high burden districts for under-five undernutrition. The districts such as Jamnagar, Junagadh, Porbandar, Rajkot, Amreli, Dev Bhumi Dwarka, Morbi, Kachchh and Ahmedabad have low burden of undernutrition in the year 2019-20.

The Inverse Distance Weighted (IDW) interpolation method for number of meals served in different blocks of Vadodara district on one day from each month of 2018 reported higher number of meals being served in Vadodara, Padra, Savli and Karjan blocks of Vadodara district. Also, the number of meals served were higher in the latter half of the year.

The PDS share in rice consumption was about 27.9 % in rural India and 19.6 % in urban India in 2011-12 as per the NSSO 68th round. The PDS share in wheat/atta consumption was about 17.3% in rural India and about 10.1 % in urban India. The share of PDS in sugar consumption was about 15.8 % in the rural sector and about 10.3% in the urban sector. The utilization was higher in rural sector than urban sector.

For rural India, the lowest score for the minimum dietary diversity for women (MDDW) score for was lowest two for Jharkhand, Manipur and Odisha and highest score was six for Kerala in 2011-12. Manipur had the least score of one and Kerala, Goa, Andhra Pradesh and Jammu and Kashmir had highest score of six for urban India. The women of only six to seven states in both rural and urban India were consuming minimum five out of ten food groups.

CONCLUSIONS

The major conclusions that emerge from the present study are

- ✓ The three major components agriculture, nutrition and health play a significant role in improving food and nutrition security. Food safety net programs also show a contributory role towards food security.
- ✓ Climatic factors affect food security in several ways and has the potential to influence the nutritional status. The future strategies stimulating and tailoring agriculture diversification through cropping patterns can help in addressing food and nutrition security.
- ✓ At national and state level, the estimated per capita availability of food grains and pulses are not sufficient to meet the demand of population. The domestic production should be increased to meet the demand-supply gap and meet the per capita availability.
- ✓ At district level of Gujarat, evidence from the present study shows that utilization of ICDS services needs improvement in Gujarat. It requires quality improvements in health and nutrition education services and infant young child feeding (IYCF) practices. The utilization of PDS across various states showed regional variations at state level for urban and rural India.
- ✓ Undernutrition in under five children remains an important health concern in several districts of Gujarat. The factors such as socio-economic status, improved sanitation, maternal education and nutritional status, exclusive breast feeding, age and sex of child have influence on nutritional status of under-five children.
- ✓ Spatial variations at state level, observed in dietary diversity of women should be considered and areas with poor dietary diversity should be focused upon for

improved food security. There is a need for primary data on dietary intake to assess nutritional outcomes.

- ✓ Geographic Information System (GIS) can be utilized as an effective technique for efficient use of resources, better planning, monitoring and decision-making process for food security.

RECOMMENDATIONS

- ✓ At national and state level, improvement in cropping patterns according to the agroclimatic zones should be encouraged.
- ✓ At state level, the utilization of PDS can be improved by planning region-specific distribution of commodities and dietary diversity of women can be improved by identification of individual food groups specific for each state.
- ✓ At district level, for utilization of ICDS services, regional variations in the prevalence of undernutrition and spatial distribution of associated factors varies from region to region, therefore instead of one fit all, region specific interventions should be planned.
- ✓ At block level of Vadodara district, the spatial mapping of number of meals served at schools for all working days can provide better picture of utilization of MDM in Vadodara district.
- ✓ Spatial analysis of the districts which are not performing well in terms of various factors should be studied individually in future.

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ANNEXURE I

Annexure I- Ethical Approval Certificate

सत्यं शिवं सुन्दरम्
Estd. 1949

Institutional Ethics Committee for Human Research (IECHR)

FACULTY OF FAMILY AND COMMUNITY SCIENCES
THE MAHARAJA SAYAJIRAO UNIVERSITY OF BARODA

Ethical Compliance Certificate 2020 – 2021

This is to certify that **Ms. Meghani Payal Nareshbhai**'s study titled, "**Spatial Mapping of Food and Nutrition Security and Associated Nutrition Indicators using Secondary Data Source**" has been approved by the Institutional Ethics Committee for Human Research (IECHR), Faculty of Family and Community Science, The Maharaja Sayajirao University of Baroda. The study has been allotted the ethical approval number **IECHR/FCSc/2020/55.**

Prof Mini Sheth
Member Secretary
IECHR

Prof Shagufa Kapadia
Chairperson
IECHR

ANNEXURE II

Annexure II- DHS Permission Letter

Oct 21, 2020

Suneeta Chandorkar
The Mharaja Sayajirao University of Baroda
India
Phone: +919426366666
Email: suneeta.chandorkar-fn@msubaroda.ac.in
Request Date: 10/20/2020

Dear Suneeta Chandorkar:

This is to confirm that you are approved to use the following Survey Datasets for your registered research paper titled: "Spatial mapping of food and nutrition security and associated indicators using secondary data source":

India

To access the datasets, please login at: https://www.dhsprogram.com/data/dataset_admin/login_main.cfm. The user name is the registered email address, and the password is the one selected during registration.

The IRB-approved procedures for DHS public-use datasets do not in any way allow respondents, households, or sample communities to be identified. There are no names of individuals or household addresses in the data files. The geographic identifiers only go down to the regional level (where regions are typically very large geographical areas encompassing several states/provinces). Each enumeration area (Primary Sampling Unit) has a PSU number in the data file, but the PSU numbers do not have any labels to indicate their names or locations. In surveys that collect GIS coordinates in the field, the coordinates are only for the enumeration area (EA) as a whole, and not for individual households, and the measured coordinates are randomly displaced within a large geographic area so that specific enumeration areas cannot be identified.

The DHS Data may be used only for the purpose of statistical reporting and analysis, and only for your registered research. To use the data for another purpose, a new research project must be registered. All DHS data should be treated as confidential, and no effort should be made to identify any household or individual respondent interviewed in the survey. Please reference the complete terms of use at: https://dhsprogram.com/Data/terms-of-use.cfm.

The data must not be passed on to other researchers without the written consent of DHS. However, if you have coresearchers registered in your account for this research paper, you are authorized to share the data with them. All data users are required to submit an electronic copy (pdf) of any reports/publications resulting from using the DHS data files to: references@dhsprogram.com.

Sincerely,

Bridgette Wellington

Bridgette Wellington
Data Archivist
The Demographic and Health Surveys (DHS) Program

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